Proceedings of the

Energy Efficiency Policy Symposium

November 9, 2000

Honolulu, Hawaii

Co-Sponsors:

Building Industry Association

Hawaii State Department of Business, Economic Development & Tourism

Hawaii Natural Energy Institute

Hawaii Renewable Energy Alliance

Hawaii Solar Energy Association

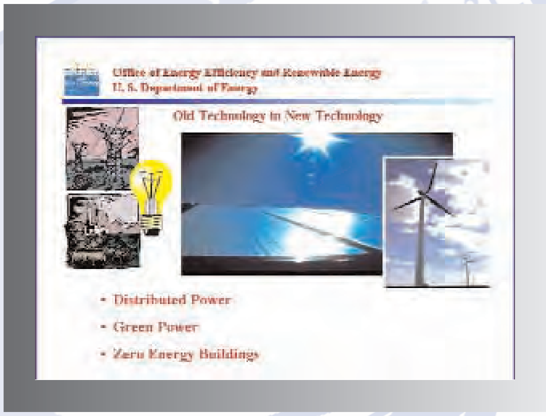
Hawaiian Electric Company, Inc.

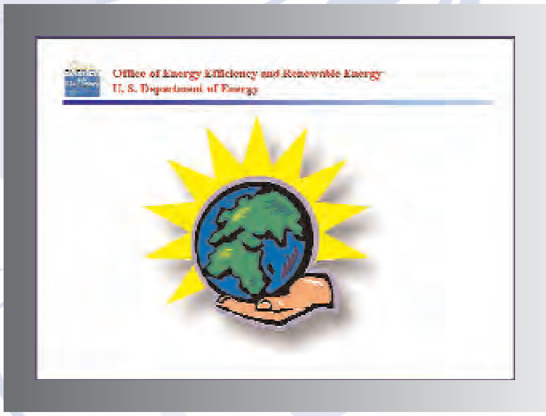
Honolulu Community Action Program

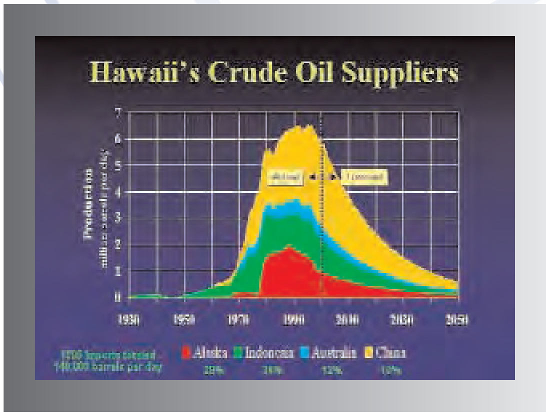
U.S. Department of Energy

U.S. Department of Housing and Urban Development

University of Hawaii







Disclaimer

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The symposium was videotaped by Sustainable Kauai. Copies of the videotape are available from them for a nominal fee. For more information, contact Dr. P. Neil, (808) 826-0101, e-mail: cre8@aloha.net.

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PREFACE

Energy-Efficiency Policy Task Force

Act 163, passed in 1998, provided for the establishment of a Task Force, supported by DBEDT, to "explore the most cost-effective means for supporting increased energy efficiency and sustainability by:

1. Examining alternatives to encourage the efficient use of energy;
2. Considering the merits of active participation in the federal Million Solar Roofs Program…;
3. Making recommendations on the most cost-effective means of increased energy efficiency."

Recommendations of the Task Force are due no later than January 1, 2002.

In 2000 DBEDT formed an Energy-Efficiency Policy Task Force (Task Force) with the following members:

Warren Bollmeier, President, Hawaii Renewable Energy Alliance
Mike Flores, Community Builder, U.S. Dept. of Housing and Urban Development
Ruby Hargrave, Executive Director, Honolulu Community Action Program
John Harrison, Executive Director, UH Environmental Center/Interim Special Assistant to the VP for Research & Graduate Education
Cully Judd, Board Member, Hawaii Solar Energy Association
Karen Nakamura, Executive Vice President, Building Industry Association of Hawaii (Chair of the Task Force)
Richard Rocheleau, Interim Director, Hawaii Natural Energy Institute
Carilyn O. Shon, Energy Conservation Program Manager; Energy, Resources and Technology Division; Department of Business, Economic Development, and Tourism
Dave Waller, Manager, Energy Services Department, Hawaiian Electric Company, Inc.
Eileen Yoshinaka, Pacific Liaison, U.S. Department of Energy

On November 9, 2001, the Task Force sponsored an Energy-Efficient Policy Symposium which included a number of distinguished speakers: an American petroleum geologist from Scotland, a professor emeritus from the University of Colorado, representatives from other states with exemplary energy policies, as well as the energy specialist from National Conference of State Legislatures which is just completing its survey of state energy policies. There were also a number of local speakers representing nonprofit organizations (Iolani School, Honolulu Community Action Program, The Consuelo Zobel Alger Foundation), private and business organizations (Off Peak, Hawaiian Electric Company, Hawaii Solar Energy Association), and economists Dr. Tom Loudat and Dr. Leroy Laney.

Although the Task Force's recommendations are due to the Legislature no later than January 1, 2002, the Task Force unanimously agreed to present their interim recommendations to the 2001 Legislature, which is presently considering the energy tax credits. The final findings and recommendations will be submitted to the Legislature no later than January 1, 2002.

Presentations of the Symposium speakers have been collected in this publication. The Symposium presentations and the recommendations of the Energy-Efficiency Task Force are also available at the following: *www.state.hi.us/dbedt/ert/symposium*.

Interim Recommendations of the Energy-Efficiency Policy Task Force

1. Continue the energy conservation income tax credits.

In the Energy-Efficiency Policy Symposium of November 9, 2001, the value of the existing energy income tax credits was a recurring theme of the speakers. Emphasis was placed on the value of tax credits, especially those (private businesses and nonprofits) in Hawaii that have experience with the tax credits. Consequently, the Energy-Efficiency Policy Task Force's investigation of alternatives to encourage the efficient use of energy and cost-effective means of increased energy efficiency points to the need and value of continued state support of the energy conservation income tax credits.

Therefore, one of the initial recommendations of the Task Force is the continuation of the tax credits until 2010, to complement the Federal program, Million Solar Roofs (MSR). MSR's goal is to have one million rooftops with solar systems by 2010. Hawaii is the acknowledged national leader in the MSR Program.

a. Present Tax Credits Make Economic Sense

With DBEDT funding, Dr. Tom Loudat updated his report on *The Economic and Fiscal Impacts of the Hawaii Energy Conservation Income Tax Credit*. His conclusions about the tax credits find that "there is a positive fiscal impact to the State…"

- Labor income effect of the tax credits is $6.6 million per year for annual systems installation of 2,477 systems…for a total of $34 million over the life of solar systems. This labor income effect is forgone if the tax credits are eliminated.
- Net total fiscal impact is…$5.6 million due to the tax credits for a given year's purchase of 2,477 systems.

In addition, the money forgone for oil payments to heat water will be kept in Hawaii to generate economic activity that leads to more jobs, income, and taxes paid.

With DBEDT funding, Dr. Leroy Laney conducted A Peer Review of the *Economic and Fiscal Impacts of the Hawaii Energy Conservation Income Tax Credit.* His critique of the paper found that, "this reviewer finds the assumptions and conclusions from them to be reasonable and sound. Furthermore, the analysis appears to have been conducted carefully and in great detail." Dr. Laney concluded his paper with some "Thoughts on Hawaii's Energy Policy Options" and noted that "research such as the Loudat paper, and the results presented above in the reviewer's own paper, provide evidence that a tax credit contributes net economic and fiscal benefits, and that this tax credit has indeed been effective in stimulating investment in solar systems over and above more conventional private market forces. It is the role of government to eliminate roadblocks, and to provide incentives for solutions, even if those solutions themselves come from the private sector."

- Costs of imported items will be higher, and practically everything we consume comes from outside the state.
- Hawaii businesses will have to pay higher prices for running and lighting their facilities.
- Finally, the most critical impact may come from the income effects on a slowing U.S. economy that will also feel the impact of higher oil prices. At the current juncture, Hawaii looks overwhelmingly to the U.S. Mainland for its externally driven growth…. Higher energy prices have been one of the main factors causing downward revisions of upcoming U.S. growth. Hawaii will feel the effects of a slowing U.S. economy more acutely….

b. Sustain Public/Private Partnerships

At present the electric utilities offer incentives (rebates) to customers who install efficiency measures to reduce their demand for electricity. These incentive programs will, in the long run, allow the utilities to delay building costly generating plants by using present facilities as efficiently as possible. The delay will also allow for the development of improved renewable and electro-technologies.

The incentive programs must meet strict regulatory requirements laid out by the Public Utilities Commission (PUC). The utilities are in compliance with the requirements and have allocated millions of dollars to incentivize consumers to be more efficient. It is very important, however, that the utility incentive programs have the complement of the energy tax credits. Without the tax credits, the number of systems installed would be substantially reduced and the cost effectiveness of the consumer efficiency programs might be called into question. Without an effective customer efficiency program, the public/private partnership will no longer be providing $14 million in funding support for residential energy efficiency programs. (Hawaiian Electric Company's projected program costs for its Residential Demand Side Management Program over a five-year period as filed in its application under the Public Utility Commission Docket 00-0209 allocates $14 million to support this program.)

c. Support Stability for Energy Businesses

Businesses need a longer lead-time on the tax credit termination date to plan and do business. With a longer sunset date, renewable and efficient technology businesses can do better business planning. A short term for the tax credits hampers business development because local renewable and efficiency businesses need longer timeframes not only to secure good property and equipment leases, but also to attract qualified and dedicated employees. The solar industry estimates that there are about 700 people employed in the solar industry and its ancillary businesses. There are also an estimated 75,000 households with solar installations, making Hawaii the state with the highest per capita installations.

The credits help to level the playing field for renewable and efficient technologies against the heavily subsidized petroleum industry.

d. Taxpayers are Counting on the Credits

The Consuelo Zobel Alger Foundation, which provides for self-help homes to low-income households, works with American Security Bank to include solar water heating systems. Without the tax credits, The Consuelo Foundation would not be able to install solar water heating systems. The tax credits allow home owners to install solar systems. The solar systems reduce home owners' monthly utility bills, thereby increasing their monthly cash flow to meet mortgage payments.

Iolani School is very pleased with the two ice storage systems they installed through a leasing agreement with First Hawaiian Leasing and, based on this experience, has developed a master plan that includes the installation of ice storage for its entire campus. They will commence construction in 2003, the expiration date of the tax credits. If the termination date is not extended, they will probably cancel this part of their master plan.

2. Extend the credits to 2010.

Extend the credits to a new expiration date of 2010 to explore and develop renewable and alternate systems and to complement the federal Million Solar Roofs program.

To shorten the term of the tax credits would be to burden business development for local solar and related businesses which must rely on longer timeframes not only to effect leases for facilities and equipment, but also to attract qualified and dedicated employees.

3. Petition the Department of Human Services to use federal funds to provide energy saving devices.

Petition the Department of Human Services to use up to 15 percent of the Low Income Home Energy Assistance Program allocation toward providing energy saving devices to low income families to reduce their energy costs.

In the year 2000 the State was allocated over $1.2 million to assist low-income families. The Department of Human Services presently uses these funds to credit utility bills of families in jeopardy of utility shut-off or about to be shut-off situations. The federal government allows states to use up to 15 percent of their LIHEAP allocation towards providing energy saving devices to low-income families to reduce their energy costs. By installing these devices, the states can provide a longer-term solution to these families.

4. Provide and support education programs.

Provide and support education programs for all levels of the community, including professional development, the general public, and formal education programs for school children. Education is essential to ensure an understanding and informed decision-making on the part of everyone as energy affects not only our daily lives, but also as it affects future generations and consequences for our future.

5. Conduct economic analyses of alternatives to the energy tax credits.

The diverse membership of the Task Force lends itself well to offering policy recommendations from members of the community. The Task Force, however, has found that before recommendations and decisions can be made about specific alternatives to the tax credits, there is a need for data and systematic analyses of alternatives. These alternatives could include loan programs, impact fees, emissions taxes, and mandates.

6. Support utility energy efficiency and renewable energy programs.

Support integrated resource planning and demand side management initiated by the utilities and the Public Utilities Commission. The contributions of these programs are discussed in 1.b. above.

7. Direct the Public Utilities Commission (PUC) to support and implement policies for energy efficiency and renewable resources.

To bridge the transition to hydrogen technology, direct that the PUC examine and implement policies to encourage and support energy efficiency and renewable resource industries and resources to replace fossil fuels. The PUC should review and evaluate energy efficiency and renewable resource programs in states such as Arizona, Calilfornia, Texas, Maine, Vermont, and Wisconsin.

8. Mandate energy efficiency and renewable energy installations.

Mandate the installation of energy efficiency and renewable technologies in state and county buildings and facilities to build upon Presidential Executive Order 13123, "Greening the Government Through Energy Efficient Energy Management."

Welcome

Karen Nakamura

Executive Director, Building Industry Association;
Chair, Energy Efficiency Policy Task Force

Good Morning, ladies and gentlemen. On behalf of the Energy Efficiency Policy Task Force, welcome and thank you for participating in today's Symposium.

My name is Karen Nakamura. I am the Executive Director of the Building Industry Association and Chair of the Energy Efficiency Policy Task Force.

We have dignitaries in our audience whom we would like to recognize and welcome:

- Senator Cal Kawamoto
- Senator Norman Sakamoto
- Senator Suzanne Chun Oakland
- Representative Hermina Morita
- Councilmember Steve Holmes of Honolulu
- Councilmember Bryan Baptiste of Kauai
- Councilmember Charmaine Tavares of Maui
- Councilmember Riki Hokama of Maui

Thank you for being with us today.

At this time, I would like to thank and recognize the members of our Task Force for their time, talents and contributions. Would you please stand as I call your name:

Richard Rocheleau, Interim Director of Hawaii Natural Energy Institute; **Warren Bollmeier**, President of Hawaii Renewable Energy Alliance; **Ruby Hargrave**, Executive Director of Honolulu Community Action Program, Inc.; **Mike Flores**, Community Development Officer, U.S. Department of Housing and Urban Development; **Cully Judd**, Board member of the Hawaii Solar Energy Association (Cully's knowledge and personal friendships with our presenters were invaluable to our success); **Dave Waller**, Manager, Energy Services Department, Hawaiian Electric Co., Inc. (we thank you Dave for your hospitality and your facilities; this could not be a free symposium without your contributions); **Eileen Yoshinaka**, Pacific Liaison, U.S. Department of Energy (Eileen, thank you for getting Peter Dreyfuss to squeeze us into his already packed speaking itinerary); **John Harrison**, Interim Special Assistant to the VP for Research & Graduate Education, U.H. Manoa (who gave us vision to look beyond Hawaii for resources current practices); and **Carilyn Shon**, Energy Conservation Program Manager, Department of Business, Economic Development & Tourism (Carilyn, thank you for facilitating our task force, keeping us on track, and coordinating the many details in putting together this symposium).

ACT 163 of the State Legislature created our task force. We have been charged to explore the most cost-effective means for supporting increased energy efficiency and sustainability by:

A. Examining alternatives to encourage the efficient use of energy;
B. Considering the merits of active participation in the federal Million Solar Roofs Program; and
C. The outcome of this Task Force is to make recommendations to our legislature on the most cost-effective means for increased energy efficiency.

Our fast paced agenda will present to you the global view; the economic impact on our island state; current practices of other states; the national perspective; and what is happening today in Hawaii.

Your input is important to this symposium because you are the front line service providers who implement the plan.

Jack Zagar

Independent Petroleum Engineering Consultant, O'Z Consultants
Associate of Malkewicz-Hueni Associates of Golden, Colorado, and
Partner with noted author and world oil reserve expert, Dr. Colin Campbell.

Jack Zagar has twenty-five years experience in North Sea, Middle East, Gulf of Mexico, and onshore U.S.A. operations in petroleum reservoir engineering and reservoir management; economic evaluations of projects, property trades, and asset sales; and corporate planning. Twenty-two years were with Exxon Corporation and Exxon U.S.A. The last three years Mr. Zagar has been engaged as an independent engineering consultant. Mr. Zagar is also an associate of Malkewicz-Hueni Associates of Golden, Colorado and is partnered with noted author and world oil reserve expert, Dr. Colin Campbell.

Dr. Colin Campbell took a D.Phil. in geology at Oxford in 1957 before joining the oil industry as an exploration geologist, working in Trinidad, Colombia and New Guinea. In 1968, he joined Amoco in New York with responsibility for worldwide new ventures and world resource assessment. In 1969, he was appointed the company's Chief Geologist in Ecuador. In 1972 he was appointed General Manager of a Texas independent's North Sea operations, before returning to Amoco as Exploration Manager in Norway in 1980. In 1984, he accepted an offer to become Executive Vice-President of Fina in Norway. In 1989 he became an independent consultant advising governments and major oil companies. He has written two books - *The Golden Century of Oil* and *The Coming Oil Crisis* - and has published widely, lectured and broadcast on oil depletion. Presently, Dr. Campbell is a partner of PetroPlan, Inc.

The End of Cheap "Conventional" Oil

by

J. J. Zagar
O'Z Consultants[1]

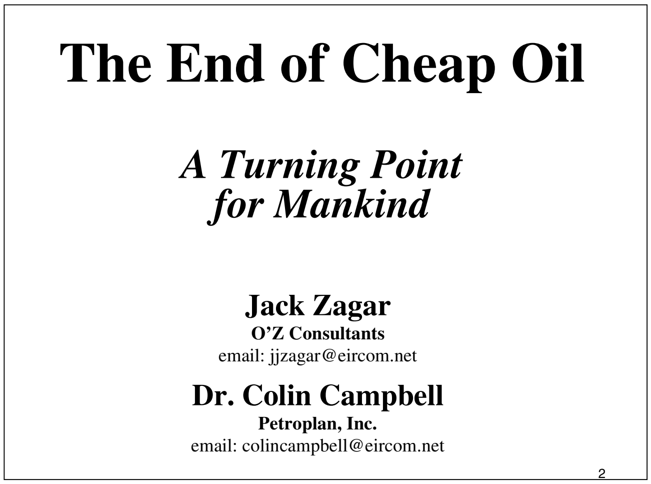
Dr. C. J. Campbell
Partner, Petroplan, Inc.[2]

Presented at the
Energy Efficiency Policy Symposium
Honolulu, Hawaii

November 9, 2000

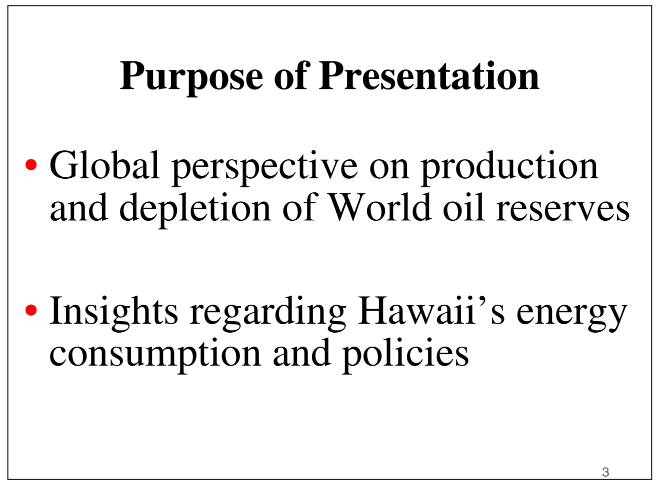
ABSTRACT

Easy to find and cheap to produce "conventional" oil in huge quantities has fueled and satisfied the World's thirst for energy this century. About 95% of all oil produced—and 90% of today's production—comes from this group of hydrocarbons. But this century of the new millennium will see the decline and exit of conventional oil as a major player on the World's energy stage. Already, outside the Middle East, conventional oil production is on the decline. And the Middle East with its vast reservoirs of oil will soon reach the mid-point of depletion and begin its irreversible decline. Currently, one barrel of conventional oil is being found for every four barrels that are produced. The Middle East now supplies 30% of the World's conventional oil production and their share is rising because, unlike in the 1970s, no new major provinces, save perhaps the Caspian, are there to deliver flush production. The stage is now set for another "energy crisis" starting with higher prices from Middle East control and followed by the onset of physical shortage around 2010. We face something new to human experience.



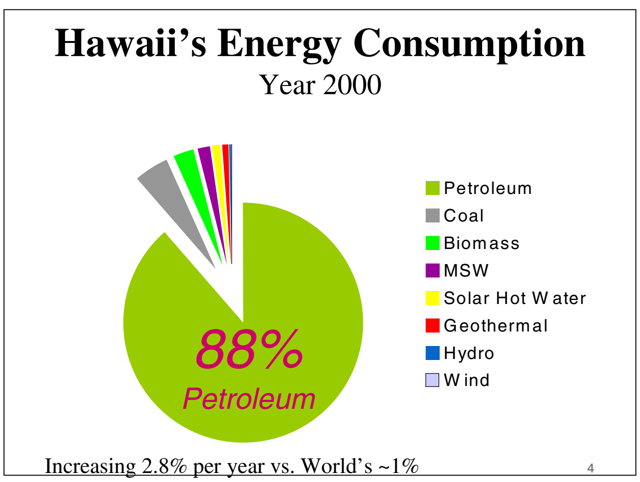
<CHART 2> Title slide

GOOD MORNING ladies and gentlemen! I would like to thank the organizers for inviting me to be with you today to speak on this increasingly important subject. My partner Dr. Colin Campbell sends his apologies for not being here to speak with you personally.



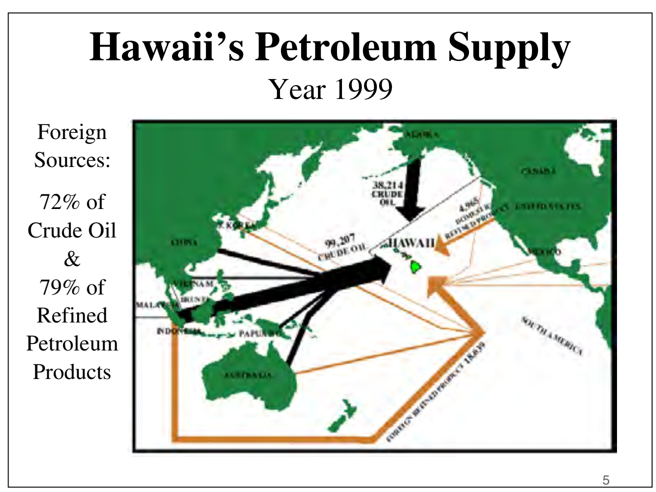
<CHART 3> Purpose of Presentation

The purpose of my presentation is to, primarily, provide you with a global perspective on the production and depletion of that fundamental commodity—crude oil—that has driven the World's economies since the middle of the last century; and, then to, briefly, offer some insights as to what this all means insofar as Hawaii's energy consumption and policies are concerned.



<CHART 4> Hawaii's Year 2000 Energy Consumption

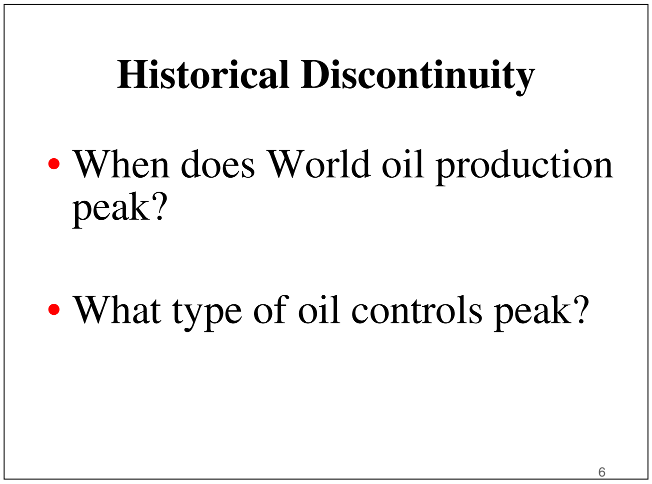
On a local level, petroleum based energy is the lifeblood of Hawaii, accounting this year for nearly 90% of the energy consumed. Hawaii's total energy consumption has increased on average 2.8% per year since 1994 compared to the World" annual average of 1.8%.



<CHART 5> Hawaii's Petroleum Supply

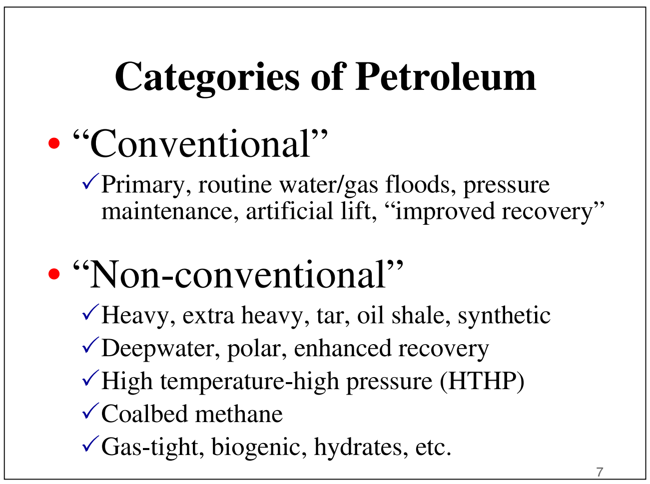
Hawaii imports daily nearly 140,000 barrels of crude oil and 24,000 barrels of refined petroleum products of which 72% and 79%, respectively, come to Hawaii from sources outside the United States.

Let me just say up front that I want to get away from the notion of "running out of oil". With the tremendous resources of heavy oils and tar sands in the world, and the likes of oil shales and conversion of natural gas to oil, running out of oil will not happen for a long time.



<CHART 6> Historic Discontinuity

Whenever I speak of the end of cheap oil, I am talking about an *historic discontinuity*, namely: *When does world oil production peak and begin its irreversible decline? And what type of oil controls peak production?* Most global economies are expanding and are expected to continue to do so. And with this expansion, cheap oil production is expected to keep pace fueling this growth. Well, what if the growth in low-cost oil production does not materialize? Let's investigate . . .



<CHART 7> Categories of Petroleum

The first and most difficult step is to define what we are talking about. It has been common practice to distinguish *conventional* from *non-conventional* hydrocarbons. Some people define as *conventional*: all oil that is commercially producible at a given date. This approach means that nothing can be measured because the goal posts move all the time.

Instead, I recognize that the family of hydrocarbons is a large one. Each member has its own endowment in Nature, its own characteristics, costs, and depletion profile. It is obvious that you can deplete light oil flowing at 20,000 barrels a day from a Middle East well much more quickly than you can extract oil from a tar sand in Canada. About 95% of all oil produced to date—and 90% of today's production—comes from this group of hydrocarbons which I will call "*conventional*" for want of a better word. It will continue to dominate supply until well past peak. This is what matters most, and I will concentrate on it today.

Non-conventional oils, most of which are listed on the lower half of this slide, are a large resource but most are slower and significantly more costly to produce. They become important primarily after peak, but they do shift peak by a few years

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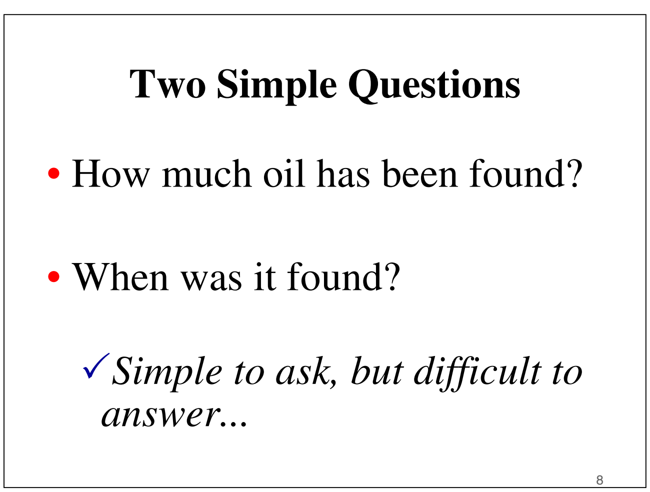
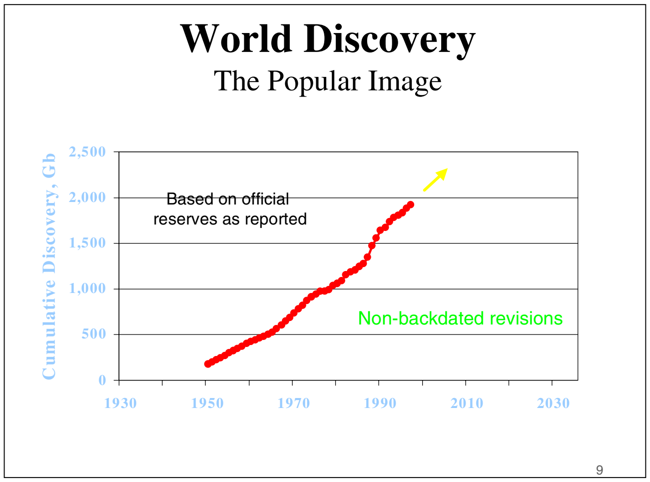


<CHART 8> Two Simple Questions

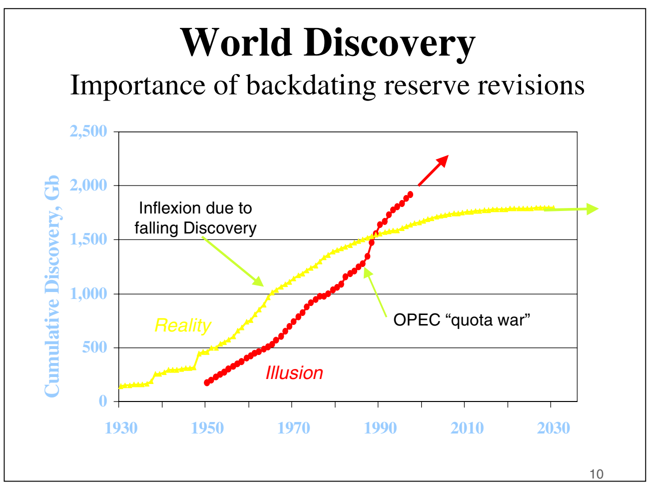
Once we have defined what kind of oil we are talking about, we have to ask two simple questions: (1) How much of this oil has been found? and (2) When was it found? These questions sound simple, but they are difficult to answer because the data are weak.



<CHART 9> World Discovery – Popular Image

This is the popular image based on official reserves as reported and promoted by oil companies. This is a plot of cumulative world oil discovery in billions of barrels versus time. It conveys the notion of discovering ever more oil, and is often explained by the ever-onward march of technology.

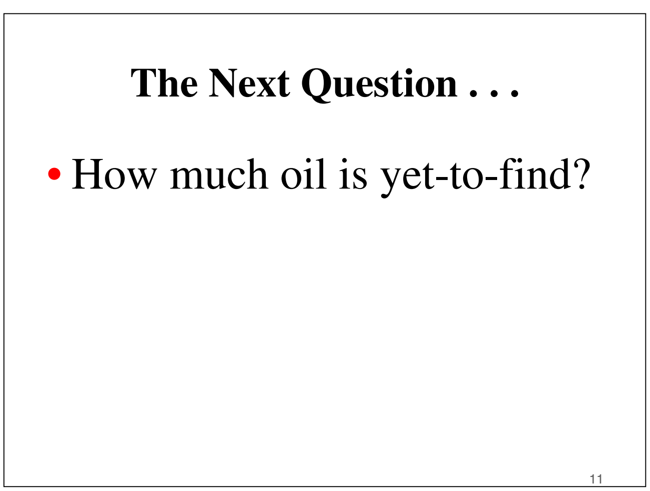
But, most of it is in the reporting, not in the reservoir. It simply reflects a correction of initial under-reporting due to the conservative booking of the reserves. This under-reporting is done for all sorts of good commercial and regulatory reasons and is the root cause of what is often referred to today as "reserve growth" in producing fields. The under-reporting is aggravated further by not back-dating the reserves to the earlier date when the field was discovered.



<CHART 10> World Discovery – Importance of Backdating

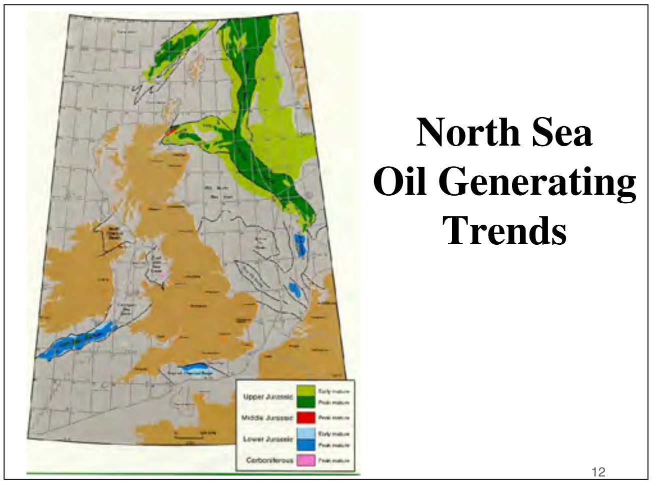
The reality of reserve projections is very different, once we use valid reserve figures properly backdated to their time of discovery. This chart is the same as the previous chart but back-dating the reserves and using the best reserve estimate I can make as illustrated with the yellow line. The bending over of this cumulative curve is due to a decline in the rate of discovery of which I will discuss later.

I have extrapolated the discovery trend of the yellow curve forward in time to open the next question: How much conventional oil is Yet-to-Find?



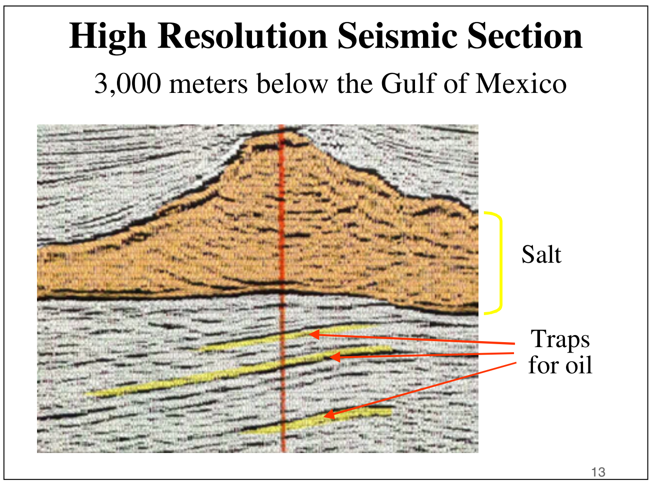
<CHART 11> The Next Question: How much oil is yet to find?

Most of the world's oil was found long ago with technology no more advanced than the hammer and hand lens. Some 60% lies in about 300 easily found giant fields. But over the last 20 years, we have seen amazing technological advances in the exploration arena.



<CHART 12>North Sea Oil Generating Trends – Geochemistry

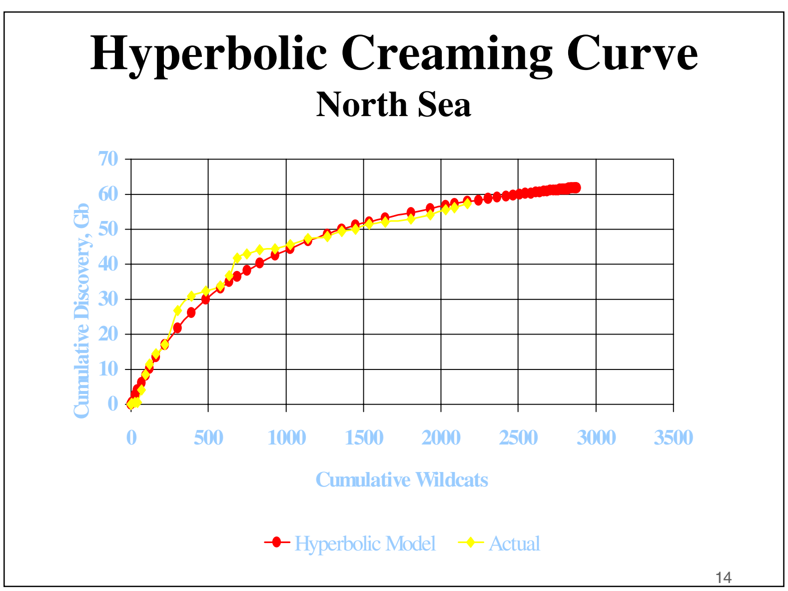
First, there is the geochemical revolution. In the 1980s, geochemistry allowed us to relate the oil in a well with the source rock from which it came. These techniques have allowed the industry to map and identify the oil generating trends of virtually the entire world. This example is of the North Sea. There is little possibility of finding oil outside these generating trends, and we now know where most of them are.



<CHART 13> High Resolution Seismic Section

Then, there is the geophysical revolution that we hear so much about in the way of 3-dimensional and even 4D seismic surveys. This technology is equally successful in telling us where oil is NOT as well as where it is. This chart shows the amazing seismic resolution that is possible. We can now see even the smallest needle in the haystack and in some cases even the oil itself. But unfortunately, the needle is still a needle. We didn't need this resolution to find the giant fields that dominate world production.

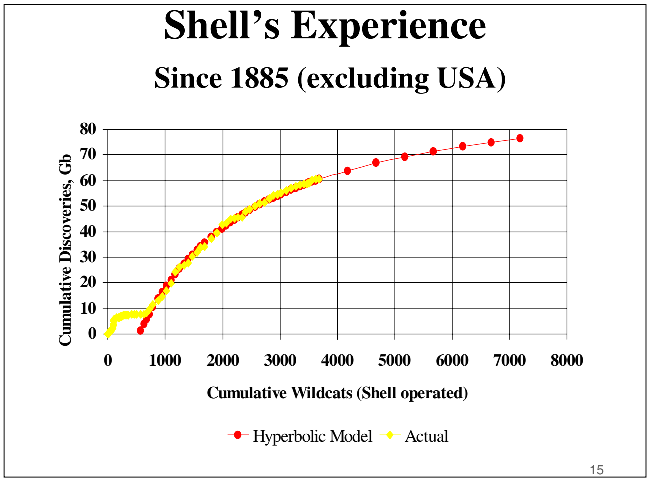
As an aside—a giant field on the World stage is any field with 500 million barrels or more of reserves. It sounds big—and it is—but the current appetite of the World is such that it consumes the equivalent of one of these giants every week.



<CHART 14> Hyperbolic Creaming Curve – North Sea

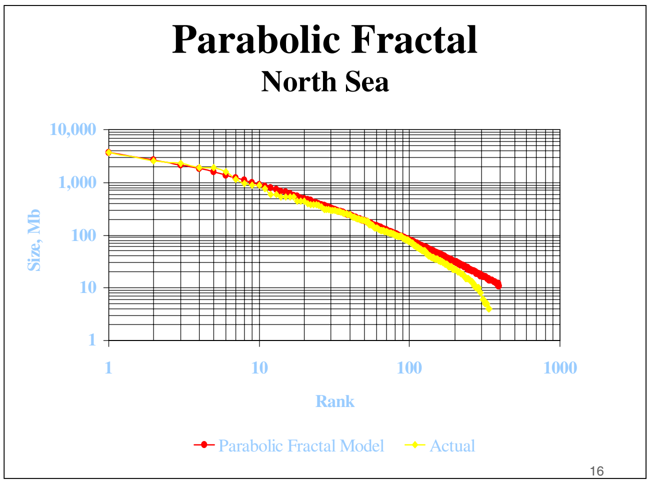
We can also use statistical techniques. This so-called hyperbolic creaming curve is one of the more powerful tools. It plots cumulative oil discovery against cumulative wildcat exploration wells. This particular one is for the North Sea. The larger fields are found first; hence, the steeper slope at the beginning of the curve. Nearly 57 Gb have been found after drilling over 2,200 wildcats. Extrapolating the trend shows that double the exploration effort would bring only a tenth more. To find an entirely new basin after more than 30 years of exploration seems highly unlikely, save perhaps for the deep water.

<CHART 15> Shell's Experience – Hyperbolic Creaming Curve



It is the same story with an individual company. Shell Oil is arguably one of the most successful explorers of the major international oil companies. Since 1885 Shell has found 60 Gb with 3,600 wells outside of the USA. If Shell drilled as many again it might find another 16 Gb. I could show you the corresponding plot for Amoco. This former oil giant found 15 Gb with 600 wells, but 14 of the 15 Gb came from the first 300 wildcats with hardly anything to show for the remainder. It perhaps explains why Amoco merged with BP.

<CHART 16> Parabolic Fractal – North Sea



Another statistical tool that we use is the parabolic fractal model. It relates field size with its relative rank. This particular one is for the North Sea. The yellow line is the size distribution of the actual fields. Once all the larger fields have been found, they set the parameters for the parabola or fractal model—the red line—which describes the whole distribution of the geologic province. The Yet-to-Find or undiscovered reserve is the difference between the model and the actual discoveries.

And there are other modeling techniques. These have all been applied as appropriate to all the basins and countries of the World to yield what I call in the next chart—The Essential Parameters for conventional oil.

<CHART 17>The Essential Parameters – Conventional Oil

Essential Parameters
Conventional Oil - YE 1999

• Produced	822 Gb	~46% Ultimate
• Reserves	827	
• Discovered	1,637	~91% Ultimate
• Yet-to-Find	151	
• Yet-to-Produce	978	
• Ultimate	1,800	

✓Production Rate 22 Gb / year (rising)
✓Depletion Rate 2.2 % / year
✓Discovery Rate 6 Gb / year (falling)

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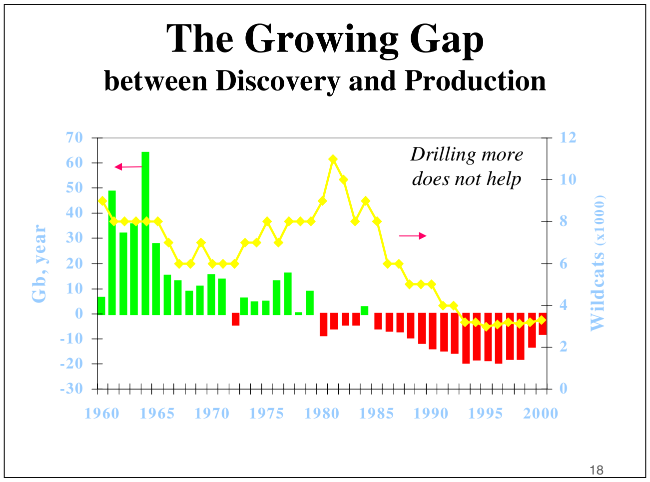
It is convenient to keep the figures as computed but they could of course—and I emphasize—be generously rounded. The public records show that for the entire World, about 822 Gb has been produced year-end 1999. My assessment for the current most likely or probability-50 reserve outlook is about 827 Gb, giving a total discovered volume of a little more than 1.6 trillion barrels. To this I have added about 151 Gb as Yet-to-Find, bringing the total Yet-to-Produce to 978 Gb or to generously round, about 1 trillion barrels. Cumulatively, the World's endowment of conventional oil is approximately 1.8 trillion barrels of which we have produced about 46% and found 91% . Now, Dr. Campbell and I are not saying that more oil – beyond our estimate of 151 Gb – will not be found. But we are saying that these additional reserves will be discovered so far out in time that they will have no influence on World peak oil.

We are producing and consuming about 22 Gb a year or 2.2% per annum of the Yet-to-Produce, and we are less than 4 years away from the mid-point of depletion. Yet, we are finding only about 6 Gb a year and that trend is falling.



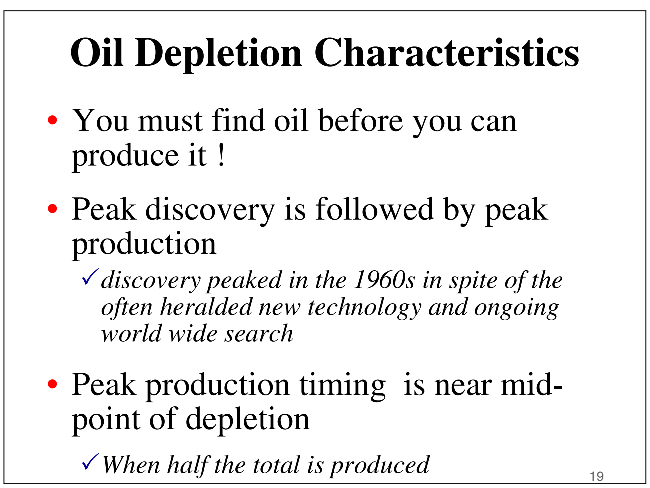
<CHART 18> The Growing Gap Between Discovery and Production

This growing gap or difference between discovery and production is perhaps better illustrated on the next chart. The discovery figures represented in this chart are <u>all</u> conventional discoveries—not just the conventional giants. Green vertical bars depict years where Discoveries exceeded Production. The red bars show years where Discoveries were less than Production. Discoveries peaked in the mid-1960s, and the industry continued finding more than it was producing up to about 1980.

The high oil prices of the early 1980s stimulated an enormous drilling effort, denoted here by this plot of world wildcat wells—the yellow line—but it did not change the underlying discovery trend. Because of the recent advances in technology it is much more difficult to drill a dry hole. About three weeks ago the Federal Reserve Chairman Alan Greenspan made this point when he was expressing his concerns over today's high oil prices and the impact on world economies. Industry's success ratio has increased but Greenspan did not mention that the amount of oil found is declining and, hence, fewer wells are being drilled. The oil industry is not willing to pay $100,000 per day rig rates for nothing.

Since the 1980s, production has not been replaced by new discoveries. 1999 and 2000 have been exceptional years with the discoveries of two super-giant fields in hitherto closed areas: the 5 Gb Azedegan field in Iran and the 10 Gb Kashagan field in the north Caspian Sea, the latter of which is the largest oil field discovered since Prudhoe Bay in Alaska in the late 1960s.

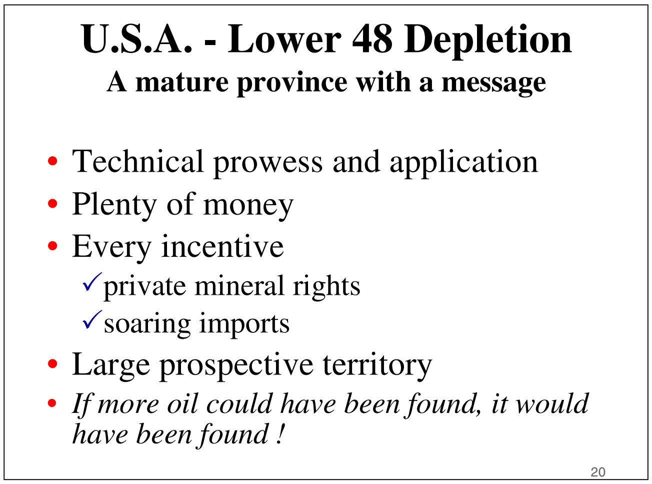
In other words, we now find on average only one barrel for every four we consume <This ratio is one found for every three consumed if you add the latest hot play Deep Water discoveries>. This fact is often clouded in annual reports by the inclusion of the "reserve growth" reserves discussed earlier.



<CHART 19> Depletion Characteristics

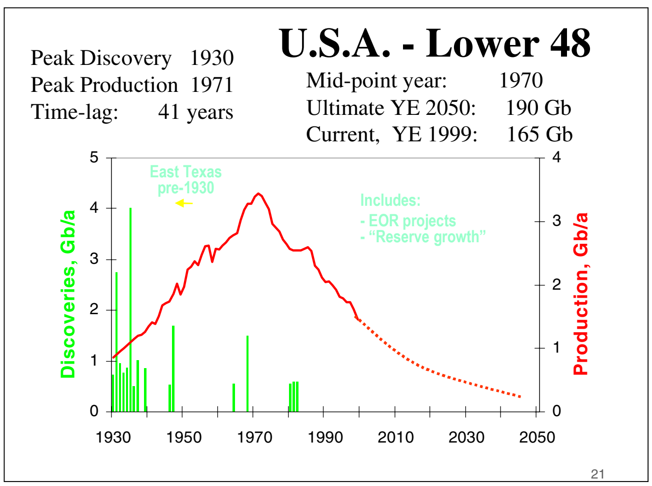
Given this depletion trend, I ask: *What will characterize the depletion of the remaining world's reserves? What forces will shape the second half of the world's oil production?*

When analyzing the data, it does not take long to come to three simple algorithms. First, "you have to find oil before you can produce it". This logic often escapes demand-side economists that see oil production as merely a function of the number of drilling rigs that can be built and wells that can be drilled. Second, peak oil discovery is followed by peak oil production. This seems intuitively obvious, but it has been overlooked by many. This, I think, is the strength of Dr. Campbell's thesis. It is a fact—not a forecast—that oil discovery peaked in the 1960s, in spite of new technology and an ongoing worldwide search, <u>and</u> that peak production will follow at some reasonable length of time thereafter. And the third algorithm is that the peak of production in any basin or country, and by extension the world, will come close to the mid-point of depletion, unless production has been artificially constrained. In other words, when half of the world's oil reserves have been produced, decline will set in.



<CHART 20> USA Lower 48 Depletion – A mature province with a message

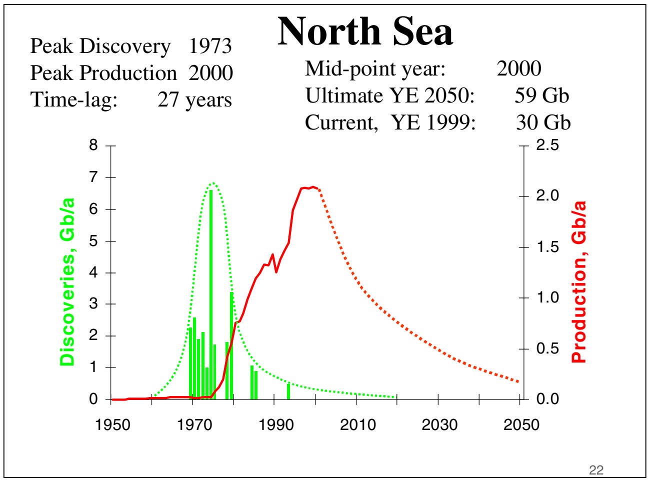
As an example, let's take a look at the World's most mature oil country – the United States – Lower 48. No one would argue that industry state-of-the art technology is readily brought to bear on whatever challenge presents itself in the way of exploration and exploitation. And that there is no shortage of money with which to leave no stone unturned. There is every incentive—from private ownership of mineral rights up through the Federal government's actions to reduce soaring oil imports that account for more than 50% of oil consumption. With 6% of the World's land area and over 4,000 miles of coast line, the USA represents a sizeable area for exploration. In short: *if more oil could have been found, it would have been found!*



<CHART 21>USA Lower 48 – plot of discoveries and production

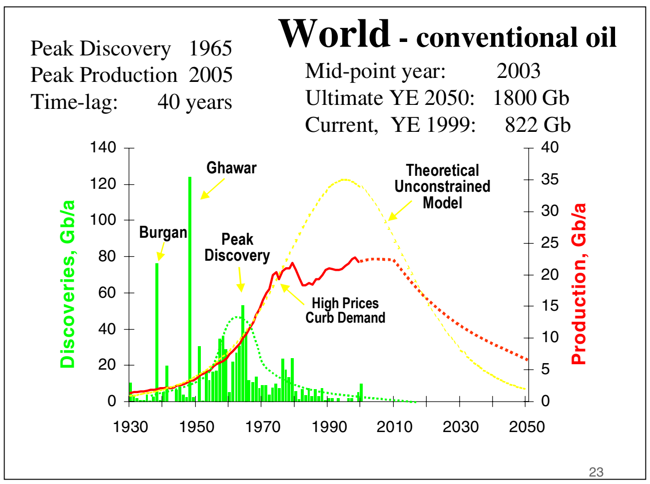
This next chart is a plot of oil production and giant field discovery for the USA Lower 48. The discoveries are shown by the green vertical bars and peaked in 1930. And no giant fields have been discovered since the early 1980s. Production is shown in red and peaked in 1971, only one year after the mid-point of depletion and nearly 40 years after peak discovery. The solid red line depicts actual reported production, while the red-dashed line is my base production forecast. Not only does this chart include my conventional classification of oil, but also oil from EOR (Enhanced Oil Recovery) projects such as miscible, chemical or thermal floods and the so-called reserve growth production. In other words, just about everything onshore and from the shallow continental shelf.

No one, I think, would dispute that the post-peak decline is a robust trend that cannot be reversed. Everything that can be done is being done. The large fluctuations in price and the many advances in technology have barely affected production. Or one could argue that without all the advances in technology, the decline would have been even steeper.



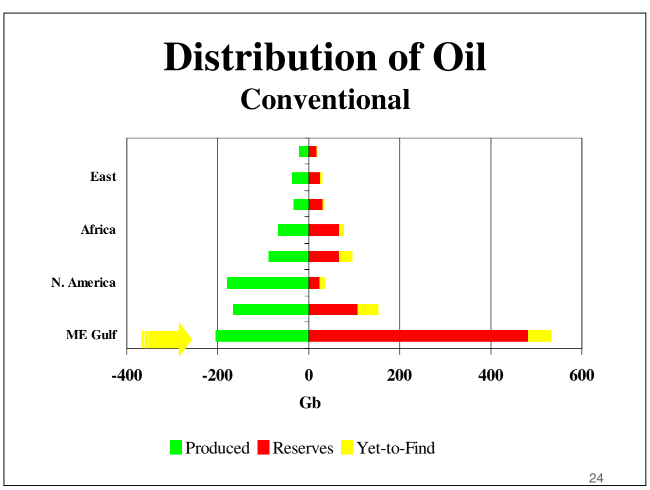
<CHART 22> North Sea – plot of discoveries and production

Now let's look at the North Sea which is now the second largest exporter after Saudi Arabia. We again see the early peak of discovery, which was in 1973. This is fact—not hypothesis. We cannot see peak production so clearly because we are standing on it. We are there all the same. Note particularly the impact of all the amazing technology that has been deployed in the North Sea. It has reduced the time lag from peak discovery to peak production, compared to the US-48, from 42 to 27 years. We are getting much more efficient at depleting our petroleum resources.



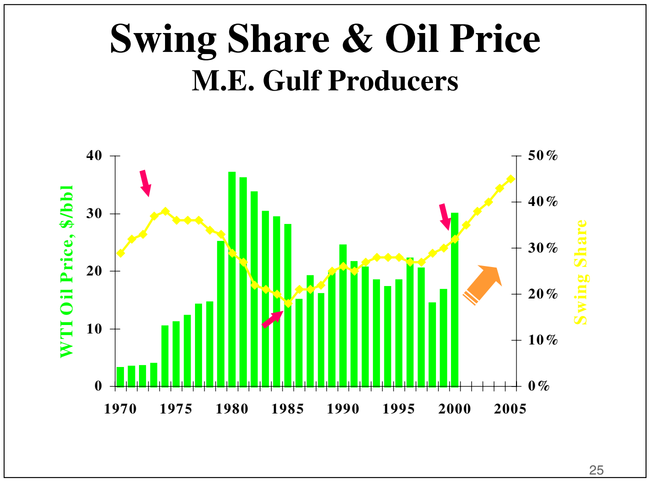
<CHART 23> World – plot of discoveries and production

This next chart is a similar plot of the World's conventional oil production. World giant oil discoveries peaked in the mid-1960s. The theoretical unconstrained production model is shown by the yellow dashed line. It is often referred to as a Hubbert curve, named after the famed Shell geologist who predicted the peak of the USA production 15-years before it did, using such a mathematical curve. The actual production peak relative to the theoretical unconstrained peak is often capped for all sorts of reasons, like cheap imports, market forces or constraint by regulatory agencies. There was a close match to the theoretical curve until the price shocks of the 1970s when high prices curbed demand. Peak has been delayed a few years and the forecasted decline is less steep than would have otherwise been the case.



<CHART 24> Distribution of Conventional Oil

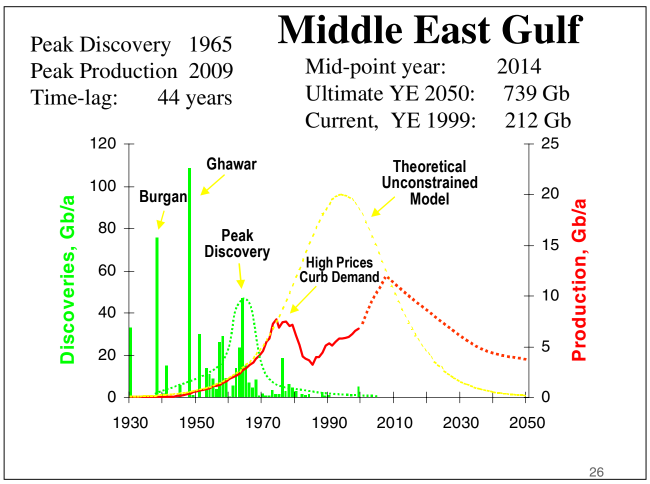
This chart summarizes the uneven distribution of conventional oil in the World. Produced oil is shown in green. The Yet-to-Produce is comprised of the known Reserves (shown in red) and the Yet-to-Find (shown in yellow). The key point here is that about half of the Yet-to-Produce lies in just five Middle East Gulf countries. These five key Middle East Gulf countries—Iraq, Iran, Kuwait, U.A.E and Saudi Arabia—are natural *"swing producers"* around peak. That is, they can make up the difference between world demand under various scenarios and what other countries can produce.



<CHART 25> Swing Share & Oil Price

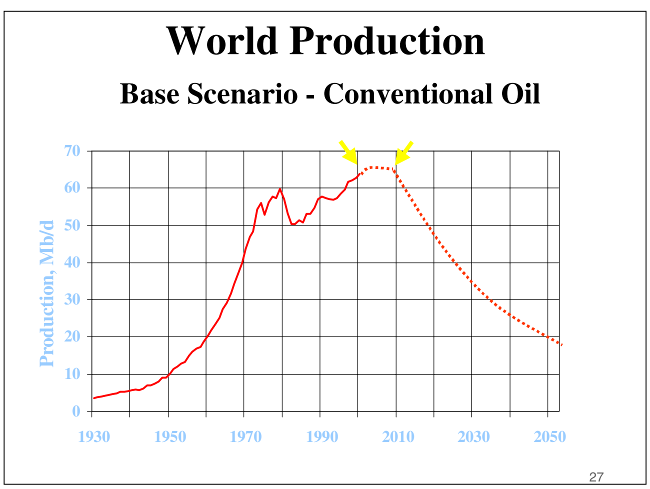
To further develop the idea of *Swing Share,* let's go to the next chart. Oil price is depicted by the vertical green bars. The share in percent of world conventional oil supply from these five Middle East countries is shown by the yellow line. It was 38% at the time of the first oil shock in 1973, but began falling because of fresh production from new giant fields in the North Sea, Alaska and elsewhere. And I stress that these new provinces had already been found. They were not a response to the price shocks as has often been claimed.

Swing Share fell to 18% in 1985. Then it started to rise and it is now about 30%. This time, it is set to continue to rise because there are no new major provinces to come on stream, save perhaps the Caspian, whose ultimate potential is still unknown. On current trends, Swing Share will reach 45% by the year 2005.



<CHART 26> Middle East Gulf Countries – plot of discoveries and production

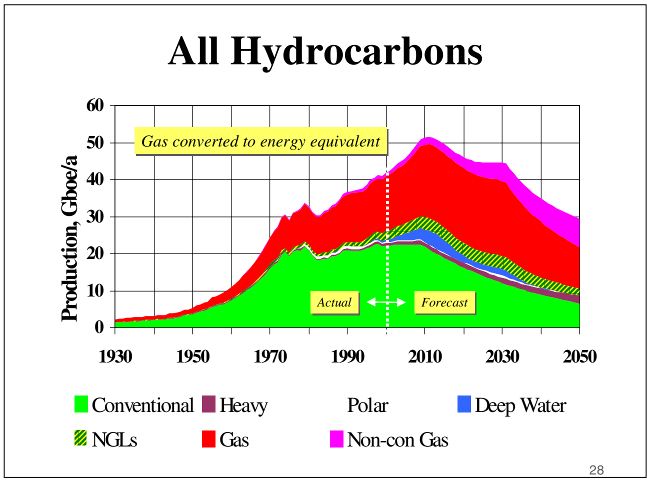
This next chart depicts the discovery and production picture for these five key Middle East Gulf countries. Two key observations here: (1) There have been very few so-called giant discoveries since 1980. And (2) to meet World demand and to compensate for the decline elsewhere in the World, Middle East Gulf production will in a few years be called upon to produce more than it ever has even though its super giant fields are now 27 years more mature since the 1973 embargo. Production will continue to rise and for the foreseeable future will do so unchecked until natural depletion brings about the inevitable decline in about 10 years or so.



<CHART 27> World Production – Base Scenario, Conventional Oil

There are many possible world production scenarios, but let me describe for you my Base Scenario shown in the next chart. It assumes that demand rises at 1.5% a year (a bit below the current level) until Swing share reaches 35% next year as non-swing production—that is the rest of the world—continues its irreversible decline. These events are assumed to convey sufficient control to the Swing countries to impose higher prices.

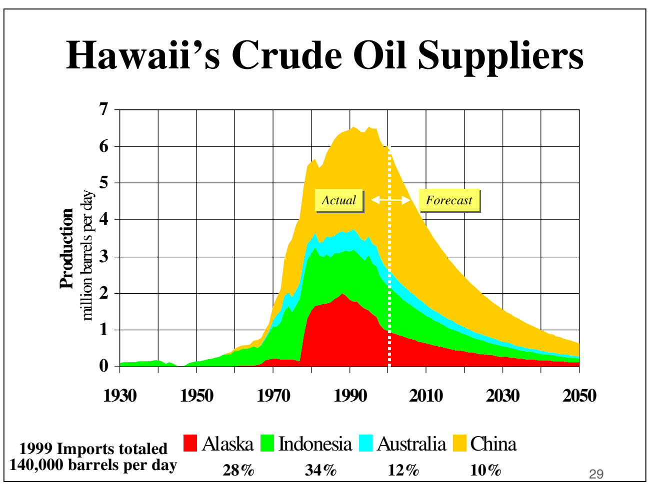
Higher prices curb demand giving a plateau—albeit a very volatile plateau—of production lasting about 10 years. The plateau ends when the Swing share has risen to 50% around the year 2010 and these countries too are close to their mid-point of depletion. Production then falls almost irrespective of price, resulting in the onset of chronic shortages of supply.



<CHART 28>All Hydrocarbons – Production profile

This next chart puts into perspective what I have been talking about. This is a plot of the principal hydrocarbon family production profiles in billions of barrels of oil equivalent per year. The green area is the Conventional Oil that I have been discussing and clearly up to now it has been the major hydrocarbon contributor and it will continue to be the main driver in determining world peak oil production.

Heavy oil, including tar sand production, is shown in the darker, burgundy color, and it continues to come on slow and steadily. Polar, which is primarily Alaska is shown in white. Deep water, shown in dark blue, will add considerably but by nature of the developments, it will be fairly short-lived, although it will extend peak production by about 5 years. NGLs or Natural Gas Liquids are the yellow/dark green cross-hatched area. NGLs will grow in parallel with Natural Gas shown here in red. On its own, Natural Gas peaks around 2020. Non-conventional gas is shown by the magenta color and includes coalbed methane, tight shale gas, deep water brine gas, HTHP fields, and deep gas in geo-pressured reservoirs.



<CHART 29> Hawaii's Crude Oil Suppliers

This chart illustrates historical and forecast crude oil production for four of the main suppliers of Hawaii" crude oil; namely, Alaska, Indonesia, Australia and China. During 1999 these four supplied nearly 85% of Hawaii's crude oil. Collectively, you can see that they have been declining since the mid-1990s and are projected to continue to do so.

Now you may rightly ask: How valid is this assessment that I have presented today?

The I.E.A. Coded Message

Why business will NOT be as usual

- Demand rises 1.8% annually to 112 Mb/d by 2020
  - ✓ oil prices rising to $25/barrel
- How is the demand met?

How is the demand met?	2010	2020
✓ NGLs	11.3	15.2
✓ Unconventional	2.4	2.4
✓ Refining/Processing gains	2.1	2.5
✓ Middle East (now 18 M/d)	40.9	45.2 (62%)
✓ Non-Middle East (now 45 M/d)	38.0	27.0
✓ "Balancing Item"	-	19.1

- Reality . . .
  - ✓ oil not $25/barrel when ME supplies 62%
  - ✓ *"Balancing Item - unidentified unconventional"* = shortage !

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<CHART 30>The IEA Coded Message

In their recently published WORLD ENERGY OUTLOOK, the International Energy Agency addressed factors that might impact the quote-unquote "business as usual" scenario. Specifically, the I.E.A. sees oil demand increasing at 1.8% annually to 112 Mb/d by the year 2020 with oil prices rising to $25 a barrel over that same period of time.

The IEA goes on to suggest that this oil demand will be met by: (1) increases in Natural Gas Liquids, (2) increases in "identified unconventional" oil to a maximum of 2.4 Mb/d by 2010, (3) increases in processing/refining liquids, and (4) increases in Middle-East production rising from its current 18 to 45 Mb/d by 2020—at which time it will be 62% of the World's production. The rest of the world meanwhile declines from its current 45 Mb/d to 27 Mb/d by 2020. And then the IEA introduces a term referred to as a "*balancing item-unidentified unconventional*" rising from zero in 2010 to 19 Mb/d by 2020.

Now…I commend the IEA for acknowledging for the first time the concept of depletion and that non-Middle East countries are on decline. But I must ask you: Is their hypothesis credible?

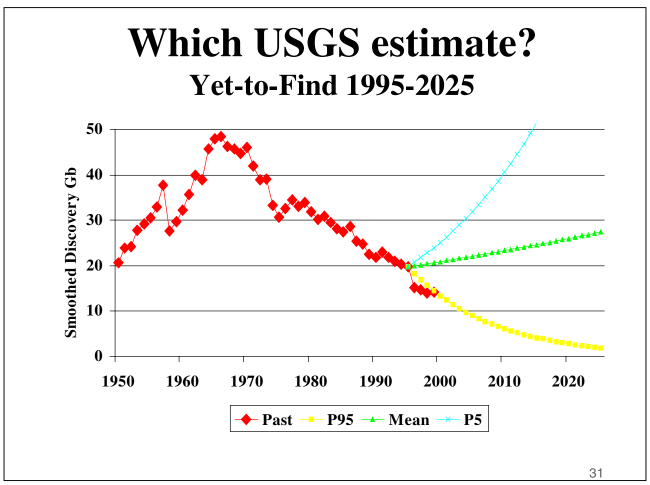
First, to meet the demand increase over the next twenty years—should it come to past—means that today's world-wide oil production would have to increase 55% to meet this target. From what we know about published reserves and remaining potential of all areas of the world, I submit to you that this is not reasonable.

Second, the growing control of the market by the Middle East is, in my opinion, not consistent with $25/b oil by the year 2020.

Third, The Middle East countries may be able to increase production by 200% but I seriously doubt that such a monumental effort would have long term sustainability or be politically palatable within those countries. Why invest in new production if NOT doing so increases or maintains your revenue via higher price?

And, Fourth, we already have huge identified deposits of unconventional reserves, so identification is not the issue. And it is inconceivable to me that production from the hypothetical "unidentified unconventional" oil could rise to 19 Mb/d in ten years when the known unconventional only makes a ceiling of 2.4 Mb/d by 2010. It appears that this "balancing" item is merely a euphemism for production shortages.

In short, I think, the IEA is suggesting that "*business will **NOT** be as usual*". In other words the IEA's position—once you read between the lines—is consistent with that of Dr. Campbell's.



<CHART 31> U.S.G.S. estimate

Last March on the eve of a key OPEC meeting, the United States Geological Survey issued a press statement releasing key findings of an internal study of remaining world oil reserves that had been ongoing since the early 1990s. In June of this year the completed study was issued. The impact of the study was to exaggerate non-OPEC oil reserves and thereby suggest that the United States does not depend on Middle East oil. This point runs counter to all the shuttle diplomacy that Energy Secretary Richardson conducted between Washington DC and Riyadh during the ensuing months of increasing oil prices.

Of course such posturing is normal in the high stakes energy game. OPEC, for its part, exaggerates its resource base to inhibit non-OPEC investments and moves to energy savings or renewables. And oil companies have no vested interested in pronouncing on depletion least their stock price tumbles.

In its latest projection for the 30-year period from 1995 through 2025, the U.S.G.S has failed to live up to its reputation of objective reporting. It has assessed the undiscovered potential of each basin with a range of subjective probabilities. It has a so-called P95 (or probability 95%) case for the most sure estimate and a P5 (or probability 5%) case for the least sure. The P5 case, shown by the blue line, has little meaning. You might as well say that there is a 5% chance that I will evolve into a frog! The P95 value, shown by the yellow line, is a fairly good estimate and is consistent with the actual discovery trend as shown on this chart. But the P5 is meaningless. The Mean value, shown here by the green line, is the one most publicized and it is also meaningless because it is influenced by the P5 value. This has been confirmed by experience in the real world because the Mean estimate is already 70 Gb short after only five years into the study period.

Campbell's Outlook

Pessimistic?

- The 150 Gb of undiscovered reserves
- 30 years of exploration
- 100,000 wildcat wells
- A trillion US$

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<CHART 32> Campbell's Outlook

At current trends, the 150 Gb of undiscovered reserves estimated by Dr. Campbell will take 30 years of exploration, and the drilling of 100,000 wildcat wells at a cost of a trillion US$. And yet many industry experts consider this reserve pessimistic.

Logical Consequences of Peak

- Oil price shock. Demand stabilizes then falls
- Danger of military intervention to secure oil
- Stockmarkets crash
  - ✓Energy smaller % of GNP, but critical %
- Global market ends
- Increased international tensions
- Self-sufficiency becomes a priority

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<CHART 33> Logical Consequences

At this time, I would like to quickly speculate about some of the consequences of the near term peak and the irreversible decline in world oil production.

I have already spoken of the oil price shock. This shock is very different from that of the mid-1970s. It is driven by resource constraints, not politics - although of course politics do enter into it. The market is beginning to perceive that OPEC may have lost control. It is a devastating realization because it means there is no supply-based ceiling on price. Accordingly, prices are set to soar. Don't forget that in to-day's money, oil price went to almost $100 a barrel in the 1970 shocks.

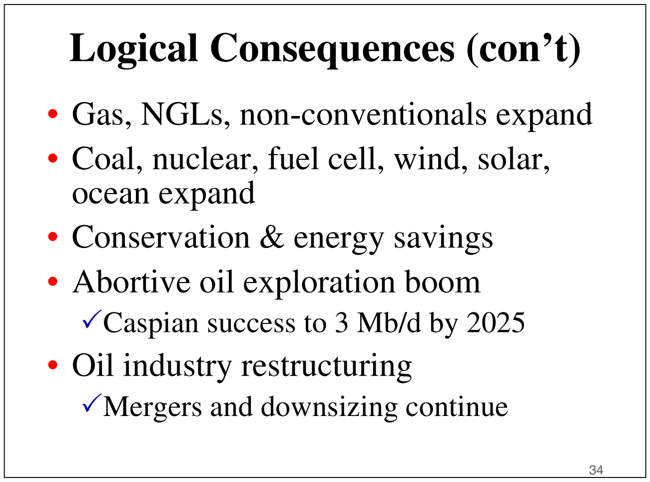
Higher prices will cause demand to stabilize then fall. The poor countries of the world will bear most of the burden.

There is, I think, a strong danger of some ill-considered military intervention to try to secure oil.

A stock market crash seems inevitable with continued high oil prices and the impact that it will have on inflation at interest rates.

Energy costs may be a smaller percent of the GNP today than at the time of the first oil embargo in 1973; but as recent events in Europe have demonstrated, it is a critical percentage. The global market may collapse because of high transport costs and global recession.

I suppose, Europe, Asia and the United States will be on a collision course for access to oil in a world of perceived growing shortage. Canada and Mexico may be under pressure from the USA to increase its imports. In short, it will be a time of great international tension and new alignments. Self-sufficiency will become a priority.



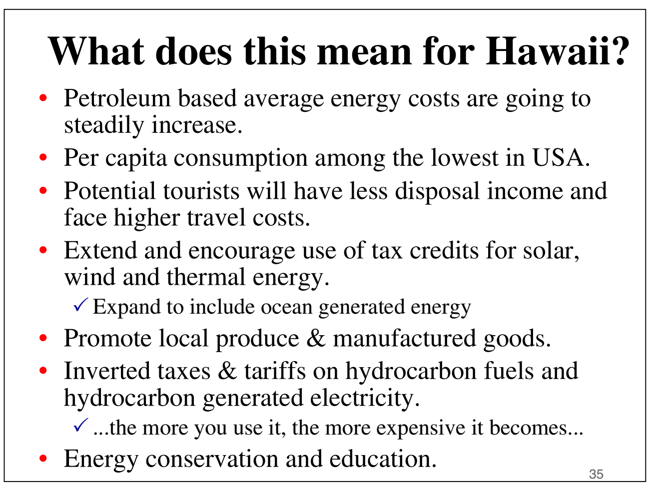
<CHART 34> Logical Consequences (con’t)

Of course, production of gas, NGLs and non-conventional deep-water, heavy oil and polar oil will expand, but in my analysis, they will lessen the decline and will shift the peak by only about 5 years. I imagine coal projects will increase and nuclear power will be rejuvenated in many countries. Fuel cells will take off. And of course solar, wind and ocean generated power will continue to find niche markets and expand.

Consumer energy savings will be in vogue again. Buying local produce (including more organically grown – to get away from costly petroleum based fertilisers) and buying local manufactured goods will make more sense that importing stuff from halfway around the World.

I suppose there will be another oil exploration boom, but that it will be abortive, finding only small fields having negligible world impact, with the Caspian Sea being an exception.

Once the moment-of-truth is realised, that there truly are not many more giants to be found, major integrated oil companies and independents will accelerate mergers and shrink as their throughput falls.



<CHART 35> What does this mean for Hawaii?

Let us consider for a moment what I have just said means for Hawaii insofar as its energy consumption and policies and economy are concerned and I assure you that this slide does not represent an exhaustive list. But, by virtue of its nearly unique geographical and political situation and endowment of natural resources, Hawaii is in a position to become a benchmark state for stewardship and utilization of energy.

Petroleum based energy costs are inexorably going to increase. Crude oil prices on peak will be as volatile as World stock markets are today. Yes, the prices will roller coaster up and down again in the interim due to the interplay of politics and market forces. But these are secondary forces and costs will rise most assuredly with average costs becoming higher and higher as resource constraints ultimately dominate.

On the other hand Hawaii’s per capita energy consumption is nearly, if not, the lowest of all the United States, amounting to less than half of the consumption of a Texas resident and merely a quarter of the consumption of an Alaskan. Your favorable tropical climate requires little in the way of heating and air conditioning requirements.

Higher petroleum costs translate to less disposable income and higher air fares for potential tourists. Given the bull market and unprecedented low energy costs of the last 10 years, how will Hawaii’s tourist industry fare in a bear or level market and with higher energy costs?

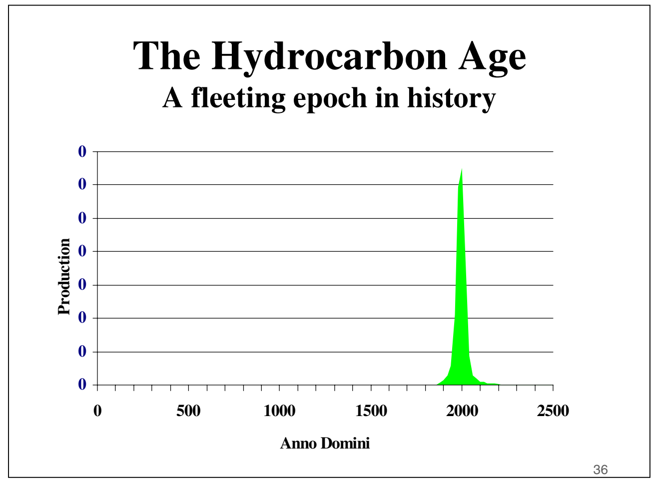
The concept of existing state energy conservation tax credits for solar, wind and thermal energy is to be applauded and further encouraged and extended. And if possible and applicable, expanded to include the use of new kinetic ocean energy technology. Given the necessary lead times, the time has come for increasing the scale of these technologies if they are to ameliorate energy costs.

Assuming cost effective infrastructures, it only makes good common sense anytime you can promote and purchase quality local produce or manufactured goods rather than import the same goods that have been produced and shipped from abroad.

Inverted taxes and tariffs on hydrocarbon fuels and hydrocarbon generated electricity would discourage waste and use while promoting alternative energies. By "inverted", I mean that the more you use it the higher it costs.

Energy conservation and its efficient use and education thereof should become inherent in all we do. For example, business on the mainland have taken the lead to reduce city traffic congestion and save transportation costs by going to so-called 9/80 work schedules; that, is 80 hours worked every 9 work days with every other Friday off. And companies are now encouraging total or partial work at home to avoid commuting and office space costs, while taking advantage of the Internet and world wide computer web to keep people in communication.

<CHART 36> The Hydrocarbon Age



So, in conclusion, I would just like to say that I know that the data points in the oil statistics are weak. But I think that it is better to have a sound-working hypothesis based on available knowledge, than to rely on blind faith alone. Peak oil will be a turning point for mankind. However, the roof does not fall in after peak. What changes are perceptions, as people come to realize that the easy growth of the past becomes the challenge of offsetting the decline of the future. To this end, education of the public, governments and private business sectors as to the realities of global oil supplies will be key to developing a mandate to act on solutions. Let us use our current high oil supply intelligently while it lasts to ease the transition.

Thank you for your attention. Dr. Campbell and I don't pretend to fully understand the situation and we certainly don't have all the answers, but I hope that what I have said will prompt you to reject accepted wisdom and investigate the situation for yourselves as you direct your business.

NOTES

[1] The views expressed are those of the author
[2] The views expressed are those of the author

Dr. Leroy Laney

Professor of Economics and Finance, Hawaii Pacific University

Dr. Laney joined the HPU faculty as a Full Professor in 1998, after a broad ranging background in banking, government, and other academic positions.

He has served as a Staff Economist on the President's Council of Economic Advisers in Washington, D.C., as an International Economist with the U.S. Treasury in Washington, and as a Senior Economist in the Federal Reserve System.

His academic experience includes adjunct teaching positions at the University of Colorado at Boulder, Southern Methodist University, the University of Texas (Arlington and Dallas campuses), and the University of Hawaii at Manoa. He also held a joint appointment in the Economics and Finance Departments at Butler University in Indianapolis during the 1989-1990 academic year, and served there as Chairman of the Economics Department.

From 1990 through 1998, his position was Senior Vice President and Chief Economist for First Hawaiian Bank in Honolulu. There he held a highly visible position as the Bank's spokesman on all international, national, and local economic matters. He has served as Chairman of the Council on Revenues of the State of Hawaii, and as a member of the Market Research Committee of the Hawaii Visitors and Convention Bureau.

Professor Laney has published widely in academic journals, Federal Reserve and other bank publications, and in edited volumes and conference proceedings. He remains a Consultant to First Hawaiian Bank, and has also consulted with the University of Hawaii Economic Research Organization, Alexander & Baldwin, Inc., Matson Navigation Company, Colliers Monroe and Friedlander, The Estate of James Campbell, the Waikiki Improvement Association, the State of Hawaii, and the County of Hawaii. He is a member of Who's Who in America, Who's Who in the World, Who's Who in Finance and Industry, Who's Who in the West, the American Economic Association, the Western Economic Association, the National Association for Business Economics, and Lambda Alpha real estate honorary.

His Ph.D. in Economics is from the University of Colorado at Boulder. He also holds a Bachelor of Industrial Engineering from Georgia Tech, and an MBA in accounting and finance from Emory University.

From 1967 to 1971, he served as a Lieutenant in the U.S. Navy Supply Corps. Dr. Laney is married to the former Sandra Prescott of Atlanta, and has two sons.

A Peer Review of <u>The Economic and Fiscal Impacts of the Hawaii Energy Conservation Income Tax Credit</u> By Thomas A. Loudat, Ph.D., Revised January 27, 1997

Submitted by:

Leroy O. Laney, Ph.D.
Professor of Economics and Finance
Hawaii Pacific University

For
A Symposium sponsored by
The Hawaii Energy Task Force
November 9, 2000

Introduction

This peer review of the subject paper has been commissioned by the Energy, Resources, and Technology Division of the State of Hawaii's Department of Business, Economic Development, and Tourism (DBED&T). The overall purpose is to provide an objective critique of Dr. Thomas Loudat's earlier paper for an Energy Symposium held at Hawaii Electric Company on November 9, 2000.

This review paper will proceed to discuss the Loudat paper in the order that it is written. Then some supplementary empirical results from the author's own investigations will be presented, and finally some thoughts on Hawaii's energy policy options will be offered.

Overview of Findings

The purpose of the Loudat paper is to provide a quantitative assessment of the impact of the State of Hawaii's Energy Conservation Income Tax Credit (ECITC) on investment in solar energy systems. This tax credit has been in effect since 1977, even though the percentage of the tax credit allowed has varied over time. Upon its introduction in 1977, the credit was 10 percent. Then it was raised to 50 percent in the years 1978 through 1985. As oil prices collapsed in the mid-1980s, the credit was lowered to 10 percent again for one year in 1986. Since then, the credit was15 percent over the 1987-1989 period, and it has been kept at 35 percent since 1990. It is fairly obvious that the amount of the credit has been influenced by the level of overall energy prices throughout its existence.

Loudat begins his paper by emphasizing the investment nature of the decision to purchase a solar system, projecting benefits out over a 25-year life span of a given system. Then, in an Executive Summary, he lists research assumptions and major conclusions. These conclusions include findings of positive fiscal and employment impacts of the ECITC program, plus an estimate that the solar industry will shrink to 59 percent of its current size if the ECITC is eliminated, even if Hawaiian Electric's current Demand Side Management (DSM) program remains in place. In contrast, if both the ECITC and DSM remain, the industry is projected to grow by up to 70 percent.

He further estimates that the State government's ECITC expenditures generate ten times that amount of overall economic output, one job per ten installed systems, and labor income of over three times the original ECITC expenditure.

These estimated benefits naturally depend on the assumed level of future energy prices. An oil crisis such as occurred during the 1975-1985 period is calculated to increase the above estimated economic and fiscal impacts by 20 to 300 percent, depending on when such crisis occurs during the life of a system.

Loudat's analysis does not attempt to measure the avoided negative externalities of continuing to burn fossil fuels. He does mention that such externalities are particularly important to an economy like Hawaii, where tourism and the environment are of such critical importance.

Summary of Analysis

It is not possible to recount all of the detailed analysis of the Loudat paper itself here; the reader is referred to that paper for those details. This section briefly reviews the highlights and assumptions of that analysis, commenting upon them where that is appropriate.

Basically, Loudat uses the State of Hawaii Input/Output model published and maintained by DBED&T to assess the economic and fiscal impacts of both costs and benefits of the ECITC expenditure. Purchase of the solar system is viewed as a 25-year investment, and Loudat considers alternative impacts if the system is cash-financed versus borrowing-financed. (If a system is borrowing-financed, overall economic benefits improve slightly but are shifted to later years.)

The economic benefit of a solar system is the stimulus it provides to an individual to purchase a solar system, as well as this purchase's consequent economic and fiscal impacts. The costs of the ECITC are the economic and fiscal impacts of purchasing fossil fuel generated energy, foregone due to the purchase of a solar system. If the ECITC is eliminated, other economic and fiscal costs would be incurred due to the estimated reduction in the size of the solar industry.

Total economic and fiscal impacts of the ECITC are calculated by multiplying the per system impacts by the estimated number of systems. This estimated number of systems depends not only on the size of the ECITC, but also on the supplemental help of the DSM program.

An oil crisis, such as occurred between 1975 and 1985, would cause electricity rate increases much greater than assumed in the base case scenario. Such rate increases mean additional energy costs savings to purchasers of solar systems, as well as added positive economic and fiscal impacts. If the oil crisis occurs early in the life of the system purchased, these positive impacts will be greater than if the crisis occurs later in its life. The reader is referred to the paper for specific assumptions and conclusions from them.

Loudat concludes his description of the analysis by outlining in detail several economic and fiscal impacts not measured by the analysis. Understandably, most of these impacts would be difficult to quantify:

- There would be a negative impact on Hawaii's position as a Pacific Basin energy development and implementation leader. (Hawaii has the highest per capita number of solar systems in the nation.)
- There would likely be a negative impact on business investment in Hawaii due to vacillating state policy, which reduces certainty of return on that investment.
- Negative impacts of such things as unemployment insurance costs and retraining are not included.
- Positive impacts of permit fees and property tax revenues are not measured.
- Positive externalities from reduced oil consumption are not included. (If the cost of these negative consequences were incorporated into the price of oil, the energy costs savings would be significantly larger. And the larger the energy costs savings, the larger are the positive economic and fiscal impact of the ECITC.)

Critique of the Paper

As any economist who has ever conducted an analysis such as that presented in the Loudat study knows, conclusions are often very sensitive to the assumptions made. Yet, the analyst is forced to make many such assumptions in order to proceed with the analysis. This particular paper might be called into question because the study was conducted for the Hawaii Solar Energy Association.

Still, this reviewer finds the assumptions and conclusions from them to be reasonable and sound. Furthermore, the analysis appears to have been conducted carefully and in great detail.

This does not deny that other analyses, with other assumptions, might reach different conclusions. Yet in the absence of other work, the burden of proof is still upon those who challenge the results of the current paper. Loudat is currently preparing an updated and revised version of the paper reviewed here. That revised paper may include other salient points that either reinforce or diminish the findings of this reviewed paper. Upon this writing, this reviewer has not seen the revised paper.

Regression Analysis of the Impact of Solar Tax Credits

While the above assumptions and conclusions are important in assessing the total net economic and fiscal impacts of the ECITC, the critical question is: Are solar tax credits effective in stimulating investment in solar energy systems? An answer to this question is important because individuals might be motivated, at least to a certain extent, by other external circumstances to invest in solar systems even without the ECITC.

For example, just the existence of higher energy prices alone could motivate a decision to invest in a solar system, because savings would exist even without a tax credit such as the ECITC. And clearly the percentage amount of the tax credit has varied with the level of energy prices over the life of the credit, so effects might potentially be hard to attribute to individual causal factors. Any public policy decision has to consider the incremental impact of that policy over and above what would occur just because of existing market forces.

Loudat attempts to address the causal impact of the tax credit on solar systems sold with a regression analysis presented on paper 18 of his paper. In that regression, one independent variable – the percentage amount of the solar tax credit – is regressed upon a dependent variable specified as the annual number of systems sold. The interval of available data at the time of the paper was 1977 to 1992.

The outcome of the regression suggests a high degree of causal impact. The adjusted R-squared is .73, and the t-statistic on the independent variable, at 6.37, is highly significant. By regressing his data in double log formulation, Loudat is able to interpret the coefficient on the single independent variable as an elasticity. The value of that coefficient indicates that, on average over the life of the ECITC, every one percent increase in the amount of the tax credit results in a 1.5 percent increase in the number of systems sold.

While this outcome constitutes tangible evidence that the credit has indeed been effective in stimulating investment in solar systems, it might be considered by some to be incomplete. That is, did investors perhaps purchase solar systems just because energy prices were higher, not so much because of the existence of the tax credit? In addition, if the purchase was borrowing financed, did the level of interest rates affect the purchase decision? These questions cannot be addressed directly with the existing regression work in the paper.

This reviewer undertook further regression analysis to address such questions specifically. Results are presented in Exhibits I through III.

Exhibit I is simply a replication of Loudat's regression, with the tax credit as the single independent variable and systems sold as the dependent variable. Outcomes are indeed the same as in the Loudat paper.

year	systems sold		tax credit	
1977	1101	7.003974137	10	2.302585093
1978	4061	8.309184528	50	3.912023005
1979	4375	8.383661799	50	3.912023005
1980	4704	8.45616849	50	3.912023005
1981	6445	8.771059915	50	3.912023005
1982	4407	8.390949465	50	3.912023005
1983	3148	8.05452261	50	3.912023005
1984	4464	8.403800504	50	3.912023005
1985	6740	8.815815204	50	3.912023005
1986	592	6.383506635	10	2.302585093
1987	354	5.869296913	15	2.708050201
1988	316	5.755742214	15	2.708050201
1989	327	5.789960171	15	2.708050201
1990	1180	7.073269717	35	3.555348061
1991	1314	7.180831199	35	3.555348061
1992	1261	7.139660336	35	3.555348061

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.862287047
R Square	0.743538951
Adjusted R Square	0.725220304
Standard Error	0.576523042
Observations	16

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	13.49098579	13.49098579	40.58918631	1.74E-05
Residual	14	4.653303458	0.332378818		
Total	15	18.14428924			

	Co efficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2.364748	0.816713	2.895443	0.011747	0.613069	4.116427	0.613069	4.116427
tax credit	1.498319	0.235179	6.370964	1.74E-05	0.993909	2.002729	0.993909	2.002729

EXHIBIT I

Exhibit II adds two other variables to Loudat's regression – the average annual price per barrel of crude oil and an interest rate. In this exhibit, the interval was kept the same for comparison to Loudat's results. Again, data regressed was in log-linear form.

Year	systems sold	tax credit	oil price	interest rate
1977	7.003974137	2.302585093	2.586259144	1.944480556
1978	8.309184528	3.912023005	2.59450816	2.118662255
1979	8.383661799	3.912023005	3.408172995	2.253394849
1980	8.45616849	3.912023005	3.602231647	2.440606391
1981	8.771059915	3.912023005	3.563032744	2.656054906
1982	8.390949465	3.912023005	3.479700443	2.565718293
1983	8.05452261	3.912023005	3.3891248	2.379546134
1984	8.403800504	3.912023005	3.351656936	2.504709277
1985	8.815815204	3.912023005	3.309447523	2.315501318
1986	6.383506635	2.302585093	2.651127054	1.989243274
1987	5.869296913	2.708050201	2.901421594	2.071913275
1988	5.755742214	2.708050201	2.692598097	2.136530509
1989	5.789960171	2.708050201	2.885359216	2.140066163
1990	7.073269717	3.555348061	3.135059339	2.124653885
1991	7.180831199	3.555348061	2.963725477	1.997417706
1992	7.139660336	3.555348061	2.946542029	1.822935087

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.880888846
R Square	0.775965158
Adjusted R Square	0.719956448
Standard Error	0.58201897
Observations	16

ANOVA					
	df	SS	MS	F	Significance F
Regression	3	14.07933627	4.693112091	13.85436572	3.33E-04
Residual	12	4.064952971	0.338746081		
Total	15	18.14428924			

	Co efficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	1.049059	1.446790	0.725094	0.482294	-2.103226	4.201346	-2.103226	4.201346
tax credit	1.321892	0.362136	3.650255	0.003325	0.532863	2.110921	0.532863	2.110921
oil price	-0.283529	0.882287	-0.321357	0.753467	-2.205869	1.638809	-2.205869	1.638809
int. rate	1.261186	1.096079	1.150633	0.272295	-1.126966	3.649338	-1.126966	3.649338

EXHIBIT II

Yet the outcomes in Exhibit II continue to support the efficacy of the tax credit. The adjusted R-squared is about the same, at .72. The elasticity on the tax credit variable falls slightly to 1.3, from 1.5 before. But the coefficient remains quite significant, with a t-statistic of 3.65.

The two added variables, the oil price and the interest rate, are not significant. The signs on their two coefficients are even the reverse of that hypothesized. (This does not necessarily mean they did not influence purchase decisions on solar systems at all, just that their causation is masked in the regression by the more important tax credit variable.)

Exhibit III updates the results in both Exhibits I and II with more recent data, from 1977 up to 1998. The Tax Research and Planning Office of the Hawaii Department of Taxation indicates that a time series on systems sold is no longer maintained, so that earlier results cannot be compared directly. However, a very similar time series on total tax returns with energy credit claims is available and was furnished to this reviewer by the Department of Taxation.

Year	returns /wc	tax credit	oil price	interest rate	ln(returns)	ln(tax cred)	ln(oil price)	ln(int rate)
1977	1101	10	13.28	6.99	7.003974137	2.302585093	2.586259144	1.944480556
1978	4256	50	13.39	8.32	8.356085031	3.912023005	2.59450816	2.118662255
1979	4866	50	30.21	9.52	8.490027523	3.912023005	3.408172995	2.253394849
1980	5827	50	36.68	11.48	8.670257567	3.912023005	3.602231647	2.440606391
1981	9908	50	35.27	14.24	9.201097791	3.912023005	3.563032744	2.656054906
1982	8644	50	32.45	13.01	9.064620718	3.912023005	3.479700443	2.565718293
1983	4695	50	29.64	10.8	8.454253392	3.912023005	3.3891248	2.379546134
1984	5433	50	28.55	12.24	8.600246747	3.912023005	3.351656936	2.504709277
1985	7161	50	27.37	10.13	8.876404915	3.912023005	3.309447523	2.315501318
1986	1413	10	14.17	7.31	7.253470383	2.302585093	2.651127054	1.989243274
1987	1016	15	18.2	7.94	6.923628628	2.708050201	2.901421594	2.071913275
1988	484	15	14.77	8.47	6.182084907	2.708050201	2.692598097	2.136530509
1989	390	15	17.91	8.5	5.966146739	2.708050201	2.885359216	2.140066163
1990	1225	35	22.99	8.37	7.110696123	3.555348061	3.135059339	2.124653885
1991	1358	35	19.37	7.37	7.213768308	3.555348061	2.963725477	1.997417706
1992	1492	35	19.04	6.19	7.307872781	3.555348061	2.946542029	1.822935087
1993	2840	35	16.79	5.15	7.951559331	3.555348061	2.820783471	1.638996715
1994	2127	35	15.95	6.68	7.662467815	3.555348061	2.769458829	1.899117988
1995	2668	35	17.2	6.39	7.889084407	3.555348061	2.844909384	1.854734268
1996	3116	35	20.37	6.18	8.044305407	3.555348061	3.01406323	1.821318271
1997	3927	35	19.27	6.22	8.275631055	3.555348061	2.958549482	1.827769907
1998	3987	35	13.07	5.15	8.290794347	3.555348061	2.570319528	1.638996715

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.818112634
R Square	0.669308283
Adjusted R Square	0.614192996
Standard Error	0.552019023
Observations	22

ANOVA					
	df	SS	MS	F	Significance F
Regression	3	11.10154631	3.700515438	12.14378675	0.000139646
Residual	18	5.48505003	0.304725002		
Total	21	16.58659634			

	Co efficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2.447598	1.103833	2.217361	0.039708	0.128528	4.766669	0.128528	4.766669
tax credit	1.182886	0.306304	3.861805	0.001142	0.539365	1.826408	0.539365	1.826408
oil price	0.195046	0.755370	0.258212	0.799172	-1.391930	1.782022	-1.391930	1.782022
int. rate	0.347955	0.715933	0.486016	0.632819	-1.156166	1.852076	-1.156166	1.852076

The outcomes of Exhibit III corroborate those presented the two previous exhibits. Adjusted R-squared falls somewhat to .61, but t-statistics on the three independent variables tell the same story. The tax credit is still highly significant, with a t-statistic of 3.86. The elasticity is now 1.2, but recall that the dependent variable is somewhat different so that results are not directly comparable to earlier ones. Both the oil price and the interest rate remain insignificant, and the sign on the interest rate in this regression is not correct.

Investigations like these could be supplemented with other regressions using different variables, intervals, and specifications. Perhaps some of these regressions might show greater influence of non-tax credit forces on the solar investment decisions. The addition of DSM effects is one possibility. Yet suffice it to say that those regressions presented here continue to support the causal impact and efficacy of the tax credit, and the lesser importance of other market forces. The fall in the value of the elasticity on the tax credit as the interval is extended may mean that the credit was less effective – per given percentage point of the credit - in later years, as oil prices fell. The return of higher oil prices, as now seems to be occurring, could likewise herald a return to a greater per point response.

Thoughts on Hawaii's Energy Policy Options

Hawaii is far more dependent on oil as a source of its energy needs than any other U.S. state. Other states can rely more heavily on sources such as hydroelectric power, coal, nuclear energy, and natural gas. Oil accounts for about 40 percent of the energy needs of the overall U.S. economy, but it accounts for an overwhelming 90 percent of the needs of Hawaii, with biomass combustion accounting for most of the remaining amount. And the certain demise of the sugar plantations means that bagasse, the remnant of sugar cane processing used for fuel, will be in increasingly short supply.

In turn, about 60 percent of Hawaii's oil consumption is for liquid fuels to power cars, buses, airplanes, and ships. Jet fuel alone accounts for almost 40 percent of our oil consumption. That gets the residents of this isolated island state to the Mainland and other destinations. But more importantly, it brings tourists here. An estimated one-third of Hawaii's jobs are tied in some way to the visitor industry, and tourism will undoubtedly remain Hawaii's most important export industry for the foreseeable future. There is no substitute for jet fuel derived from oil.

Perhaps even more relevant in gauging Hawaii's dependence on oil -- and the state's vulnerability to potential disruptions in oil supplies -- is the fact that it must be shipped over very long distances to be consumed here. The nearest supplier is thousands of miles away.

There is no time like the present for sober reflection on Hawaii's dependence on oil. As this paper is written, oil prices are climbing to their highest levels in years. Hawaii's economy will feel this in a number of ways, even as the economy is just recovering from an unprecedented decade of very low growth or actual recession.

- Our own transportation costs will be higher. Hawaii residents cannot drive as far as those on the Mainland, but gasoline prices here traditionally run among the highest in the nation anyway.
- Costs of imported items will be higher, and practically everything we consume comes from outside the state.
- Hawaii businesses will have to pay higher prices for running and lighting their facilities.
- Hawaii is especially vulnerable via the tourism linkage. Higher airfares will mean more expensive Hawaii vacations and perhaps fewer tourists.
- Finally, the most critical impact may come from the income effects on a slowing U.S. economy that will also feel the impact of higher oil prices. At the current juncture, Hawaii looks overwhelmingly to the U.S. Mainland for its externally driven growth. Gone are the days when Japan, another energy-vulnerable economy, provided the main impetus to our local growth. An increasingly significant minority among U.S. economic forecasters is raising the probability of impending U.S. recession. This was not the case as recently as a few months ago, but the Federal Reserve may not get its carefully engineered "soft landing" for the U.S. economy. Higher energy prices have been one of the main factors causing downward revisions of upcoming U.S. growth. Hawaii will feel the effects of a slowing U.S. economy acutely, just because much of its present growth can be attributed to injections from the Mainland. This has come not just in more robust tourism figures, but in things like burgeoning offshore real estate demand.

Yet, at the same time Hawaii is vulnerable to oil, it is blessed with more renewable energy resources than most other economies. Among these are wind, sunlight, geothermal heat, flowing water, and ocean resources. Many of these have been tried in the past, but they have not replaced oil mainly because of the costs associated with their production have not been overcome.

Wind power works only when the wind blows, and connection to the electric grid can cause operating problems. Even assuming the best scenario, wind is likely to contribute only a small share of Hawaii's total power generation needs in the future.

With one of the world's most active volcanoes in Hawaii, one might logically expect big attempts to capture the benefits of geothermal conversion. Such technologies have been proven successful in places like New Zealand and Iceland. And even now in Hawaii, the Big Island benefits significantly from commercially produced geothermal energy. Studies indicate the potential for much more development, even though one stumbling block in the past has been social and spiritual conflicts.

Hawaii is surrounded by deep water, and ocean thermal energy conversion has been the subject of experimentation for years. The main problem here, again, is the cost of production.

Finally, Hawaii has more than its share of sunlight, a resource that we exploit via tourism and in other non-energy generation ways also. Solar technology is commercially available and environmentally friendly. Sunlight can generate electricity directly through photovoltaic cells, or it can heat a fluid for conventional power generation. Photovoltaics may make more sense for small systems that are removed from the utility grid, but costs of generation are again high. So electricity generation from the sun often encounters the same cost hurdle as other renewable sources, but solar heated hot water makes the most sense.

The implications for public policy emerging from all this seem to be the following:

- Oil dependent Hawaii should continue to aggressively pursue other energy sources. Higher cost generation now may give way to lower costs in the future as new technologies emerge.
- Subsidy of alternative energy sources is not free, either via tax credits or by other means. But as Hawaii's economy emerges from the lackluster 1990s into a period of sustained higher growth, as it is now doing, higher tax revenues will make such subsidy much more affordable.

- Higher oil prices, such as the world is once again experiencing, make potential benefits of this subsidy greater than before, perhaps much greater. Periods of low oil prices, such as the world has had in recent years, breed complacency about alternative sources. Yet concern comes back with a vengeance as oil prices rise gain.
- Finally, research such as the Loudat paper, and the results presented above in this reviewer's own paper, provide evidence that a tax credit contributes net economic and fiscal benefits, and that this tax credit has indeed been effective in stimulating investment in solar systems over and above more conventional private market forces. It is the role of government to eliminate roadblocks, and to provide incentives for solutions, even if those solutions themselves come from the private sector.

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Dr. Loudat received his Ph.D. from the University of Hawaii in 1980. His field of study was economics with an emphasis in Agricultural and Resource Economics. After receiving his Ph.D. he taught in the California State University system and at the University of Hawaii. Simultaneous with teaching he conducted research and engaged in private consulting. His research focus has been impact analysis, the economics of mineral extraction from the Hawaii EEZ, and the economics of various agricultural/ aquaculture/ forestry crops in Hawaii. His consulting emphasis has been in forensic economics as well as the research fields noted. He currently engages is his private consulting practice and community-based economic development projects serving on the Board of Directors of PILI (the Pacific Islands Land Institute) and the Wood Valley Water and Farm cooperative.

The Economic and Fiscal Impacts of The Hawaii Energy Conservation Income Tax Credit

(Revised from January 27, 1997)

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Prepared for:
Energy, Resources & Technology Division
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US Department of Energy (funding source)
and
The Hawaii Solar Energy Association

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EXECUTIVE SUMMARY

The overall objective of this research is to assess the impact to the State of Hawaii of the Energy Conservation Income Tax Credit (ECITC). Before presenting the overall conclusions related to this objective, it is important to note that the decision to purchase a solar system is an investment decision. This means that a solar system provides benefits for its entire life (25 years) as opposed to the year of its purchase only. The analysis is performed on this basis. Thus, the economic and fiscal impacts (benefits less costs to the economy and State government) of purchasing a solar system do not end the year of its purchase. Rather, they continue for the life of a solar system. Initial and subsequent year solar systems have cumulative impacts to those generated by systems installed in previous and subsequent years.

ASSUMPTIONS

Important research assumptions are the following.

1. The benefit of the ECITC is the stimulus this expenditure provides to an individual to purchase a solar system and this purchase's consequent economic and fiscal impacts.

2. The cost of the ECITC is the economic and fiscal impacts foregone due to reduced purchases of fossil fuel-generated energy to heat water caused by the purchase of a solar system.

3. The cost if the ECITC is eliminated is the economic and fiscal impacts foregone due its elimination including any direct fiscal expenditures (*i.e.* unemployment insurance).

4. If the ECITC is eliminated the electric utility Demand Side Management (DSM) program is eliminated as well.

MAJOR RESEARCH CONCLUSIONS

The major research conclusions are the following.

1. The ECITC serves as a market signal to consumers that stimulate investment in solar systems. The number of solar systems purchased would decrease by 90% if the ECITC is eliminated. This effect could be due to economic, informational and/or behavioral factors.

2. The effective year one cost to the State of the ECITC is the value of the credit refunded to the purchaser of a solar system of $1,327 less tax revenues generated from the purchase of a solar system of $999. The effective year one cost is $527, which is 40 percent of the value of the ECITC refunded to a solar system purchaser. There is no ECITC expenditure for the 17% of all solar system purchasers who do not claim the credit.

3. With the ECITC (*i.e.* the status quo is maintained), there is a positive fiscal impact to the State over the life of a solar system purchased of $1,842 per system. This is due to an average annual positive expected fiscal impact of a solar system of $99 per year from years 2-25 of the life of a system. This positive net fiscal impact is due to the energy savings from solar systems the value of which is exogenous to Hawaii's economy.

4. The net fiscal impact of each system purchased with no ECITC claim is a positive $3,169. The number of these system purchases, the majority of which are military installs, would decrease if the ECITC were eliminated due to the simultaneous elimination of the utility DSM rebate program.

5. The ECITC employment impact over the life of a solar system is positive. That is, by stimulating investment in solar systems, the total State ECITC expenditure increases the total number of jobs in the state. For year 1 the increase in total jobs is a net of about 1 job per 13 solar systems installed. The average annual increase in total jobs for years 2-25 is 1.5 jobs per solar 100 systems installed. Correspondingly, labor income increases due to the ECITC.

6. If the ECITC is eliminated and the solar industry shrinks to 10% of its current 2,764 systems installed per year size, the State will suffer a net fiscal loss of approximately $3,165 per solar system in year 1. First year losses are primarily due to fiscal expenditures in the form of unemployment compensation the State would incur due to a decrease in total jobs caused by the elimination of the ECITC. There is also a negative revenue effect in year 1 of $800. Year 2-25 negative fiscal impacts are due to the loss of the positive fiscal impacts of a solar system over this period as well as possible continuing unemployment compensation or other fiscal costs due to a solar industry size decrease.

OTHER RESEARCH CONCLUSIONS

Other research conclusions are the following.

1. The (net) total State ECITC expenditure for the estimated 2,764, 83% of whom claim the credit, is negative $0.3 million in year 1. The average annual fiscal impact of the ECITC in years 2-25 of these systems is positive $0.24 million per year, such that the overall fiscal impact over the life of systems purchased in a given year is $5.6 million.

2. The job impact of systems installed in a given year at the current credit level is 194 jobs in year 1 and an annual average of 38 jobs for years 2-25. Year 2-25 impacts are cumulative to impacts from systems installed previously and those expected to be installed in subsequent years.

3. If the ECITC is eliminated, the State is estimated to incur direct fiscal expenditures in the form of unemployment insurance costs in excess (by $7.5 million) of the cost of the ECITC the assumed year of its elimination. Direct fiscal costs could continue after year 1 if workers who lose their jobs due to the elimination of the ECITC are unable to find alternative jobs in the period assumed for this analysis (16.6 weeks). Such costs are "avoided" by not eliminating the ECITC. The elimination of the ECITC also leads to a reversal of the positive net revenue impacts caused by the ECITC after year 1 becoming negative $0.91 million in years 2-25.

4. An oil price real rate of increase (decrease) of 1.4% (-1.7%) relative to the base case 0.2% expected increase causes a 25% (-30%) increase (decrease) in the net fiscal benefits and employment effect of the ECITC.

5. The value of tangible and intangible impacts of the ECITC not included in the analysis would have positive economic and fiscal impacts. This is primarily due to "avoiding" the cost of negative externalities associated with burning fossil fuels. The costs associated with these negative externalities are "avoided" due to reduced fossil fuel use brought about by the ECITC. The quantification of these costs "avoided" by the ECITC is beyond the scope of this analysis. They are of particular relevance to Hawaii, however, given the inter-relationships between economic development, especially tourism, the environment and energy use.

ANALYSIS DISCUSSION

INTRODUCTION

The objective of this research is to assess the impact to the State of the Energy Conservation Income Tax Credit (ECITC) on behalf of the Hawaii Solar Energy Association and the Energy Task Force. This entails assessing economic and fiscal impacts in the form of costs and benefits caused by the ECITC. These impacts are estimated using the State of Hawaii 1992 Input/Output model published by the State Department of Business, Economic Development & Tourism (DBEDT). How this is done and the results from performing the assessment are presented in the sections below. These results provide the basis for the various conclusions drawn from this research presented in the Executive Summary.

THE SOLAR SYSTEM PURCHASE DECISION

The decision to purchase a solar system is an investment decision as opposed to a consumption decision. This means that once purchased, a solar system produces benefits over its 25-year useful life. Thus, the economic impacts of purchasing a solar system do not end the year of its purchase, they continue for the life of the system.

Viewing the purchase of a solar system from an investment perspective, Table 1 shows that the purchase of a solar system without the ECITC provides an average annual rate of return ranging from 12.3 percent to its purchaser. This rate of return is due to the annual energy cost savings a solar system provides over its life. In spite of such a favorable economic signal, the number of systems purchased in Hawaii is largely a function of the existence and size of the total tax credit. This could be due to economic reasons as the ECITC improves the economic return to the system purchaser. The ECITC could also be an informational factor (*e.g.* purchasers do not know or become aware of the benefits of a solar system without the ECITC) and/or behavioral factor (*e.g.* purchasers are motivated by ECITC tax savings for reasons related to tax savings themselves and/or support for State energy policy as embodied in the ECITC) affecting purchase decisions. Whatever the reason, the ECITC serves as a market signal to consumers stimulating investment in solar systems.

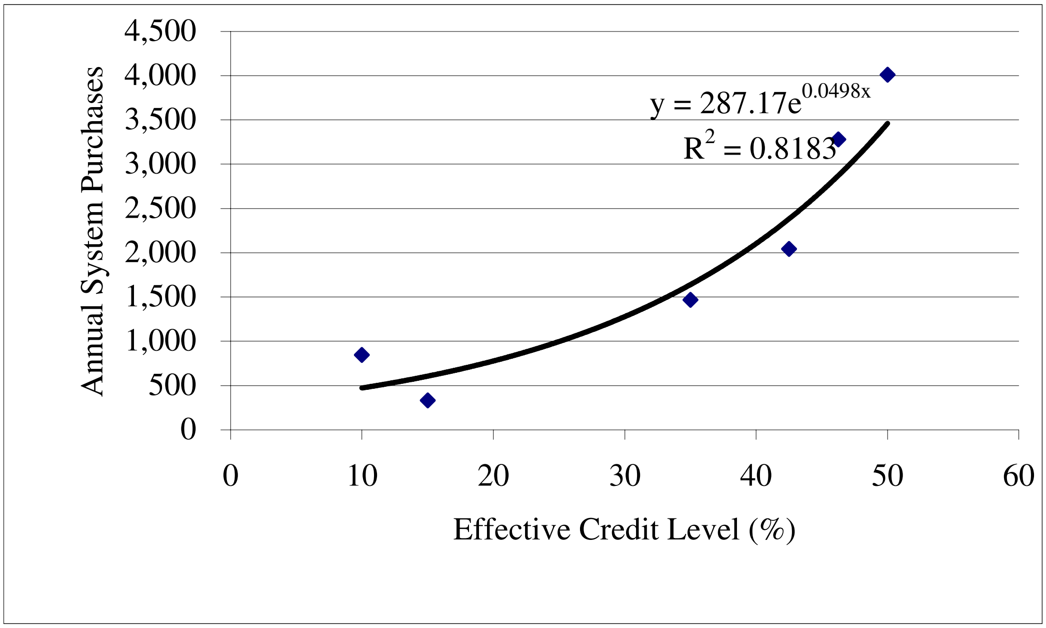
Table 1: The Investment Performance of a Solar System (assumed cash purchase)

Item	No ECITC	With ECITC
Investment Payback (years)	9	5
Net Present Value	$2,359	$4,300
Internal Rate of Return	12.3%	28.9%

The Relationship Between Credit Levels and Solar Systems Purchased

Chart 1 supports the conclusion just noted. It shows the estimated relationship between the size of the effective tax credit and the number of solar systems purchased in Hawaii, which increases with the size of the effective credit.

Chart 1: The Relationship Between the Size of the Credit and Statewide Solar System Purchases



Source: report p. 21

Using Chart 1 results, the expected annual number of solar system purchases is:

- 287 if there is no credit,
- 1,641 if there is an ECITC credit of 35% but no DSM rebate, and
- 2,764 if there is an ECITC with the current DSM rebate which provides an effective credit of 45% of the purchase price at the current ECITC and rebate levels.

These results suggest a reduction in the number of systems sold of 2,477 or 90% if the ECITC and DSM program are eliminated.

ECONOMIC AND FISCAL IMPACTS OF THE ECITC

Economic impacts are changes in output, employment and labor income in the general economy. Fiscal impacts are changes in government expenditures and revenues. Economic and fiscal impacts measured in this analysis are caused by the State government's expenditure on the ECITC or the elimination of the ECITC.

Expenditure Pattern Changes Caused by the Purchase of a Solar System

Purchase of a solar system changes expenditure patterns of the purchaser. Specifically, if a solar purchase is made, the purchaser either purchases the solar system with cash from savings (cash purchase) or from borrowed moneys (system financed). Once installed, the solar system requires preventative maintenance and part replacement costs over its life. Solar systems reduce energy costs thereby freeing money for alternative consumption expenditures. This energy cost savings can be spent on other goods and services, the assumption of this analysis. Since any energy cost savings is an exogenous impact, there are no offsets to this spending.

This expenditure pattern change causes economic and fiscal impacts. An increase (decrease) in the size of the solar industry due to the elimination or expansion of the ECITC increases (decreases) the economic and fiscal impacts. This includes economic and fiscal impacts caused by changes in the level of oil imports.

The Solar System Purchase Decision and ECITC Benefits and Costs

The benefit of the ECITC is the stimulus it provides to an individual to purchase a solar system and this purchase's consequent economic and fiscal impacts. The cost of the ECITC, are the economic and fiscal impacts of purchasing fossil fuel-generated energy to heat water *foregone* due to the purchase of a solar system. Benefits less costs indicate the net impact of the ECITC. There are also benefits and costs related to the DSM rebate program the existence of which is assumed contingent upon the existence of the ECITC.

If the ECITC were eliminated, other economic and fiscal costs would be incurred for each system not purchased because there is no ECITC and DSM program. These include output, employment and labor income decreases and their consequent impact on State tax revenues, and direct fiscal expenditures to the State in the form of unemployment insurance benefits. Costs could also include other expenditures due to temporary and possible permanent unemployment caused by a size reduction of the solar industry due to ECITC elimination.

Net Impact of the ECITC – Case 1

Table 2 shows ECITC benefits and costs and the ECITC impact (*i.e.* benefits less costs) for the first year and the average annual impact for years 2-25, for the base case scenario for Case 1. Case 1 is the status quo situation where solar system purchasers receive a tax credit (*i.e.* the ECITC) from the State and DSM rebate the year the system is purchased. Of the estimated annual total number of systems purchased, 83% claim the ECITC. Purchasers not claiming the ECITC yet obtain the DSM rebate.

For Case 1, benefits equal the economic and fiscal impacts of the purchase of a solar system caused by the ECITC. Costs equal the economic and fiscal impacts due to fossil fuel-generated energy purchases to heat water *foregone* due to the purchase of a solar system. The base case scenario assumes the solar system is purchased is 100% financed, the purchaser receives a $728 rebate, and real annual increases in energy costs of 0.2% for the life of the system.

Table 2: Economic and Fiscal Impacts of a Single ECITC Stimulated System Purchase

Item	Benefits		Costs		(Benefits Less Costs)		TOTAL
	Year 1	Avg/Yr Years 2-25	Year 1	Years 2-25	Year 1	Avg/Yr Years 2-25	
Economic Impacts							
Total Output	$10,657	$843	$2,735	($704)	$7,922	$1,546	**$45,032**
Employment	0.133	0.011	0.055	(0.004)	0.078	0.015	
Total Labor Income	$4,368	$299	$1,693	($162)	$2,675	$461	**$13,742**
Fiscal Impacts							
Total Revenues	$999	$47	$199	($51)	$800	$99	**$3,169**
Total Expenditures							
ECITC Expenditure	$1,327	$0	$0	$0	$1,327	$0	**$1,327**
Direct Fiscal Expend.	$0	$0	$0	$0	$0	$0	**$0**
NET FISCAL IMPACT	($328)	$47	$199	($51)	($527)	$99	**$1,842**

Source: Report pp. 12-14 and 17-18

Table 2 shows purchase of a solar system has positive economic impacts (*i.e.* output, employment and labor income impacts). That is, the economic benefits of the ECITC expenditure are greater than the economic costs of a solar system purchased with the ECITC. Specifically,

- Economic output stimulated by the purchase of a solar system increases $8 thousand in year 1 and an average of $1.5 thousand per year for years 2-25;
- 7.8 total jobs per 100 solar systems installed are generated in year 1 and an average of 1.5 jobs per year per 100 solar systems purchased from years 2-25 of the life of these systems;

- Over $2.6 thousand labor income is generated in year 1 and an average of $461 from years 2-25.

Table 2 shows a negative net fiscal impact to the State (*i.e.* revenues less than expenditures) in year 1 of $527 for Case 1. The net fiscal impact to the State is less than the $1,327 ECITC amount due to the fact that net revenues generated by ECITC stimulated solar system purchasers are $800 in year 1. Net revenues in years 2-25 average $99 per year. In total, the net fiscal impact to the state over the life of a solar system is $1.8 thousand.

Net Impact of the ECITC Elimination – Case 2

Table 3 shows benefits and costs for the first year and years 2-25, for the base case scenario for Case 2. Case 2 is the situation where the ECITC is eliminated. Estimated benefits and costs for Case 2 are the opposite of Case 1 with two changes. First, the ECITC expenditure is eliminated. Second, a fiscal expenditure of $1,828 unemployment compensation per system not installed due to the elimination of the ECITC is assumed incurred by the state the year the ECITC is eliminated and $154 years 2-25 due to the loss of jobs, job creation and assumed consequent fiscal costs caused by the ECITC elimination. This expenditure is assumed spent as unemployment compensation income on personal consumption.

In contrast to Case 1, Table 3 shows that for Case 2, each of the positive economic impacts becomes a negative impact. This is because the economic benefits foregone due to the existence the ECITC are greater than the economic costs saved due to its elimination.

Table 3: Economic and Fiscal Impacts per Solar System Not Installed Due to the Elimination of the ECITC

Item	Benefits Year 1	Benefits Avg/Yr Years 2-25	Costs Year 1	Costs Avg/Yr Years 2-25	(Benefits Less Costs) Year 1	(Benefits Less Costs) Avg/Yr Years 2-25	TOTAL
Economic Impacts							
Total Output	($10,657)	($843)	($2,194)	$1,714	($8,463)	($2,557)	($95,391)
Employment	(0.133)	(0.011)	(0.050)	0.014	(0.083)	(0.025)	
Total Labor Income	($4,368)	($299)	($1,490)	$542	($2,878)	($841)	($31,470)
Fiscal Impacts							
Total Revenues	($999)	($47)	($160)	$125	($839)	($172)	($6,696)
Total Expenditures							
ECITC Expenditure	$0	$0	$0	$0	$0	$0	$0
Direct Fiscal Expend.	$2,326	$196	$0	$0	$2,326	$196	$9,004
NET FISCAL IMPACT	($3,325)	($244)	($160)	$125	($3,165)	($369)	($15,700)

From a fiscal impact perspective, it is important to note that:

- The effective cost of the ECITC (Case 1) is $524 in year 1, or 40 percent of the ECITC paid to the purchaser of a solar system the year the credit is claimed. This cost is more than compensated for over the life of a solar system due to the net positive fiscal impacts of a solar system after year 1 such that at the State reaps a positive return to its investment.
- If the ECITC is eliminated, the negative net fiscal impact to the State is more than 6 times larger the year the ECITC is eliminated.
- The level of the negative fiscal impacts after year 1 if the ECITC is eliminated (Case 2) depends on the capacity of economy to generate jobs for workers who otherwise would have been employed by an ECITC supported solar industry and the output and labor income level of replacement jobs.

TOTAL ECONOMIC AND FISCAL IMPACTS OF THE ECITC

Total economic and fiscal impacts of the ECITC are calculated by multiplying the per system impacts shown in Tables 2 and 3 by the marginal number of system purchases related to the ECITC (Case 1) or, stated otherwise, which are not purchased because the ECITC is eliminated (Case 2). The product for the ECITC cost is multiplied by the percentage of purchasers who claim the ECITC to account for non-ECITC purchases. Based on the relationship between solar system purchases and the effective credit level shown in Chart 1, the estimated marginal number of solar system purchases related to the ECITC based on the current effective credit level of 45% is 2,477. The number of solar systems purchases related to the effective credit level will increase (decrease) due to an increase (decrease) in either the ECITC and/or DSM rebate levels according to the relationship shown in Chart 1. Table 4 shows the total economic and fiscal impacts of the ECITC for cases 1 and 2.

Table 4: Total Economic and Fiscal Impacts of the ECITC

	Benefits less Costs (millions of dollars)					
	Case 1			Case 2		
Item	Year 1	Avg/Yr Years 2-25	Total	Year 1	Avg/Yr Years 2-25	Total
Economic Impacts						
Total Output	$19.6	$3.83	$111.5	($21.0)	($6.33)	($172.9)
Employment	194	38		(207)	(62)	
Total Labor Income	$6.6	$1.14	$34.0	($7.1)	($2.08)	($57.1)
Fiscal Impacts						
Total Revenues	$2.0	$0.24	$7.8	($2.1)	($0.427)	($12.3)
Total Expenditures						
ECITC Expenditure	$2.2	$0.00	$2.2	$0.00	$0.00	$0.0
Direct Fiscal Expend.	$0.00	$0.00	$0.0	$5.8	$0.49	$17.4
NET FISCAL IMPACT	($0.3)	$0.24	$5.6	($7.8)	($0.91)	($29.8)

Source: Tables 2, 3 and Chart 1

Year 1 and Years 2-25 Average Annual Impacts For Cases 1 and 2

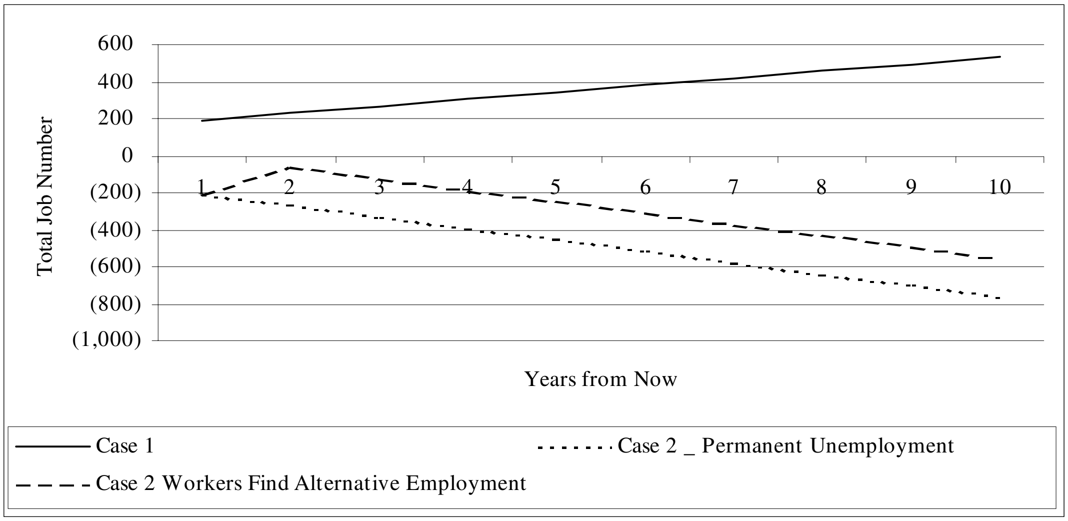
Table 4 shows the following related to year 1 and years 2-25 average annual impacts for cases 1 and 2.

- The total employment effect of the ECITC is 194 total jobs for annual system installation of 2,477 systems and an average of 38 total jobs created each year the ECITC exists (Case 1) related to service and maintenance of systems installed in a given year. Employment effects are foregone if the ECITC is eliminated (Case 2).
- The labor income effect of the ECITC is $6.6 million per year for annual system installation of 2,477 systems and an average of $1.14 million labor income for systems installed in a given year for a total of $34 million over the life of the systems (Case 1). This labor income effect is foregone if the ECITC is eliminated (Case 2).
- The Case 1 net total fiscal impact of the ECITC is negative $0.3 in year 1 and positive $0.24 million in years 2-25 for a total fiscal impact of positive $5.6 million due to the ECITC for a given year's purchase of 2,477 systems. For Case 2, the year 1 fiscal impact of the ECITC is negative $7.8 million for the 2,477 not purchased due to the elimination of the ECITC. The total average annual fiscal impact for years 2-25 for Case 2 is negative $0.91 million for an overall impact of negative $29.8 million.

Cumulative Job and Fiscal Impacts For Cases 1 and 2

The cumulative job effects are shown in Chart 2. It shows that the ECITC has a significant total job effect relative to not having the ECITC (i.e. Case 2). This relative effect is significantly greater if one assumes that the installation jobs lost due to the elimination of the ECITC result in permanent unemployment as Chart 2 shows.

Chart 2: Case 1 and 2 Cumulative Total Job Effects



Source: Table 4

The cumulative fiscal impacts are shown in Chart 3. It shows that fiscal impacts of the ECITC (i.e. Case 1) are increasingly positive in contrast to the increasingly negative fiscal impacts caused by ECITC elimination (i.e. Case 2). This relative effect is significantly greater if one assumes that the installation jobs lost due to the elimination of the ECITC result in permanent unemployment as Chart 3 shows.

Chart 3: Case 1 and 2 Cumulative Total Fiscal Impacts

Source: Table 4

Impact Changes Due to Base Case Scenario Assumption Changes

The results presented in Tables 2 and 3 are for the base case scenario. As noted, the base case scenario assumes that the solar system purchase is financed, the purchaser receives a $728 rebate from the electric utility via the Demand Side Management (DSM) program and oil costs increase at a real average annual rate of 0.2% over the life of a solar system. Altering any of these assumptions alters the estimated economic and fiscal impacts of the ECITC. The changes discussed below are made relative to the base case scenario.

System Financed versus Purchased with Cash: If a system is financed rather than purchased both the overall economic and fiscal impacts remain approximately the same as the cash purchase situation. However, the year 1 negative fiscal impact is greater than a financed purchase where as year 2-25 positive fiscal impacts are greater. Likewise, year 1 positive economic benefits are deferred to years 2-25 from year 1.

DSM Rebate of $1000: If the DSM rebate is $1000 for Oahu retrofits, or the same as the DSM rebate level for new Oahu systems and system purchases on neighbor islands, the economic and fiscal impacts improve by 25-30% relative to the current $500 rebate level.

Oil Prices: High (low) oil price changes increase (decrease) economic and fiscal economic impacts of the ECITC by 25% (-30%).

Economic and Fiscal Impacts Not Measured

Tangible economic and fiscal impacts of the ECITC not measured in this analysis include the following.

1. The negative impact on Hawaii's position as a Pacific Basin energy development and implementation leader. This leadership position is exemplified by the fact that Hawaii has the highest state per capita number of solar systems in the nation and HECO's receipt of the prestigious Edison Award in 1994 for its heat pump water heating system program. This negative impact could have long-term negative impacts on potential export revenues due to reduced involvement of Hawaii's solar industry (due to its reduced size) in the Pacific Basin.

2. The negative impact on business investment in Hawaii due to vacillating state policy, which reduces business environment certainty, and thus investment. This is of particular relevance and veracity for various solar industry members who have forestalled expansion plans on Oahu and the neighbor islands due to the threat the ECITC will be eliminated.

3. The negative impact of direct fiscal expenditures if the ECITC is eliminated that would be incurred by the State in addition to those measured in this analysis (*i.e.* unemployment insurance costs). These include: potential welfare benefit expenditures to displaced workers, expenditures for direct State involvement in retraining programs for new jobs or direct subsidies for new job creation, and revenue losses to the State due to private sector expense increases to re-train workers for new jobs and for the creation of new jobs.

4. Positive ECITC fiscal impacts to Hawaii counties in the form of permit fees and increased property tax revenues.

5. The option value (*i.e.* the value of having a solar industry of its current size) lost to the State given solar industry downsizing if the ECITC is eliminated.

Intangible ECITC economic and fiscal impacts arise due to positive externalities (side effects) from reduced oil consumption brought about by the ECITC. These are reduced air, land and water pollution and attendant problems including global warming and acid rain. If the cost of these negative consequences of burning fossil fuels were incorporated into the price of oil, the energy cost savings estimated in this analysis would be significantly larger. The larger the energy cost savings, the larger are the positive ECITC economic and fiscal impacts.

Marwan Masri

Manager, The Renewable Energy Program, California Energy Commission

Mr. Masri was born in 1945. He has a graduate degree in economics from the University of California. His experience includes twenty-two years in the energy field, and fifteen years as a lecturer in economics at several universities in California with particular emphasis on the economics of energy and the environment. He has also spoken at numerous international conferences dealing with the economics of energy and the environment. As a senior economist at the California Energy Commission, he directed an interdisciplinary team that conducted technical and policy research on a wide range of energy issues, including: the comparative economics of alternative energy resources; the valuation of environmental impacts of energy production; global climate change; and the economics of energy research, development, and demonstration. Since October 1996, Mr. Masri has directed the Renewable Energy Program established by Assembly Bill 1890 and Senate Bill 90. This program administers $540 million in incentive funds to support existing, new and emerging renewable technologies in California during the state's transition to a competitive electricity market and beyond.

Energy Symposium
November 9, 2000

The California Energy Commission's
Renewable Energy Program

Marwan Masri,
Program Manager

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Presentation Contents

- Background
- Structure
- Status
- Next Steps

3

Program Development Background

- AB 1890, passed in September 1996, allocated $540 million; ordered CEC Policy Report
- SB 90, passed in November 1997, codified most of Commission's policy recommendations
- Guidebooks were developed to flesh out details of participation in each of five accounts; adopted January 1998

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Renewable Power And The Restructured Market

- Stable fuel costs can lead to easier fixed-price contracts and more stable consumer prices
- Environmental characteristics lead to easier permitting, quicker construction
- Distributed nature of some option can provide power where needed
- Modularity, can be added incrementally to meet growing demand

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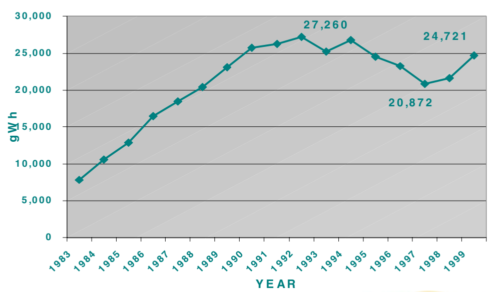
Non-Hydro Renewable GWh



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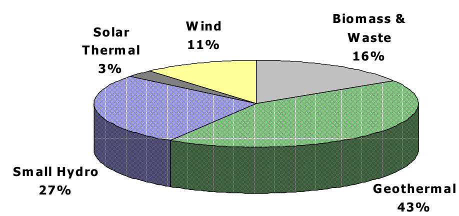
California Renewable Energy

33,779 GWh in 1999 (12% of Total)



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Presentation Contents

- Background
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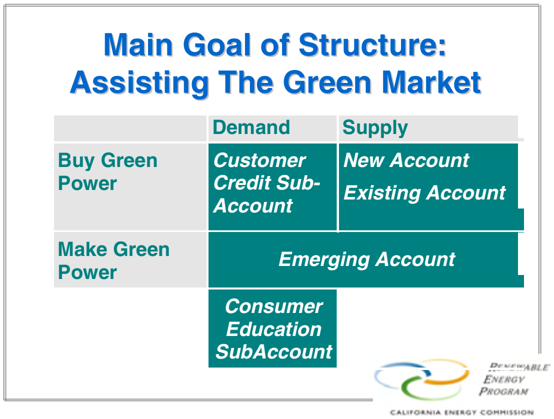
Structured As Five "Accounts"

- Existing Technologies ($243 Million)
- New Technologies ($162 Million)
- Emerging Technologies ($54 Million)
- Customer Credit Subaccount ($75.6 million)
- Consumer Education Subaccount ($5.4 million)



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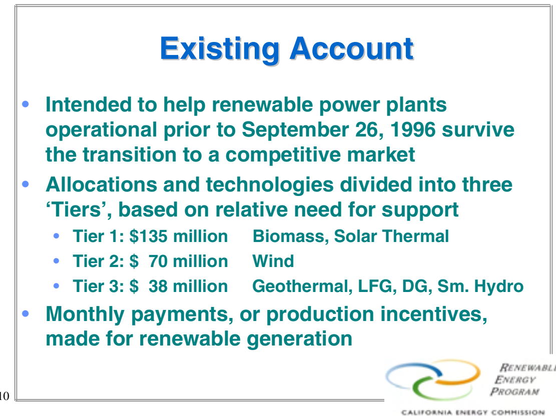

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Existing Account

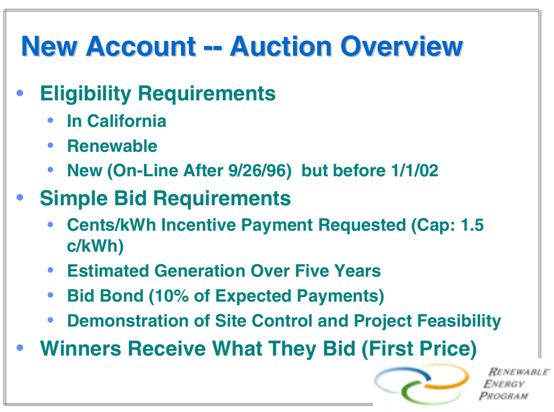
- Funds are distributed monthly to renewable suppliers through a cents per kilowatt-hour (kWh) payment for eligible renewable electricity generation.

- Payments are based on the difference between the market price [either the short-run avoided cost (SRAC) price or the California Power Exchange (CalPX) price] and the target price, subject to the cap, and limited by the amount of funds available in the Existing Account each month.

New Account

- The first New Account auction was held in June 1998 and resulted in 55 winning bids for projects totaling more than 500 megawatts (MW) of new renewable generation.

- Auction participants were required to submit the cents/kWh incentive they wished to receive (capped at 1.5 cents/kWh), an estimate of their first five years of generation, a detailed description of the proposed project, and a bid bond equal to 10% of their proposed total award (incentive multiplied by generation).



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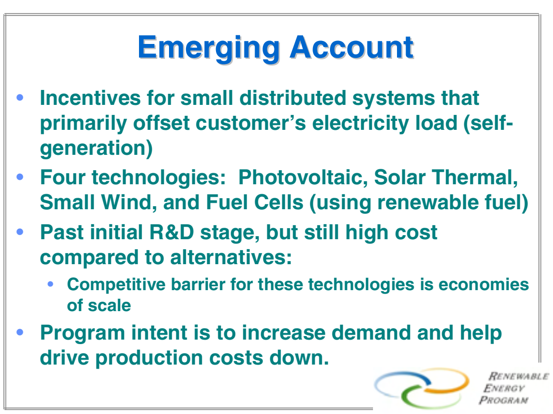
- A total of $162 million was conditionally allocated to the 55 winning project bids; funding is conditional on passing six milestones and coming on-line before January 1, 2002. Projects receive no funding until they begin generating electricity for sale.

Emerging Account

- The Emerging Account's Buydown Program provides payments to buyers, sellers, lessors or lessees of eligible electricity generating systems that are powered by emerging renewable resources.

- The Buydown Program is open to generating systems of all sizes but is intended to favor small generating systems, such as those typically used by residential or small commercial and agricultural customers.

- Intent of the Buydown Program is to reduce the net cost to the end user of generating equipment using



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emerging renewable technologies, thereby stimulating sales of such systems. Increased sales are expected to encourage manufacturers, sellers, and installers to expand their operations and reduce their costs.

Customer Credit Subaccount

- Program intent is to 'jump-start' the renewable or green market in California
- Provides incentives for purchasing eligible renewable energy through direct access marketplace
- Eligible renewable energy is generally from existing or new in-state powerplants not under contract to or owned by existing utilities

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Customer Credit SubAccount: How Program Works

- Commission provides an incentive of up to 1.5 cents/kWh for purchases of eligible renewable energy
- Administrative costs reduced by distributing funding through energy service providers
- Incentive $ capped for large Commercial and Industrial customers (> 20 KW) at $1,000/year

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Consumer Education SubAccount

- $5.4 million collected over four years
- Expended to:
  - promote renewable energy
  - provide information on renewable technologies
  - help develop a consumer market
- Explicitly covers both green power and emerging technologies markets

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Existing Account

- Pays cents/kWh production incentives (capped at 1.5 cents/kWh) to renewable generators on-line before 9-96
- 259 existing renewable facilities (over 4,000 MW) have received more than $130 million
  - Tier 1 facilities (biomass, solar thermal, waste tire) have received $80 million
  - Tier 2 facilities (wind) have received $30 million
  - Tier 3 facilities (digester gas, geothermal, landfill gas, MSW, and small hydro) have received $20 million
- More than 70 facilities have gone "off the cliff" but are continuing to operate

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Customer Credit Subaccount

- The Customer Credit Subaccount program began when the electricity market opened on March 31, 1998 and is expected to continue through December 2001 with funding allocated through Senate Bill 90.

- In most cases, electricity providers pass the credit on to consumers through a discounted electricity price; the credit is included in the electricity price. Providers must inform consumers about the credit on their bill.

- The customer credit, which is currently set at 1.0 cent/kWh, is a credit for the purchase of eligible renewable energy. The rebate is given to eligible consumers who purchase eligible renewable energy from a registered renewable provider.

- In most cases, electricity providers pass the credit on to consumers through a discounted electricity price; the credit is included in the electricity price.

- At the opening of the program, the credit level was set at 1.5 cents/kWh, the maximum allowable by law. The Commission has since lowered the credit level in response to market growth and the growing demand on funds.

Consumer Education

- After gathering stakeholder input, the Energy Commission adopted the *Renewable Energy Consumer Education Marketing Plan* in February 1999.

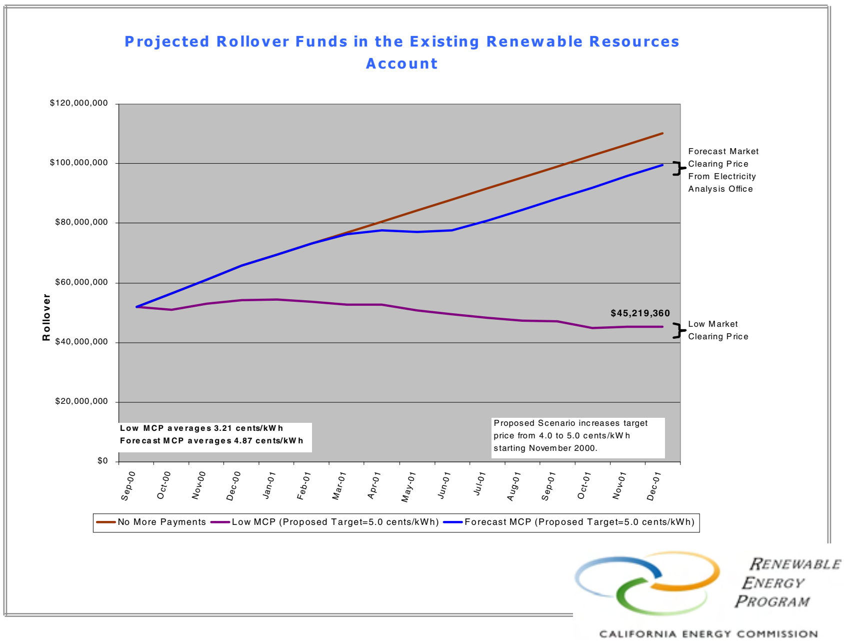
- The Marketing Plan outlines two action paths; one for renewable energy from the grid and a separate for emerging renewable technologies: 80% or $4.32 million for marketing and educational activities to promote the renewable energy market; 20% or $1.08 million for marketing and educational activities to promote emerging renewable technologies for on-site generation of renewable power.

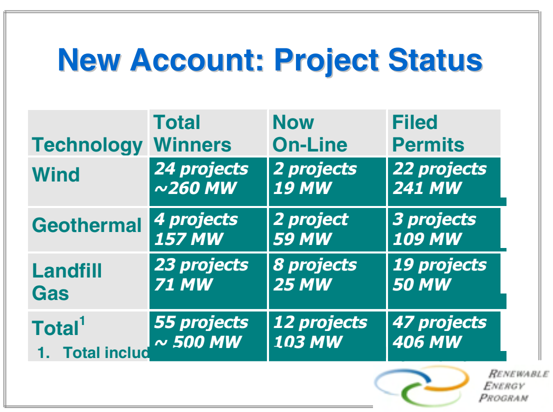
Status: Existing Account

- As a result of high short-run avoided cost (SRAC) prices, the rollover has nearly tripled for the three tiers combined and is currently over $40 million. The rollover is the amount of money that is available in the Existing Account bus has not yet been paid out to facilities. Any funds that are not paid in one month are added to the following month's allocation and made available for that month's payments cycle.

- SRAC prices are expected to stay high, and it is unlikely that payments will be made to any facilities in Tiers 1, 2, or 3 through the end of 2000.

- The term "off the cliff" refers to the end of a facility's fixed payment period of its contract with a utility.





New Account: Project Status

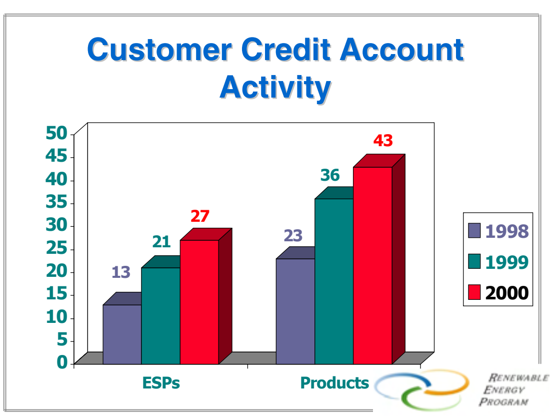
Technology	Total Winners	Now On-Line	Filed Permits
Wind	24 projects ~260 MW	2 projects 19 MW	22 projects 241 MW
Geothermal	4 projects 157 MW	2 project 59 MW	3 projects 109 MW
Landfill Gas	23 projects 71 MW	8 projects 25 MW	19 projects 50 MW
Total[1]	55 projects ~ 500 MW	12 projects 103 MW	47 projects 406 MW

1. Total includ

Status: New Account

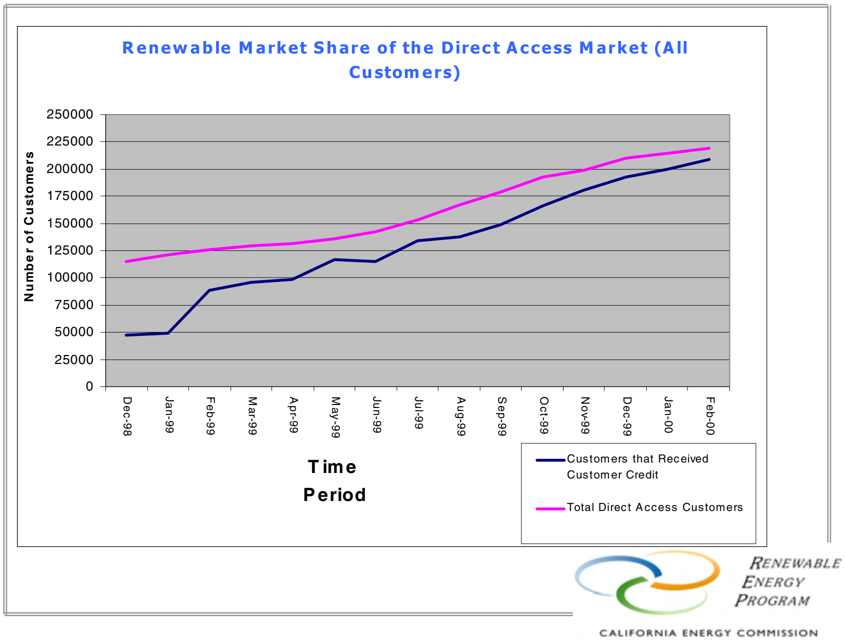
- Winning projects are expected to pass six milestones, including applying for and receiving necessary permits, starting construction, and coming on-line, before receiving any payments. Filing for permits is Milestone 2.

- As of October 1, 2000, 12 participating projects totaling over 100 MW were on-line and producing renewable energy (eight landfill gas facilities, two wind facilities, and two geothermal plants).



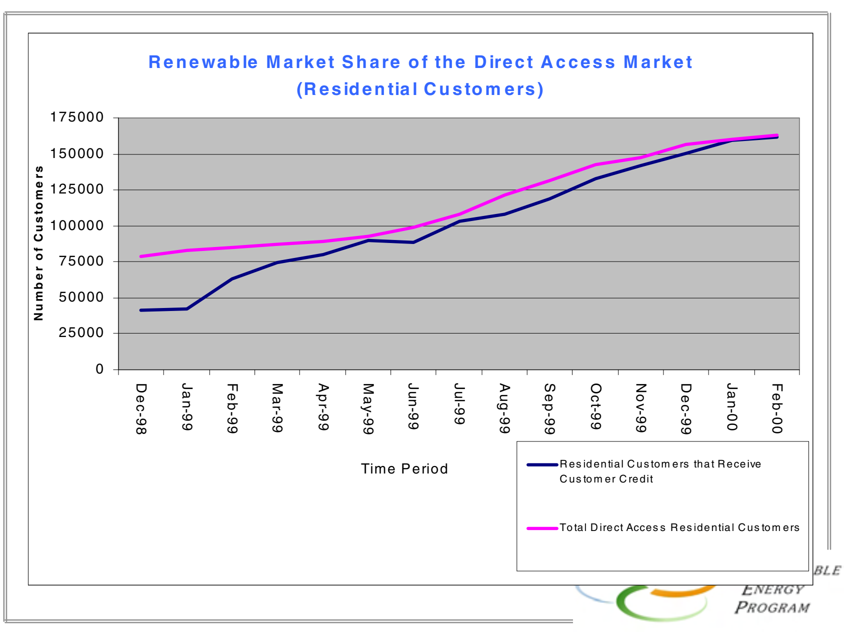
Status: Customer Credit Account

Energy Service Performance Contracts and products under the customer credit account are shown.



Renewable Market Share of the Direct Access Market (All Customers)

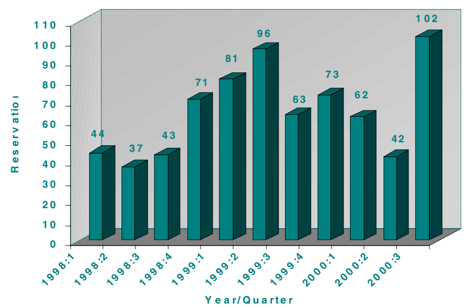
Most of the customers who have switched service providers have chosen renewable energy.



Renewable Market Share of the Direct Access Market (Residential Customers)

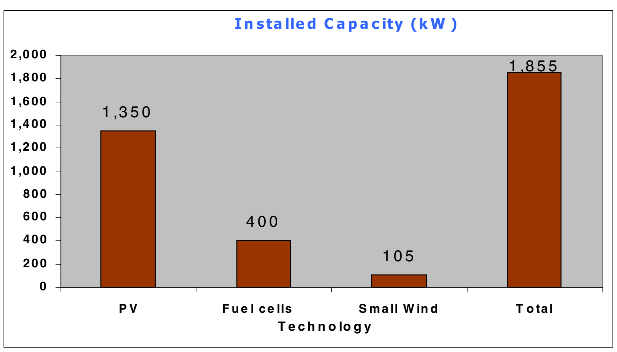
The trend is even more pronounced among residential customers. Almost all of the customers who have switched service providers have chosen renewable energy.

Emerging Account: Reservation Growth Over Time



Reservations by Category

Completed Systems	395
Received	35
Approved	223
Total	653



Presentation Contents

- Background
- Structure
- Status
- Next Steps

Program Evaluation

- Report to Legislature on November 1, 2000
- Additional evaluation planned in 2000-2001
- Final report to Legislature in early 2002

Second Auction

Second auction for new renewable resources released October 12 with bids due November 15, 2000

- $40 million available, reallocated from Existing Account
- Bids due November 15, 2000
- Projects must come on-line by December 31, 2001
- 10% incentive bonus for projects coming on-line by or before June 1, 2001
- Penalties for projects coming on-line after July 1, 2001

RENEWABLE ENERGY PROGRAM
CALIFORNIA ENERGY COMMISSION

Second Auction

- The $40 million was reallocated from the Existing Account's rollover funds.

- Primary purpose of the auction is to help ease the energy shortage that California could face in the summer of 2001.

Extension of Public Goods Charge

AB 995 (Wright) and SB 1194 (Sher) recently signed by Governor extends funding for renewables for 10 years at current level ($135 million/year)

CEC to develop "investment plan" recommending allocation among:

- new renewable energy
- emerging renewable technologies
- customer credits for renewables
- customer education
- incentives to reduce biomass fuel costs
- solar thermal generating resources
- fuel cell technologies that meet certain criteria

Held workshops (10/30, 10/31, 11/2) to receive public input

RENEWABLE ENERGY PROGRAM
CALIFORNIA ENERGY COMMISSION

Extension of Public Goods Charge

The program has been extended for another 10 years. In order to provide confidence to investors, the relatively long-term (10 years) commitment was necessary.

Matthew H. Brown

Program Director, The Energy Project
National Conference of State Legislatures

Matthew H. Brown is the Director of the National Conference of State Legislatures' Energy Project, which is responsible for advising state legislatures on energy issues. He and the Energy Project staff serve the needs of the 50 state legislatures on such issues as electric industry regulation, renewable energy, state energy planning, energy efficiency in buildings and alternative fuel vehicles. Mr. Brown has an extensive background in numerous areas of energy policy, and specializes in consulting services to state legislatures on these many complex issues.

Mr. Brown has been one of the country's most active national advisors to state legislatures on electric industry restructuring. He is the author of numerous articles on the issue, focusing on such subjects as state and local tax issues, public benefits and the efficacy of competitive markets. He is also called on by legislative leadership and committees on a regular basis to offer his services. He has spoken, sometimes on multiple occasions, before over half the nation's state legislatures. On these occasions he is usually a featured witness before legislative committees, frequently speaking and answering questions for a half to a full day. He has also been called on to offer his services to legislative party caucuses and to legislative staff members.

Mr. Brown has authored or co-authored numerous publications on renewable energy analyzing such issues as the development and history of the renewable energy, the efficacy of renewable energy incentives and others. He and the Energy Project staff have also assembled numerous "Energy Institutes"-- small and focused seminars for state legislators and staff on renewable energy and electric industry restructuring. He is a frequent speaker before legislative bodies and general energy audiences on renewable energy issues and a member of the National Wind Coordinating Committee Steering Committee.

Before joining the National Conference of State Legislatures, Mr. Brown was the Director of Special Projects for the City of New York Department of Telecommunications and Energy. In this capacity he was worked closely with the State Energy Office and Public Service Commission on a variety of renewable energy and alternative fuel vehicle issues. His duties also included an effort to deploy more renewable energy installations in City facilities.

Mr. Brown holds a BA from Brown University in Providence, Rhode Island and an MBA from New York University.

Renewable Energy Policies

Matthew Brown
Energy Program Director
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Organization of Remarks

- What, generally, have states done?
- Why have they done it?
- What levels of support have states offered to renewables?

2

Renewables Polices

- A system benefit fund
- A renewable portfolio standard
- Property tax incentives
- Net Metering
- State approval for green pricing programs

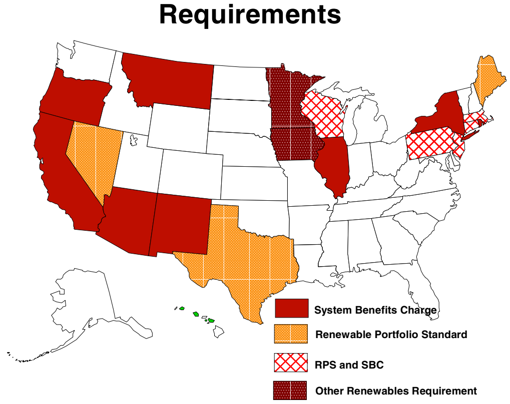
3

Renewables Policies

- State purchasing programs
- Income tax incentives
- Sales tax incentives
- Grants and loans
- Disclosure and Certification programs
- Contractor licensing programs
- Equipment certification

4

States with Renewable Energy Requirements



Effect of RPS & SBC Policies on Renewable Resources

RPS Policies (new by 2010)	3,800 MW
SBC Policies (new by 2010)	1,000 MW
National RPS – 7.5%	53,500 MW
Green Power (new by 2001)	300 MW
Total U.S. Generating Capacity	775,884 MW
Non Hydro Renewables (1998)	15,249 MW

Sources: LBNL/NREL study, NREL, and EIA

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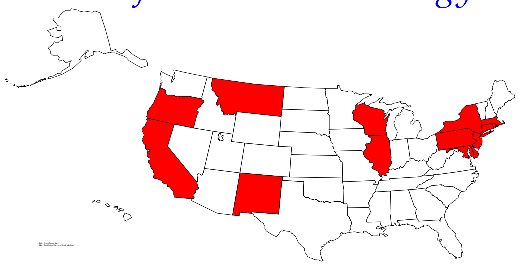
States w/System Benefit Charges for Renewable Energy



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A system benefits charge is a fee that every customer pays. It is almost always collected by the Distribution Company and remitted to the state. The funds that accumulate from a system benefits charge are allocated by law to a variety of activities. The categories of activities that are supported by a system benefits charge include:

- renewable energy
- energy efficiency
- low income customer support
- displaced utility worker retraining
- research and development
- other

These funds are sometimes set up to sunset after a period. In other cases, such as Massachusetts, they do not sunset.

Arguments for/against SBC

For	Against
● SBCs are small compared to stranded costs	● SBCs add to rates
● SBCs are competitively neutral and are flexible	● SBCs "re"regulate in era of "de"regulation
● SBCs preserve necessary programs	● SBCs preserve programs that are unnecessary

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Supporters of a system benefits charge justify it as follows: "In a competitive marketplace, certain somewhat higher cost activities that are valuable to society will not be maintained by the private sector as they have been in the past. The system benefits charge is means to keep those programs alive without penalizing any one customer."

Those in opposition to the charge point to the additional cost that it imposes and suggest that such programs should be supported by the competitive marketplace if they are to survive.

Why Have States Adopted System Benefit Funds?

- Traditional entities that have paid for efficiency, renewables, low income and research and development programs no longer do so.
- Each provides benefits that these states want to preserve.
  - Reliability benefits
  - Environmental benefits
  - Affordable service

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Administration of System Benefit Funds

- Funds can be administered by:
  - non-profit or quasi-governmental entity (as in Connecticut Innovations or Mass. Economic Development Fund)
  - utility
  - state energy office (as in the California Energy Commission)
  - state utility commission

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Administration Does Matter

- A state renewables fund to subsidize wind or biomass from an SBC can, if money flows into the state general fund, cause an equivalent decrease in federal wind/biomass tax credits.
- Such funds need to be kept out of state general funds in order to supplement, rather than offset, the federal tax credit.

11

Administration Does Matter

- Administration by a quasi-government entity may allow direct investment of funds for economic development purposes.
- Administration with an Energy Office may allow closer coordination with other state policy goals.

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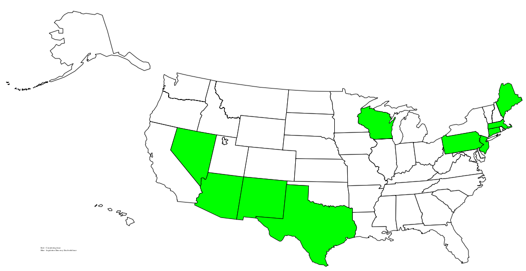
Connecticut and Massachusetts have opted for more of the economic development approach. In Connecticut, for instance, Connecticut Innovations manages the renewable energy portion of the system benefit funds, and will make direct investments in renewable energy companies that do business in Connecticut.

California has opted to allow state agencies to run these programs.

Renewable Portfolio Standard Programs (RPS)



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A renewable portfolio standard (RPS) is a means to continue support for renewable energy in a competitive marketplace or, in a few occasions, in a monopoly marketplace.

In general, a portfolio standard requires that each retail electricity seller include some amount of renewable energy as part of its product mix. This requirement is usually tradable, so that a retailer with less than the required mix would be able to purchase credits from one with greater than the required percentage.

State Approaches to RPS

- **CT:** New renewable .5% by 7/1/00; increasing by .25%/yr thru 7/09; Existing renew. increasing from 5.5% to 7% by 2009
- **ME:** 30% RPS (in-state RPS was already 50% - mostly hydro)
- **NJ:** By 1/1/06, 1% Class I renewables; By 1/1/12, 4% Class I renewables

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States choose different percentages for the requirement, with most hovering around 2-10 percent. One state, Maine, has a 30% requirement. This 30% amount actually reflects the amount of renewable energy already in the state's mix even before restructuring.

Connecticut established a program that defined Class I and Class II renewables. Class I renewables are new projects. Class II renewables are projects that existed at the time that the restructuring law was enacted.

Maine has included in its definition of renewables municipal solid waste. Most states do not include this resource in their definition of renewables.

A Texas Case Study

- Texas Instituted a 2000 MW portfolio standard.
  - To be phased in from 2003 to 2009.
- Big issues:
  - cost
  - technological feasibility
- Turning out to be cheaper than expected.
  - Especially with rising gas prices

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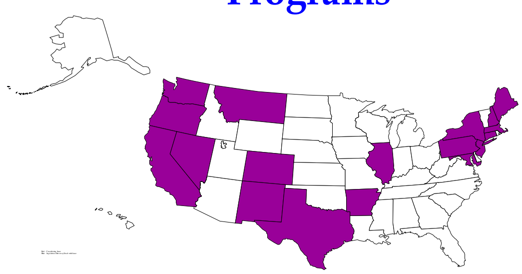
Texas has a 2000 MW portfolio standard, which will result in significant wind energy development. The energy cost is turning out to be lower than expected, especially with the recent increase in the price of natural gas.

Two PA utilities, PECO and PP&L have a 2% RPS that increases annually by 0.5% unless the RPS increases costs by more than 2%. These were included in the settlement with the two utilities that was made after the law was passed.

Nevada has a "solar" portfolio standard, which requires that a small percentage of the electricity sold come from solar-generated electricity. Nevada's RPS began at 0.2% of total consumption, rising to 1% by 2010. Half of this is to be obtained from solar energy sources.

Disclosure & Certification Programs



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Most states that have put a restructuring law in place have included a provision for some type of consumer disclosure in their legislation. This generally includes a requirement for disclosure of price, terms and environmental characteristics of the electricity contracted for.

States Requiring Disclosure

- By Legislation
  - AZ -CT
  - OR -MA
  - ME
  - MT
  - NV
  - IL
  - CA
  - PA
  - TX
- By Commission
  - VT
  - RI
  - NH
  - NY
  - NJ
  - CO
  - NY

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State Approaches to Disclosure and Certification

- CA: coal, large and small hydro (<or>30MW) nat.gas, nuke, biomass waste, geothermal, solar and wind.
  - To be renewable no more than 25% fossil;
  - "Green-e" brand for at least 50% renewable.
- MA: CO_2, NO_x, SO_2, heavy metals
- CO: state hasn't restructured but requires utilities to divulge price of G,T&D and source; no emissions b/c not equitable

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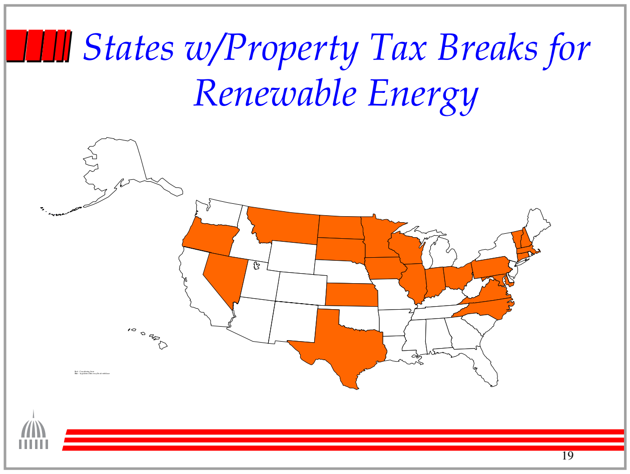
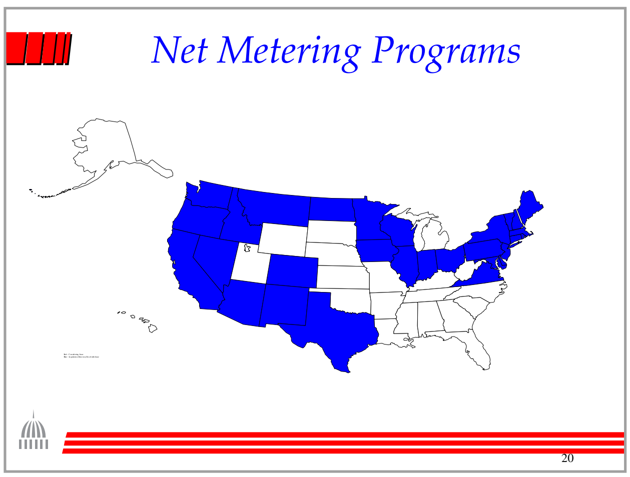
Colorado is an example of a state that has put this requirement in place that has not passed a restructuring law.

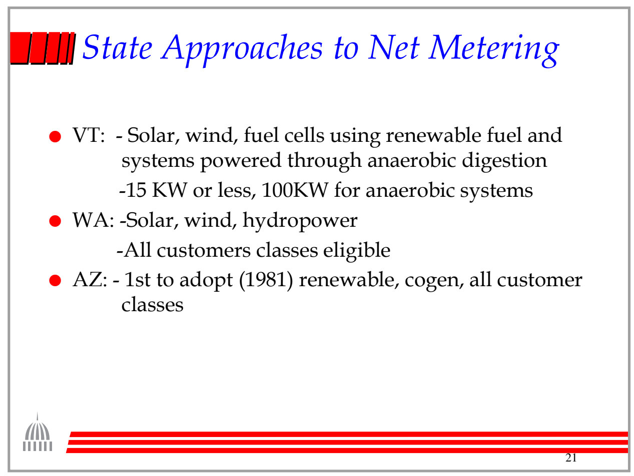


Property tax breaks can come in a number of forms, including some type of reduction in the assessed value of the property (i.e. assessing it a lower-than-typical percent of its true value) or perhaps classifying certain types of wind energy property as non-taxable (i.e. perhaps not taxing the foundation or tower but taxing the turbine itself, as in Minnesota).

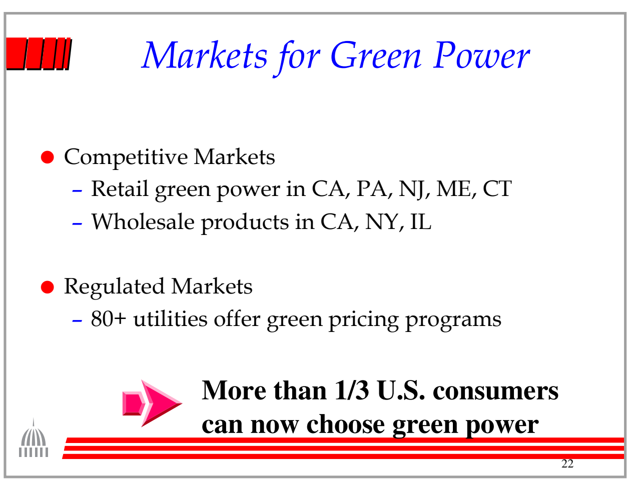
The reason that we need to be "thoughtful" and perhaps wary of property tax breaks for wind in particular, is that you don't want to lose community support for the wind development. Most developers I've talked to don't really suggest big property tax breaks for wind.

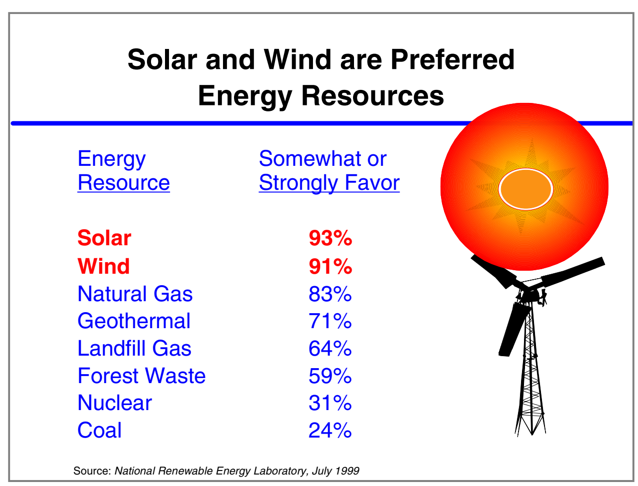
Net metering allows small renewable power generators to sell electricity back to their utility at the retail electric rate. In essence it means these customers can “run the meter backwards.” If a consumer who buys electricity at 8 cents per kWh installs solar panels on his/her roof that consumer can sell electricity back to the utility when not using it at 8 cents per kWh.

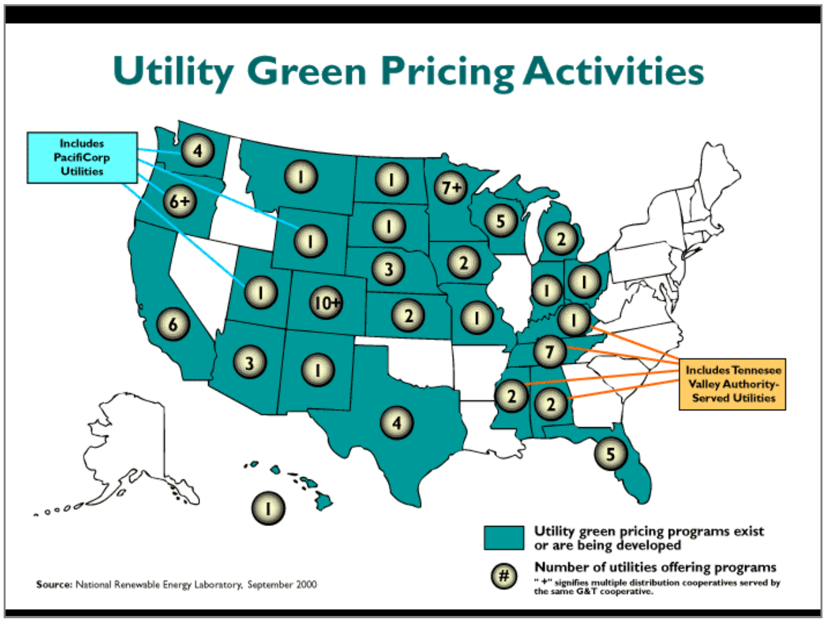




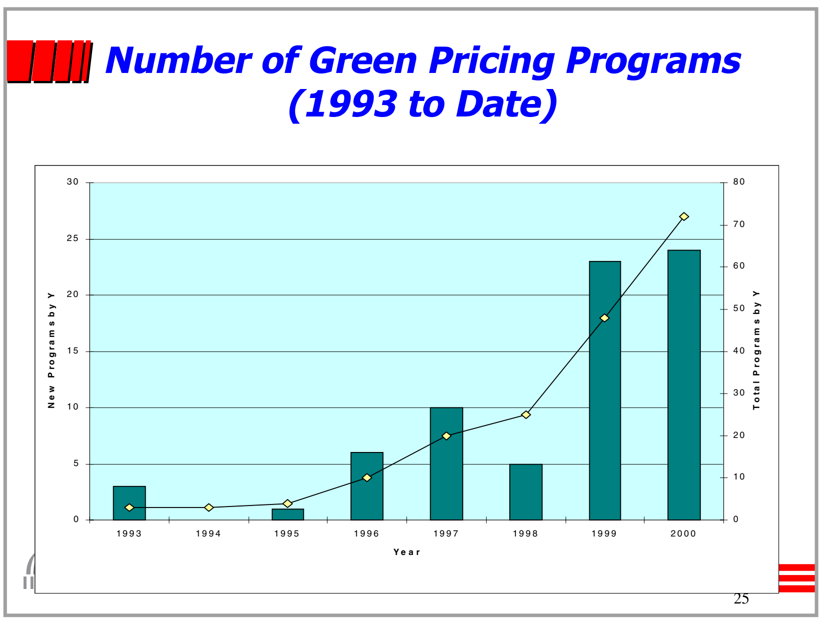
30 states now have a net metering law of some kind in place. This is usually, but not always, done as part of a larger electricity restructuring law. The rules usually give an upper limit to the size of a qualifying installation (Delaware and Oregon, for instance, qualify systems up to 25 kW). They also specify what type of resources qualify for the program.



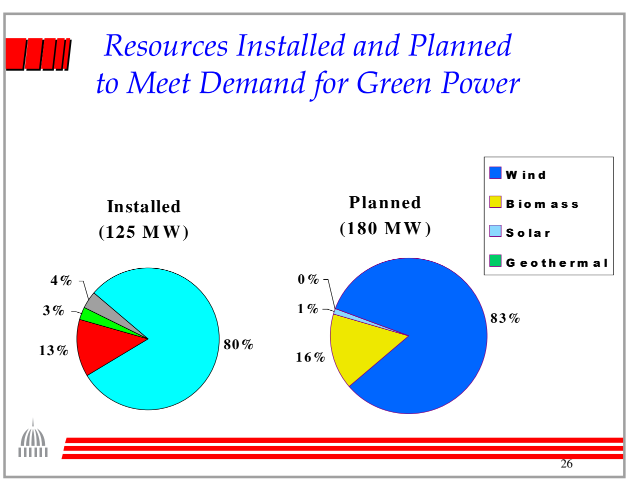


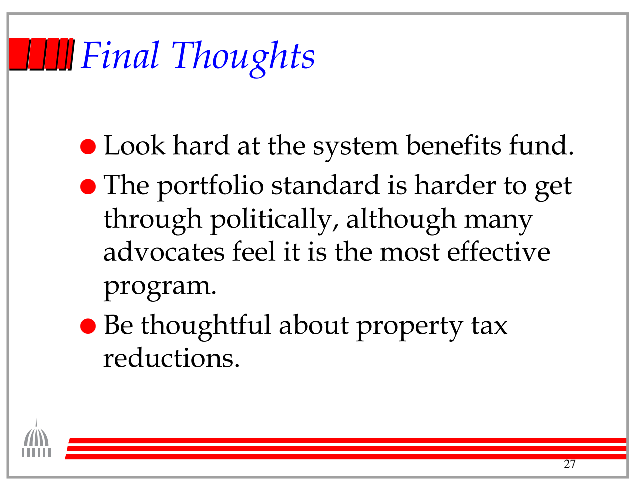


Many utilities offer green pricing programs. Green pricing programs allow customers to choose "green" power sources, and to pay a premium for the service.



The number of green pricing programs has been increasing. In some cases, customers are on "waiting lists" while new renewable energy projects are developed to meet the demand.





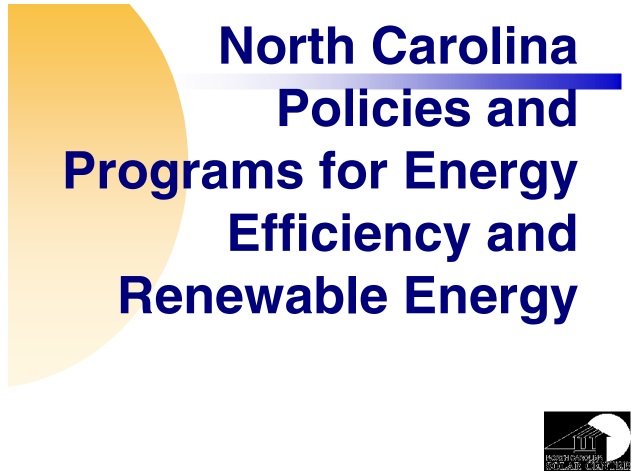
Robert McGuffey

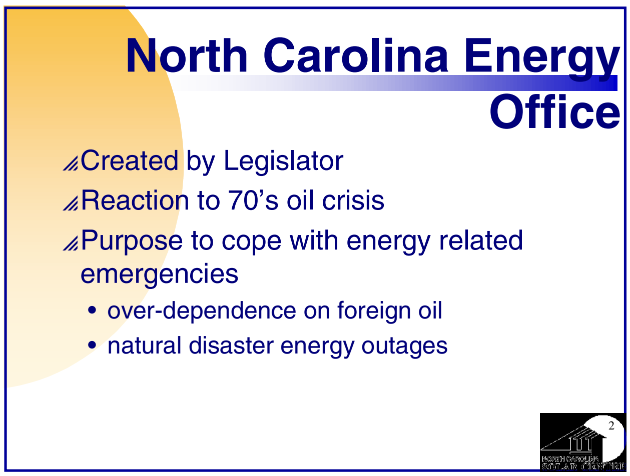
Solar Engineering Specialist
North Carolina Solar Center, North Carolina State University

Mr. McGuffey has worked since 1995 in commercial and industrial energy conservation outreach with both the Industrial Assessment Center and the North Carolina Solar Center. During that time, he has participated in industrial audits with the Industrial Assessment Center and has conducted commercial and industrial audits for the North Carolina Solar Center going to more than 50 facilities. He has managed the Solar Center's Commercial Industrial Program for the last 4 years. In parallel with his commercial and industrial outreach work, he has been working on other research projects. He conducted a commercial, industrial study for the National Renewable Energy Laboratory. He and Mr. Stevens have been testing a roof integrated concentrated solar collector system for Duke Solar. He has worked with this project at North Carolina State University and at Sandia National Laboratory in New Mexico. Prior to joining the North Carolina Solar Center staff, he had 20 years work experience in the compressed air and petroleum industries.

North Carolina Policies and Programs for Energy Efficiency and Renewable Energy

Presentation by Robert McGuffey, Solar Engineering Specialist with the North Carolina Solar Center of the University of North Carolina.





The Energy Division was created by the N.C. Legislature to help North Carolinians cope with energy-related emergencies – emergencies that can arise from an over-dependence on foreign oil or from energy outages created by natural disasters.

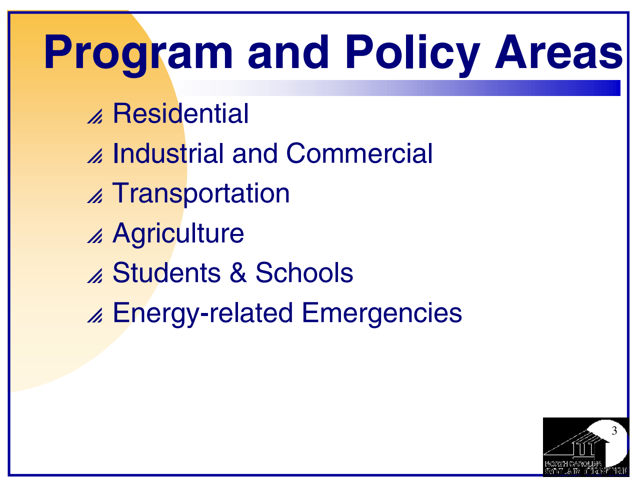
The Division has pioneered a series of programs to develop newer and better technologies that preserve our fuel supplies while helping to protect the environment. Division programs have provided direct assistance to people in every one of the state's 100 counties, helping families and individuals save on energy bills.

Residential –The Energy Office provides workshops, seminars, brochures, manuals and other sources of information to help reduce spending on heating and cooling.

Industrial and Commercial – Find out about energy audits, steam trap surveys, humidity control, motor efficiency and other technologies that help small and large business cut operating costs.

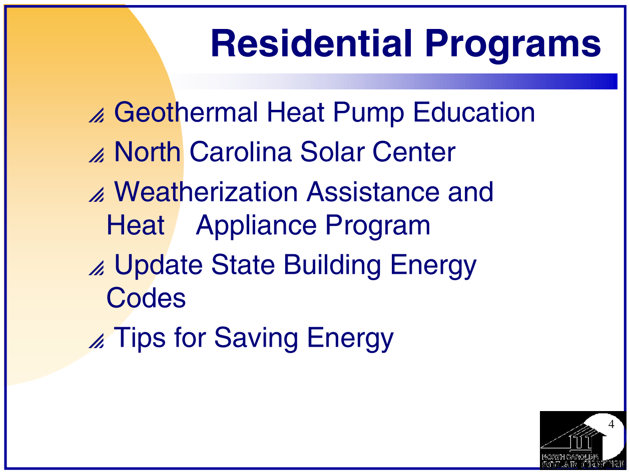
Transportation– Our transportation system is on the brink of dramatic changes. Find out about alternative fuel vehicles, electric cars, fuel cells, and other changes coming down the road.

Agriculture – Our programs range from fish barns and preventive maintenance to biomass and postharvest technologies. The bottom line is increased profits for North Carolina farmers.



Students & Schools – Topics include science facts, school construction, daylighting, student energy patrols and success stories of schools that have saved taxpayers big money on energy costs.

Energy-related Emergencies – Tips and guidelines on what to do in energy-related emergencies created by hurricanes, tornadoes, snowstorms, ice storms, extreme heat and other forms of severe weather.



Of the program areas mentioned above, the Residential and Industrial-Commercial offer the most opportunities for energy efficiency recommendations and renewable energy applications.

Energy Division residential programs apply new technologies, provide assistance to residents, and encourage the adoption of energy conservation and renewable technologies.

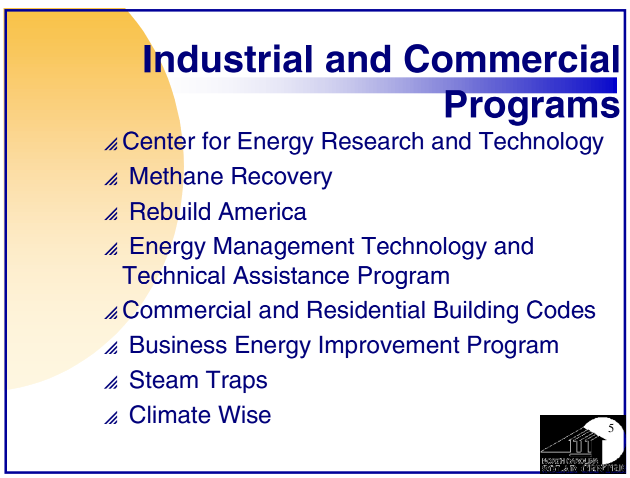
Geothermal Heat Pump Education - educational opportunities and materials that describe residential geothermal heat pumps.

NC Solar Center serves as a clearinghouse for information, technical assistance and education on solar and renewable energy technologies.

Weatherization provides funds to local community action agencies for the purchase and installation of insulation, weatherstripping and other weatherization improvements Repair and Replacement Program (HARRP), offers assistance to families to repair, replace, or perform energy conservation.

Building Energy Codes - Workshops will be developed and presented throughout the state on the N.C. Residential Energy Codes. The building code is a simplified version of the 1995 Model Energy Code (MEC), and it is mandatory statewide. Training is provided for building professionals – such as code inspectors, architects, engineers, builders, and insulation contractors – to ensure that residences in North Carolina are energy efficient.

Tips for Saving Energy - Energy Division staff has assembled a list of energy-saving practices that will help you save energy and lower your utility bills. Recommendations are listed for winter and summer seasons. Refer to the Publications section for printed information and web-based articles.



Center for Energy Research and Technology – The Center for Energy Research and Technology at N.C. A&T State University is researching energy use and energy efficiency in buildings and industrial processes.

Methane Recovery – The Division has led several methane-recovery efforts that have helped curtail the release of the greenhouse gas into the environment and led to technologies that use methane for fuel.

Rebuild America – The program helps municipalities offset the trend of declining downtowns through cooperative local efforts that boost downtown business. Help includes funding and technical assistance.

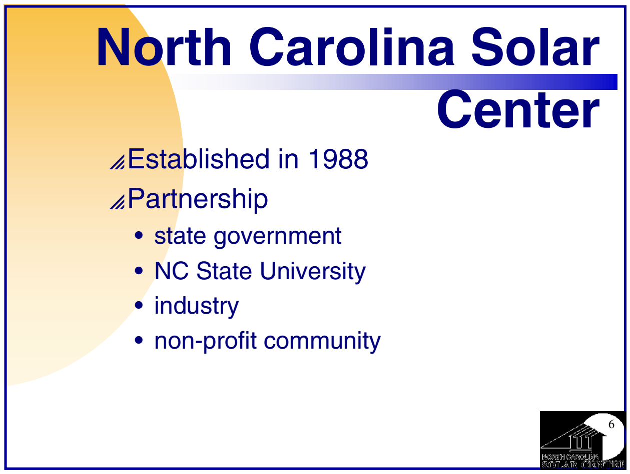
Energy Management Technology and Technical Assistance Program – For the commercial and industrial sector, the program, located at the Industrial Extension Service at North Carolina State University, helps facility managers and maintenance supervisors reduce operating costs.

Commercial and Residential Building Codes – Workshops help builders, contractors, building code officials, developers and design professionals learn the latest in energy technologies and techniques.

Business Energy Improvement Program – The loan program helps businesses make building improvements that produce a quick energy-savings return on the money invested.

Steam Traps – With the state's industrial base in mind, the Division designed a steam trap program that helps companies identify energy trouble spots in the production process. Companies in the state have been able to reduce their steam losses, which often add dramatically to a company's energy costs.

Climate Wise –A coalition of state and federal government agencies, the Climate Wise Program aims to protect the environment by encouraging businesses to take part in projects that improve energy efficiency and waste reduction, while cutting back on energy bills dramatically.



Founded in 1988, the North Carolina Solar Center represents a unique partnership between state government, NC State University and the solar industry and nonprofit community. Recognizing the need for a central clearinghouse that could assist the state's citizens in using solar energy, these three entities joined together to launch the Center with sponsorship from the Energy Division of the NC Department of Commerce.

Dedicated on October 17, 1988, in a formal ceremony at the NCSU Solar House, the Center's educational showcase facility, the Center opened up with an aggressive set of programs to serve professionals and the public. Among other U.S. universities and state agencies, its comprehensive array of outreach and extension services quickly vaulted it to recognition as one of the premiere solar centers in the country.

In the decade since its founding, the Center has grown and developed into an organization with diverse capabilities and services. While serving North Carolinians will always be its first priority, the Center now operates a number of national and international programs. These range from hosting the nation's database of incentives for renewable energy to providing technical assistance to other states for utility interconnection of photovoltaic systems. Internationally, the Center has installed photovoltaic systems on schools in a rural region in Bolivia, the poorest of all South American nations.

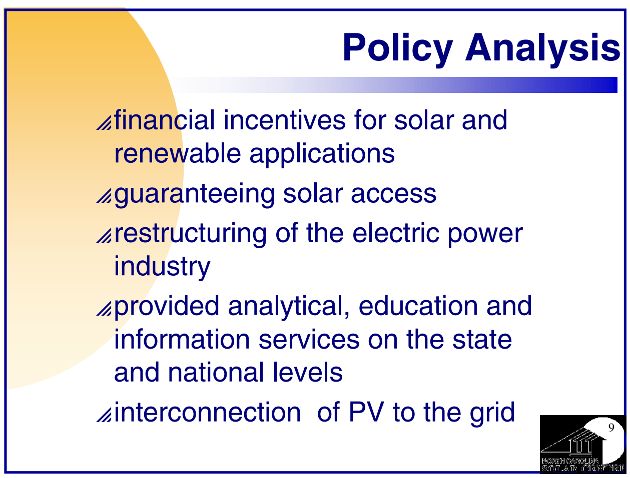
McKimmon Center-NC State University Center for Continuing Education located on the NC State University campus.

NC Solar House-Constructed in 1981, built by NC State Engineering Department, showcase facility for education, demonstration and research.

Research Annex-With the advent of a research program, the Center received approval from the University to create a Solar Research Annex, adjacent to the NCSU Solar House, that could be used for research and testing purposes.

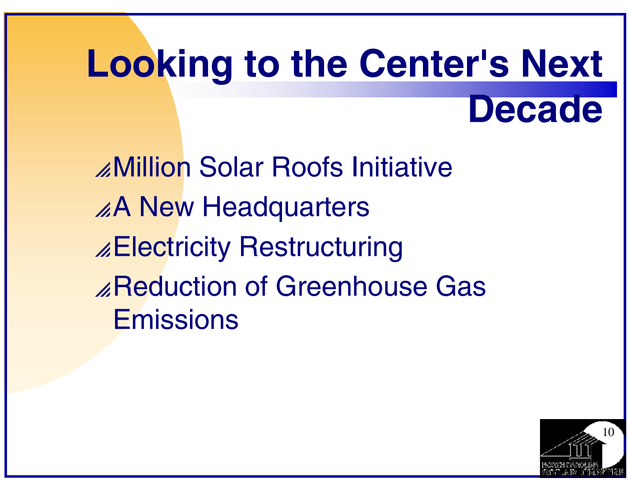
Electric Vehicle Garage & Solar Charging Station-the center has received a grant from the NC Department on Environment and Natural Resources, Mobil Source Emissions Section to combined solar charging station, electric vehicle and alternative fuel vehicle demonstration facility next to the NC Solar House.

NC Solar House - Open to the public six days a week, the Solar House provides tours for numerous professional, civic and educational groups each year. In 1998, more than 20,000 people visited the facility from around the world.
Outreach and Extension - Information is available through a tool-free hot line, publications and videos, web site, solar home tours and exhibits at events and conferences.
Research and Development - Testing and evaluating building-integrated photovoltaic systems catalyzed the development of a research program at the Solar Center in 1995. Testing of the *Power Roof*, a large solar thermal system intended for location on industrial rooftops and to provide process heat, absorption cooling and electricity.
Education and Training - Since its formation, the Center has concentrated a large portion of its resources on training professionals and providing educational opportunities for decision-makers and the public to learn about solar energy.
International Programs - The Center's first project was to install photovoltaic systems on 15 rural schools in the Alalay region in the Andes Mountains, in Bolivia.
Demonstrating Solar Technology In trying new technologies and showing them to the public, the Center has provided leadership in designing, installing and monitoring a number of systems around the state.
Policy Analysis In the policy arena, the Solar Center has provided analytical, education and information services on the state and national levels.



In North Carolina, the Center has analyzed the potential impacts of electricity restructuring on renewable energy and energy efficiency, under contract to the NC Solar Energy Association, and made recommendations on how renewable energy could be advanced in a competitive electricity marketplace. This work has led to presentations before the NC Utilities Commission, the Study Commission on the Future of Electric Power, and numerous other organizations.

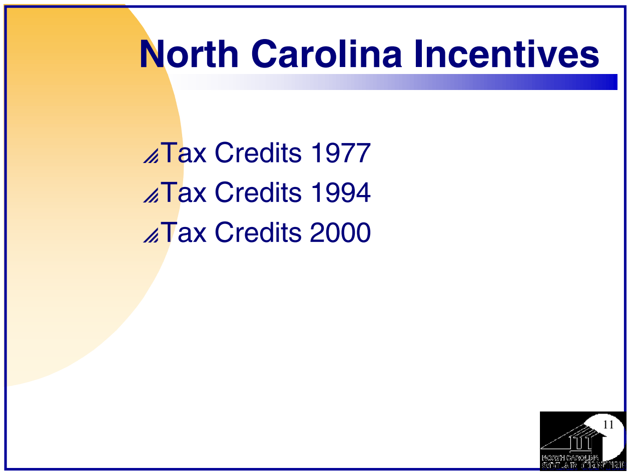
On the state level, the Center has also assisted the NC Department of Revenue in revising the guidelines for the state tax credits and assessing the potential revenue impacts of proposed changes in the credits. And, the Center has conducted research on the steps that will be needed for the state to reach its goal of obtaining 20% of its energy from renewable resources by 2010.



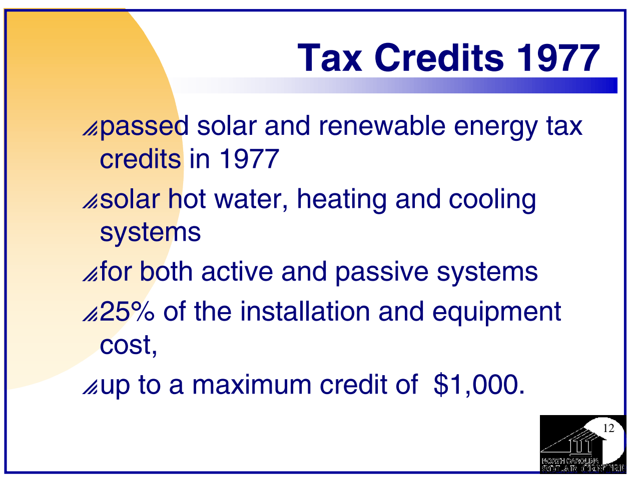
Million Solar Roofs Initiative…North Carolina is a new Partner is this national drive to install 1 million solar systems on rooftops by 2010. The Solar Center will be leading this effort, working with communities throughout the state to develop local programs and get installations in place.
A New Headquarters…the Solar Center has outgrown its quarters in the McKimmon Center and must seek shelter for its rapidly expanding programs.

Electricity Restructuring…with wholesale competition in place nationwide and more than 60% of the nation's population living in states that have decided let consumers choose their electricity providers, retail competition in North Carolina could occur within the next several years. Such an event could open the door to the generation of electricity from renewable resources and, if North Carolina follows the lead of a number of other states, could result in the creation of a Public Benefits Fund or Renewable Portfolio Standard to accelerate the development of renewable energy in our state.

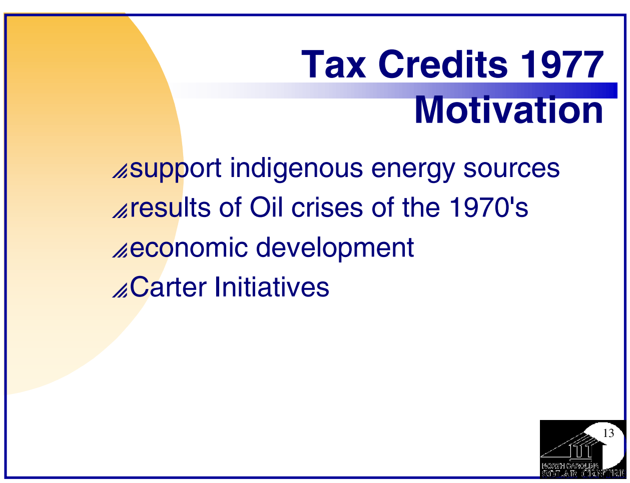
Reduction of Greenhouse Gas Emissions…the Kyoto Treaty on Climate Change calls the industrialized nations to reduce their greenhouse gas emissions by 7% below the nation's 1990 levels by 2008. Already, the U.S. is 7% above this number and still climbing. If the U.S. ratifies the Kyoto Treaty or chooses to tackle global warming with a major reduction in these emissions, then renewable energy will be called upon to provide increasingly larger shares of our state's energy needs.



The North Carolina General Assembly originally passed solar and renewable energy tax credits in 1977, spurred by the need to support indigenous energy sources as a result of the Oil crises of the 1970's. North Carolina joined many other states and the Federal government in making tax incentives for solar available.

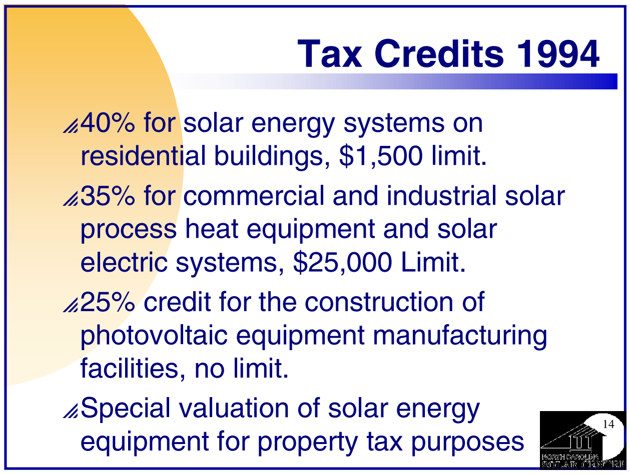


A tax credit was established for installing solar hot water, heating and cooling systems in any building in North Carolina. The credit was for both active and passive systems. The credit limit was 25% of the installation and equipment cost, up to a maximum credit of $1,000.



Tax incentives were used for the purpose of economic development by luring renewable energy industry to the state to build product for the renewable energy sector with existing industry.

The Carter Initiatives were the moral equivalency of war. "Energy will be the immediate test of our ability to unite this nation," Carter said. "It can also be the standard around which we rally. On the battlefield of energy we can win for our nation a new confidence and we can seize control again for our common destiny."

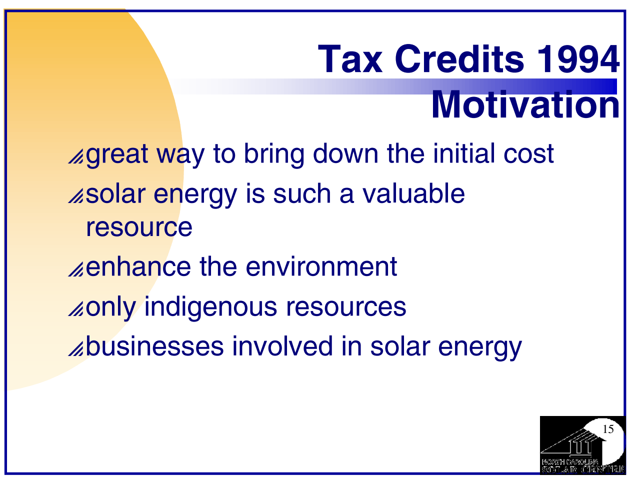


Solar systems on residential buildings The most frequently used solar tax provision was the 40% credit for residential buildings. This credit was for 40% of the cost of the system up to $1,500 and is applicable to both the personal and corporate income taxes.

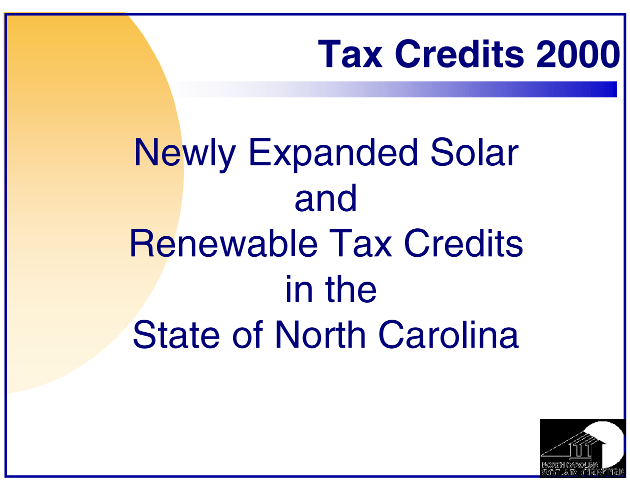
Commercial and Industrial Tax Credit A business could claim a 35% credit up to a maximum of $25,000 for the cost associated with the installation and equipment for active, passive or solar electric systems. This credit provided significant savings for a business looking to implement a solar application.

PV Manufacturers Credit In addition to the 35% corporate tax credit for solar installations to provide heat or electricity, North Carolina offered a corporate income tax credit to manufacturers of photovoltaic systems. The credit was equal to 25% of the construction and equipment costs of a photovoltaic manufacturing facility. There was no maximum limit to the credit.

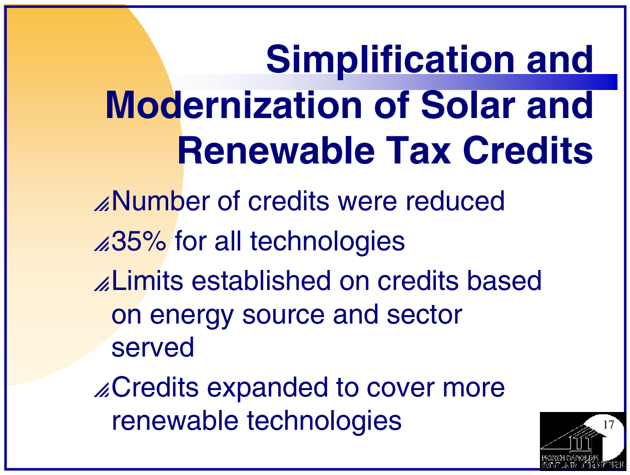
Special Valuation for Property Taxes This property tax exclusion allows for active solar heating and cooling systems to be assessed at not more than the value of a conventional heating or cooling system for the purposes of property taxation. This applies only to active solar systems and does not include any land or structural elements of buildings such as walls and roofs. Specifically, a "system" includes all controls, tanks, pumps, heat exchangers and other equipment used directly and exclusively for the conversion of solar energy for heating or cooling. Residential, commercial, and industrial property is eligible for this exclusion.



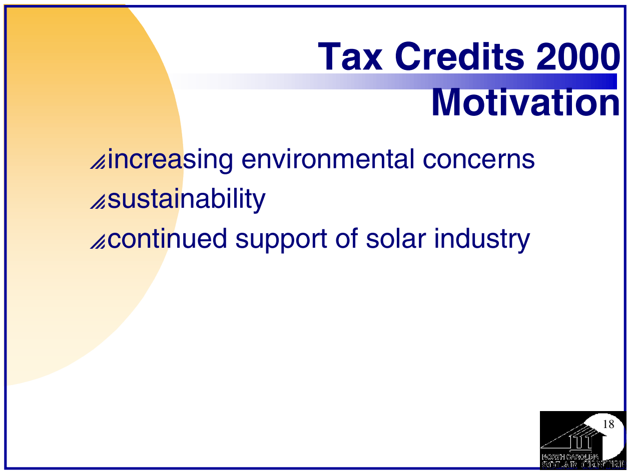
The tax credits are a great way to bring down the initial cost of a solar energy system for your home or business. This is important in North Carolina where solar energy is such a valuable resource. Not only does solar energy enhance the environment by reducing emissions associated with electricity generation, but using solar energy and other renewable resources is taking advantage of North Carolina's only indigenous resources – while there is no coal or natural gas found in North Carolina, renewable energy resources are abundant. It is also important for the state to support solar energy because there are many North Carolina businesses involved in solar energy.



To simplify and modernize the North Carolina tax credits for solar and other renewable energy sources, new legislation was enacted in the 1999 legislative session.



Fourteen different credits were eliminated and replaced by one general credit that covered residential and non-residential solar and other renewable energy property. A credit of 35% was established for all renewable energy sources, with the maximum limits varying by renewable energy resource or technology, and by residential or non-residential sectors.

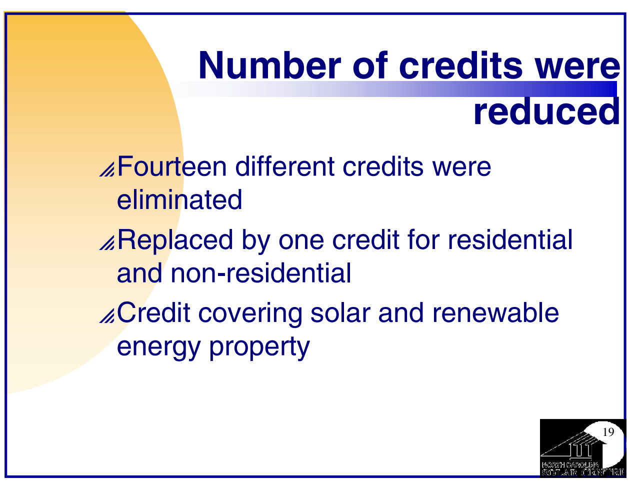


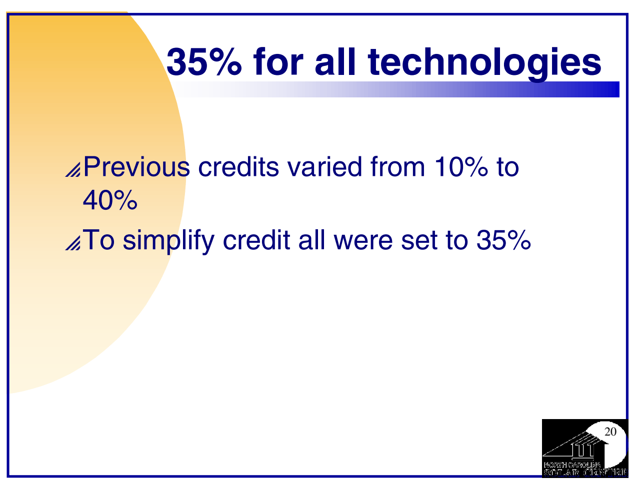
The motivations that drove the continuation of the credits in 1994 are still the same in 2000, but with a growing increase in the concerns for the environment and sustainability of industry and the economy.

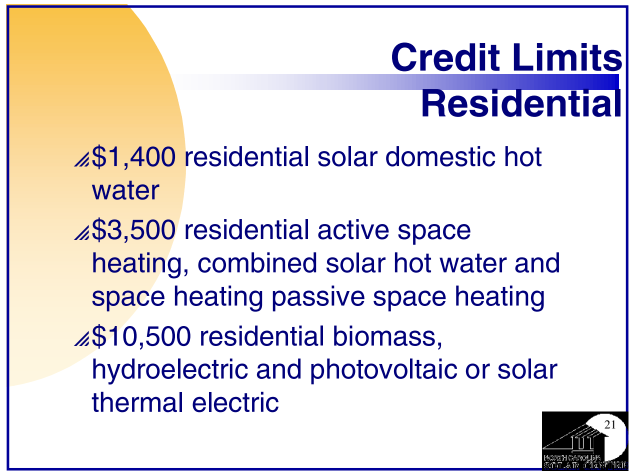
The solar and renewable industries continue to grow in the state with the aid of the renewable tax credits. These credits are essential to help build the infrastructure the industry needs to become sustainable.

Fourteen different credits were eliminated and replaced by one general credit that covered residential and non-residential solar and other renewable energy property

- Residential active, passive solar thermal and solar electric were 40% to $1500
- Commercial active, passive solar thermal and solar electric were 35% to $25,000
- Hydro 10% to $5,000
- Wind 10% to $1,000

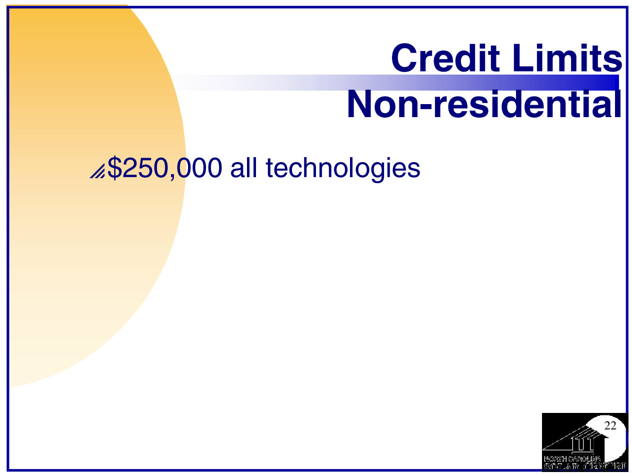




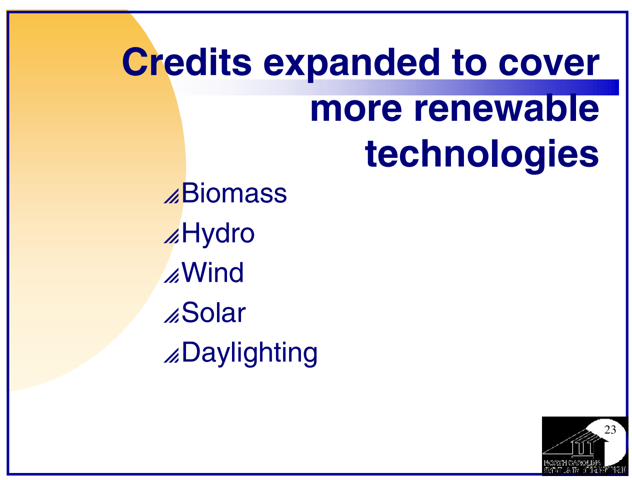


- Biomass: 35%, limit $10,500 Per Installation
- Hydroelectric: 35%, limit $10,500 Per Installation
- Solar Energy Equipment for Domestic Water Heating: 35%, limit $1,400 Per Dwelling Unit

- Solar Energy Equipment for Active Space Heating: 35%, limit $3,500 Per Dwelling Unit
- Solar Energy Equipment for Combined Active Space and Domestic Hot Water Systems: 35%, limit $3,500 Per Dwelling Unit
- Solar Energy Equipment for Passive Space Heating: 35%, limit $3,500 Per Dwelling Unit
- Solar Energy (Systems not covered by the $1,400 and $3,500 credit): 35%, limit $10,500 Per Installation
- Wind: 35%, limit $10,500 Per Installation

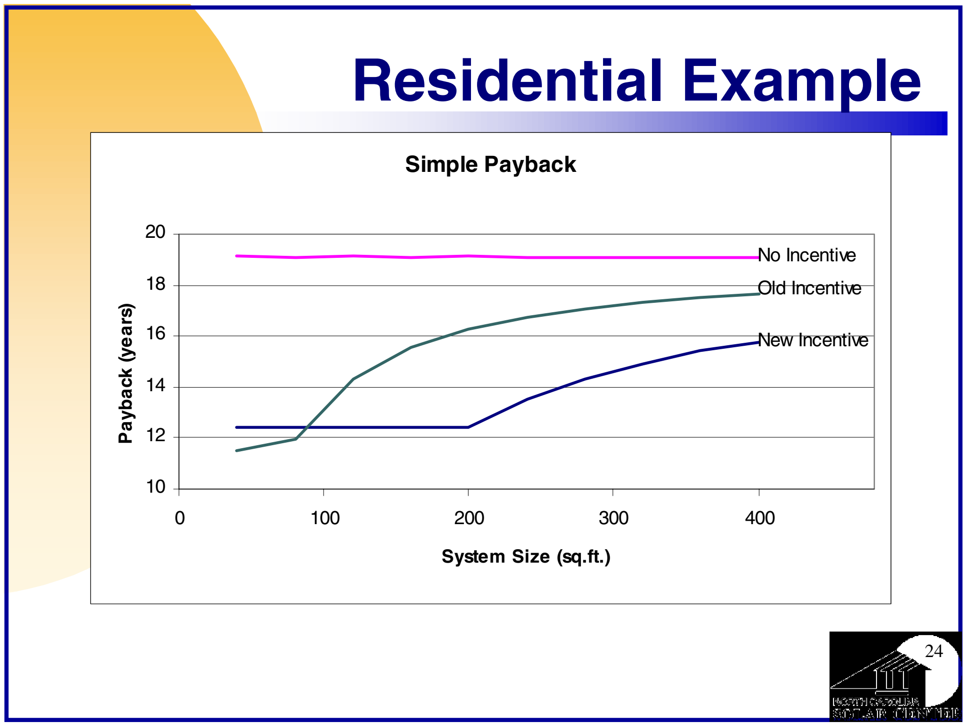


- Biomass: 35% to $250,000 Per Installation
- Hydroelectric: 35% to $250,000 Per Installation
- Solar Energy Equipment for Domestic Water Heating: 35% to $250,000 Per Installation
- Solar Energy Equipment for Active Space Heating: 35% to $250,000 Per Installation
- Solar Energy Equipment for Combined Active Space and Domestic Hot Water Systems: 35% to $250,000 Per Installation
- Solar Energy Equipment for Daylighting: 35% to $250,000 Per Installation
- Solar Energy Equipment for Solar Electric or Other Solar Thermal Applications: 35% to
- $250,000 Per Installation
- Wind: 35% to $250,000 Per Installation



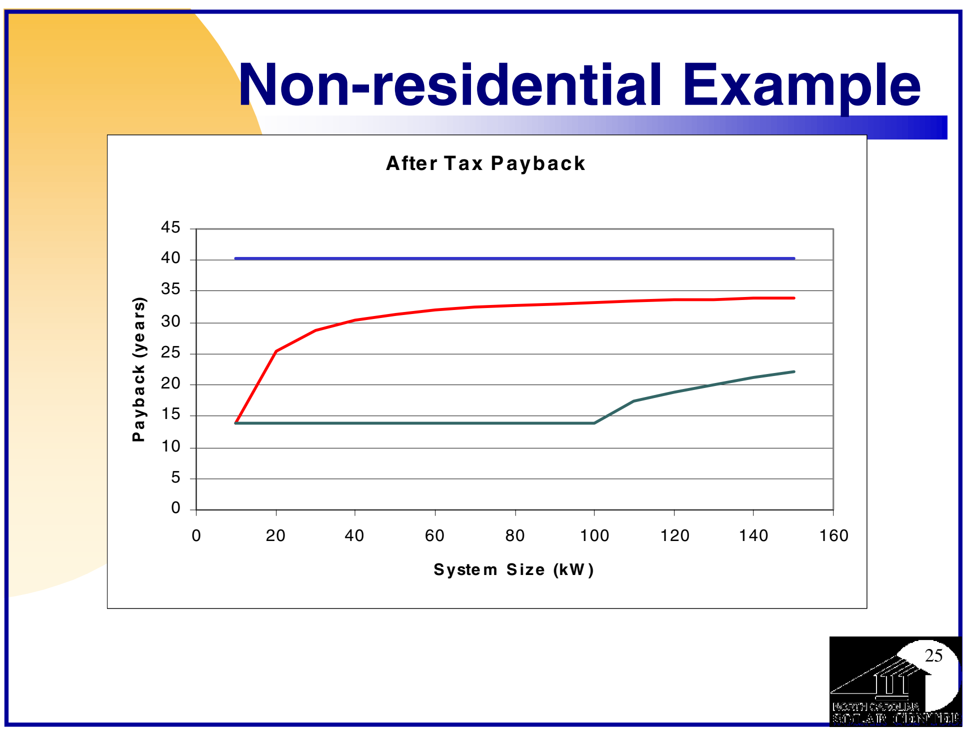
More renewable technologies are now included.
Biomass: 100% of the cost of biomass equipment that uses renewable biomass resources for biofuel production of ethanol, methanol, and biodiesel; anaerobic biogas production of methane utilizing agricultural and animal waste or garbage; or commercial thermal or electrical generation from renewable energy crops or wood waste materials. The term also includes related devices for converting, conditioning, and storing the liquid fuels, gas, and electricity produced with biomass equipment, including installation cost.
Hydro: 100% of the cost of equipment to generate electricity at an existing dam or free-flowing waterway, including related devices to convert, condition or store the electricity, including installation cost.
Wind: 100% of the cost of equipment to generate electricity or mechanical power from wind energy, including related devices for converting, conditioning, and storing the electricity produced, including installation cost.
Solar: 100% of the cost of collectors, storage, controls and heat exchangers used for solar system only, including installation cost.

Daylighting: 100% of the cost of lighting controls, vertical roof monitors, baffles, lightshelves, lightshelf glazing, advanced daylighting glazing, roof monitor glazing and daylighting transport systems, including installation cost.



Residential Example

The effect on the simple payback by the changes in the tax incentives is shown for solar energy equipment used for active space heating, calculated at an estimated cost of $50 per square foot, used to replace electric resistance heating. The simple paybacks on systems with collector areas from 40 square feet to 400 square feet were compared with no tax incentives, the old tax incentive of 40% (with a $1,500 limit), and the new tax incentive of 35% (with a $3,500 limit).



Industrial and Commercial Example

This graph shows the effect on the simple payback by the changes in the tax incentives if solar energy equipment, at an estimated cost of $7 per watt, is used to produce electricity to replace electricity from the grid. The after tax paybacks on systems with collector areas from 10 kW to 150 kW were compared with no tax incentives, the old tax incentive of 35% (with a $25,000 limit), and the new tax incentive of 35% with a $250,000 limit. The after tax payback in the graph also takes into account the 10% Federal tax credit and 5 year accelerated depreciation.

Michael L. Neary

Executive Director, Arizona Solar Energy Industries Association

Michael Neary is principal of Desert Sun Solar, Inc., which has been involved in a variety of activities in the solar industry for the past fifteen years. Mr. Neary acts as executive director of the Arizona chapter of the Solar Energy Industries Association (SEIA) and has worked with local solar companies on marketing, product development, and meeting national standards, such as the Solar Rating and Certification Corporation's (SRCC's) OG-300 rating for solar water heating systems.

He is a registered lobbyist in the state of Arizona and has recently worked towards passage of legislation in that state, including the state's solar tax credit, sales tax exemption, reduced tax rates for utility solar and renewable power generation facilities and other measures that benefit solar and renewables. He has also worked towards the adoption of a renewable energy portfolio standard and support for homeowners' rights to install solar energy systems on their residences.

In addition to his activities for the Solar Energy Industries Association, Mr. Neary was appointed by Governor Jane D. Hull to Arizona's Solar Advisory Council and is on the Board of Directors of the Arizona Solar Energy Association, the Arizona Chapter of the American Solar Energy Society (ASES). Mr. Neary has written extensively on codes, covenants, and restrictions (CC&R) issues, and spearheaded efforts to develop a national Strategy and Action Plan directed to the problems of CC&Rs.

Arizona Public Policy - Solar and Renewable Energy

Michael Neary

Arizona Solar Energy Industries Association

For approximately seven years, the Arizona Solar Energy Industries Association (ARISEIA) and the Concerned Arizonans for Renewable Energy (CARE) have been actively working on legislation that creates positive public policy promoting greater use of solar and renewable energy in Arizona.

Two public bodies in the state of Arizona have the authority to approve measures that support good public policy related to solar and renewable energy in the state of Arizona:

- Arizona Corporation Commission: Responsible for the regulation of public service corporations
- Arizona Legislature: Branch of state government that creates laws related to solar and renewables

Arizona Corporation Commission

Regulates Public Service Corporations

Arizona Legislature

Creates laws related to solar and renewables

2

Arizona Corporation Commission

Renewable Energy Portfolio Standard benefits solar and renewable energy in Arizona's electric industry restructuring process by requiring a small percentage of the electricity provided consumers be generated from solar resources.

3

The Arizona Corporation Commission recently adopted a Renewable Energy Portfolio Standard which benefits solar and renewable energy in Arizona's electric industry restructuring process by requiring a small percentage of the electricity provided consumers be generated from solar resources.

Renewable Energy Portfolio Standard Docket R14-2-1609

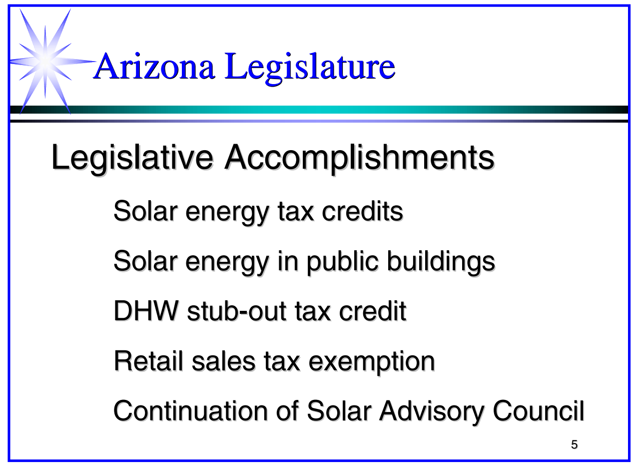
2001	0.2%
2002	0.4%
2003	0.6%
2004	0.8%
2005 -12	1.0%

50% Solar electric

50% Other clean renewables, including solar thermal water heating

4

In recent years, a bipartisan effort so pass legislation supportive of solar and renewable energy has been successful in the passage of the following measures:



Solar energy tax credits
The tax credit allows a direct credit of 25% of the cost of the system with a $1000 maximum. The credit may be carried forward for a period of five years.

Solar energy in public buildings
This bill requires the state of Arizona to use any solar or renewable energy application, including passive design, that has a direct pay back of seven years or less when remodeling or building state buildings.

DHW stub-out tax credit
Allows home builders a credit of $75 to “stub out”, or install, transport lines for solar water heating systems and/or a 220V electrical line to be used for electric vehicle recharging.

Retail sales tax exemption
Extended a sales tax exemption for solar retail companies.

Continuation of Solar Advisory Council
Extended the life of the Solar Advisory Council, a body of solar experts that advises the Arizona Department of Commerce, Energy Office in matters related to solar and renewable energy.

Contractors sales tax exemption
Included solar contractors in the exemption of solar taxes for solar systems.

Energy efficient homes tax deduction
Created a income tax deduction for the building of energy efficient homes. The top ten percent of energy efficient homes in a given year will qualify for a $5000 income tax deduction.

Utility Tax Valuation
Equalizes the property taxes paid by utilities on solar and renewable energy power plants with that of a traditional power plant.

2001 Legislative agenda

Deed restrictions/CC&R’s-strengthen current law
One of the major barriers to the installation of residential solar thermal and PV systems in Arizona’s metropolitan areas are restrictions placed on rooftop solar installations by builders and developers in the Conditions, Covenants and Restrictions (CC&R’s) that are placed on homes in planned communities. Arizona’s Legislature passed a law in 1979 prohibiting such restrictions, but the law is largely ignored by developers.

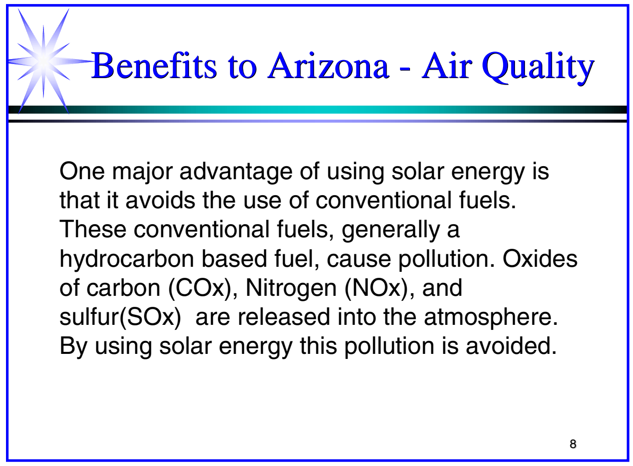
Commercial solar tax credit
In recent sessions, legislation has been introduced that would allow a commercial credit of 25% of the cost of a solar system with a $5000 maximum.

Funding for solar energy projects/programs

In order to increase promotion of solar and renewable energy to the public and to promote Arizona as prime location for solar and renewable energy companies, legislation has been introduce to provide the Arizona Department of Commerce, Energy Office with $300,000 a year for a two year period.

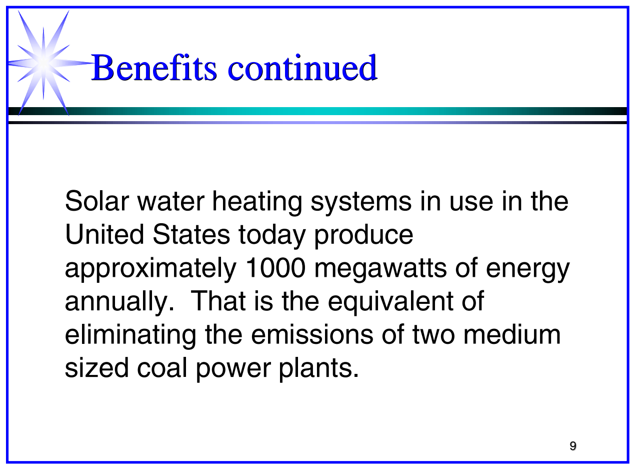
SOLAR ENERGY AIR QUALITY BENEFITS TO ARIZONA

Over 1.5 million Americans have invested in solar, mostly hot water systems for their homes and businesses. Surveys taken over the last ten years confirm that the vast majority of owners (94% or more) consider that investment a wise decision. Enough energy falls on every Arizona household every day to more than meet the energy needs of that house. Developing that resource would benefit Arizona both economically and environmentally. The opportunity exists to develop that resource and make Arizona a leader in solar technology.

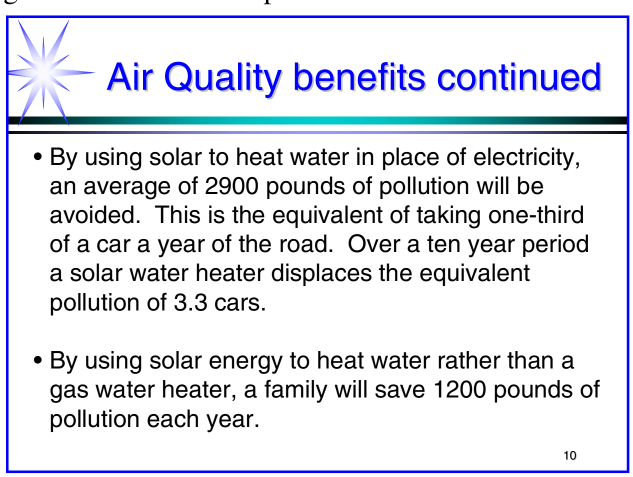


AIR QUALITY BENEFITS

- Solar energy is pollution free.
- Solar water heating systems in use in the United States today produce approximately 1000 megawatts of energy annually. That is the equivalent eliminating the emissions of two medium sized coal power plants.
- One major advantage of using solar energy is that it avoids the use of conventional fuels. These conventional fuels, generally a hydrocarbon based fuel, cause pollution, oxides of carbon (COx), Nitrogen (NOx), and sulfur(SOx) are released into the atmosphere. By using solar energy this pollution is avoided.

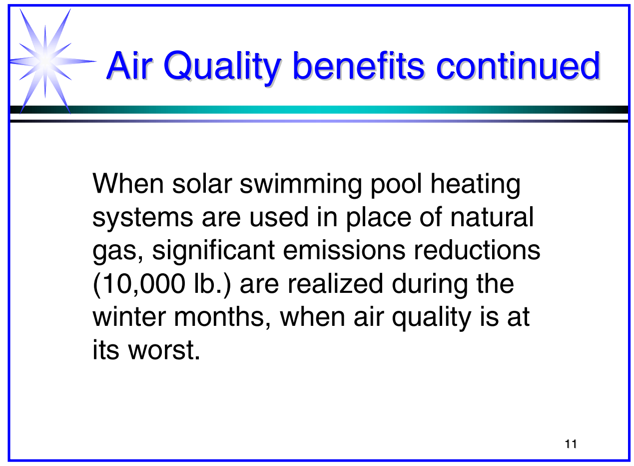


- By using solar to heat water rather than electricity, a family will keep an average of 2900 pounds of pollution from entering our atmosphere each year.
- By using solar energy to heat water, rather than a gas water heater, a family will save 1200 pounds of pollution each year. When solar energy replaces gas water heaters the pollution avoided is site based. These and the above figures are based on 55% of a 70 gallon per day load at 120 degrees. The vast majority of solar water heating systems in Arizona will supply 95% of that load, increasing the air quality benefits.
- Most solar DHW system users are able to supply 100% of their hot water from April through October. Arizona's current solar tax credit provides for a 25% credit with a $1000 maximum allowable credit. The new generation of solar water heating systems provide long term service, performance and reliability. The Arizona Department of Commerce, Energy Office, in consultation with the solar industry, has adopted standards to insure that all domestic solar water heating systems installed in Arizona are certified by a third party meet the highest standards for quality and performance. To insure the highest standards for installation,



the solar industry in conjunction with the Arizona Department of Commerce, Energy Office has developed a program for the certification of installers of solar water heating systems. The majority of solar thermal technicians in Arizona are certified. The infrastructure for a major solar DHW industry is in place.

- Improving the energy efficiency of Arizona's commercial and residential buildings through passive solar design will have a beneficial impact on air quality. Passive solar design in new construction will reduce the energy consumption of Arizona's housing stock with little or no additional costs. Simple solar orientation of a house will result in a 15% energy reduction. Properly orienting a subdivision will cost approximately $1.00 per lot.



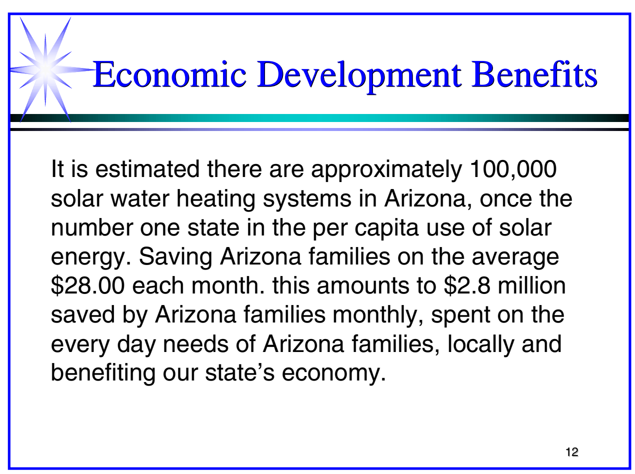
- Arizona's Energy Policy, which was developed at the request of the legislature in 1988, through the input of hundreds of Arizona citizens, makes solar energy the number one priority. In 1995, a survey of Arizona adult heads of households found that 95% would be willing to pay more for electricity if it came from a cleaner resources. Over half of that group would be willing to pay $7 per month more for electricity.

- The U.S. Department of Energy's Million Roof Initiative plans on installing one million solar systems in the United States by the year 2010. This will be accomplished through low interest long term loans and planned buy downs of photovoltaics. Arizona is a natural location to take advantage of the program to install solar water heating systems.

- Electric utility restructuring offers opportunities to improve air quality with solar energy. The Solar Portfolio Standard calls for electric service providers to obtain one half of one percent of their electricity from solar in 1999 and one percent by the year 2003. Based on the maximum cost of 30 cents per kWh for a solar resource this would increase the average residential customer's bill by 18 cents in 1999 and $1.80 per month in 2003. Currently the Sacramento Municipal Power District (SMUD) is installing solar electric resources for less than 20 cents per kWh. A systems benefit charge will also be created to benefit renewable technologies. The use of system benefits charge funds to facilitate the installation of solar would provide additional incentives for consumers and businesses to use solar.

ECONOMIC BENEFITS

- By the end of the Federal solar tax credit Arizona was the number one state in the per capita use of solar energy.
- By some estimates there are approximately one-hundred thousand solar water heating systems in service in Arizona. These systems save Arizona families on the average $28.00 each month. This amounts to 2.8 million dollars that is saved by Arizona families every month. This money is spent on the every day needs of Arizona families.



- Money saved with solar is kept in our community. Input/output analysis demonstrates that each $1.00 spent to acquire energy resources from outside a community generates only $0.33 of economic activity within the community. However each $1.00 spent within the community produces, through the economic multiplier effect, about $1.67 of local economic activity.

Economic Development Benefits Continued

Money saved with solar is kept in our community.

- Input/output analysis demonstrates that each $1.00 spent to acquire energy resources from outside a community generates only $0.33 of economic activity within the community.
- However, each $1.00 spent within the community produces, through the economic multiplier effect, about $1.67 of local economic activity.

13

- The investment in solar and energy-efficient technology increases local economic activity three ways. First local businesses that sell solar and energy conserving goods and services benefit directly. Second, a regenerative cycle is created when funds realized through energy savings in businesses are reinvested in the businesses, Third, lower utility bills for commercial and residential energy consumers result in increased profits and disposable income. With all three effects much of the profit or money saved will be spent locally.

Economic Development Benefits Continued

Local businesses that sell and use solar and energy conserving goods and services benefit directly. A regenerative cycle is created when funds realized through energy savings are reinvested in the business. Also, lower utility bills for commercial and residential energy consumers result in increased profits and disposable income, with money spent locally.

14

- The Arizona solar industry is a potential job creator. The solar product industry and portions of the solar construction industry are labor intensive in nature since there is use of local materials and equipment manufactured in the state. Installation and maintenance of systems has the potential for the creation of hundreds of jobs.

Economic Development Benefits Continued

The Arizona solar industry is a potential job creator. The solar industry and portions of the solar construction industry are labor intensive in nature and there is use of local materials and equipment manufactured in the state.

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15

Solar Industry Recommendations - Arizona

- Develop programs and additional incentives to promote the use of cost effective solar and renewable energy technology.
- Pass legislation to create a commercial tax credit.
- End deed restrictions and CC&R's against the installation of residential solar heating systems.

16

Solar Industry Recommendations - Arizona

- Make use of the electric utility restructuring process to promote the installation of all solar technologies.
- Take advantage of and promote the Department of Energy's Million Rooftop initiative to install solar in Arizona.

17

Peter Dreyfuss

Deputy Chief of Staff, U. S. Department of Energy
Office of Energy Efficiency and Renewable Energy

Peter Dreyfuss is Deputy Chief of Staff to the Assistant Secretary for the Office of Energy Efficiency and Renewable Energy at the U.S. Department of Energy. This Office develops and deploys efficient and clean energy technologies that meet our nation's energy needs, enhance our environment and strengthen our national competitiveness. He was appointed to this position in the Spring of 1999.

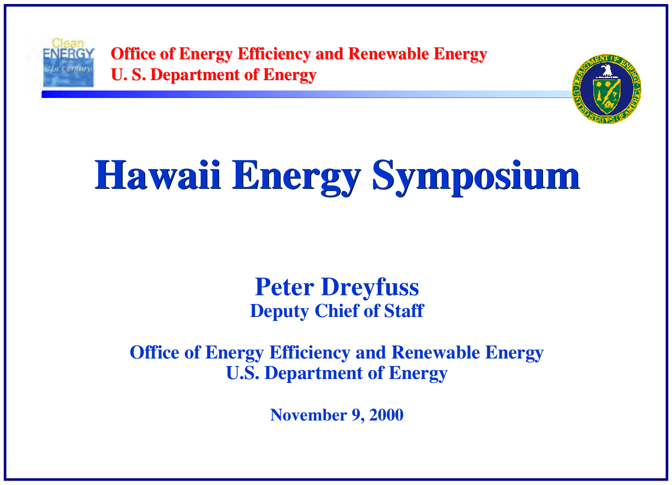
In the summer of 1997, he was appointed a Special Assistant at the U.S. Department of Energy to work in the area of energy efficiency and renewable energy with a focus on enhancement of DOE's community programs, serving as the senior advisor on community programs. He is the DOE staff representative to the President's Community Empowerment Board. In the Fall of 1997, he was also appointed National Coordinator of the President's Million Solar Roofs Initiative, a strategy to place solar energy systems on the roofs of one million U.S. buildings by 2010.

Dreyfuss has worked for nearly thirty years in the human services and community development area and for the past twenty years in energy efficiency, transportation and environmental programs.

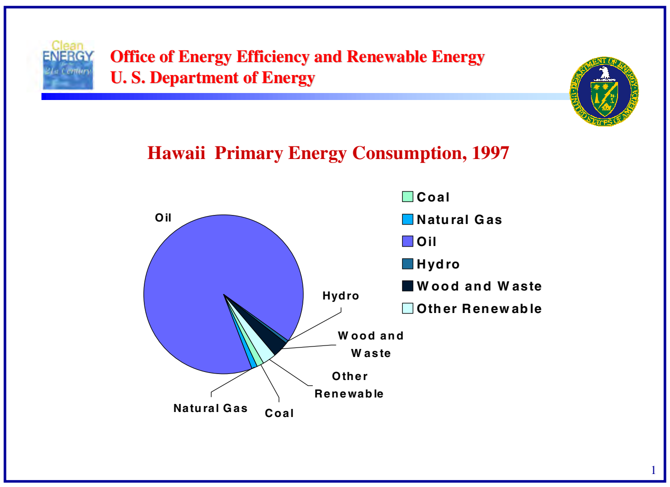
Dreyfuss has been involved in numerous local, state and national efforts. Nationally, he served on the National Renewable Energy Laboratory's State and Local Advisory Board; the Surface Transportation Policy Project's advisory committee on local involvement in transportation; DOE's working group on the Weatherization Assistance Program; and United Way of America's Energy Advisory Committee.

At the state level, he was Chair of the Missouri Governor's Energy Future Coalition; chair of the Missouri Highway and Transportation Department's Environmental Committee; and was a member of the Governor's Environmental Education Commission. Dreyfuss was also the principal author of the *Missouri Statewide Energy Study*, completed in 1993 and principal consultant for *Economic Opportunities Through Energy Efficiency,* a report to the Missouri Legislature in 1994.

At the local level, while in Kansas City, Dreyfuss was involved in numerous civic endeavors including the local Environment and Energy Commission, the Housing Information Center, Mid America Assistance Coalition, Kansas City Spirit Festival; Greater Kansas City Chamber of Commerce; Kansas City FOCUS strategic planning effort; and he served as chairman of the citizen's advisory committee to the local metropolitan planning organization.

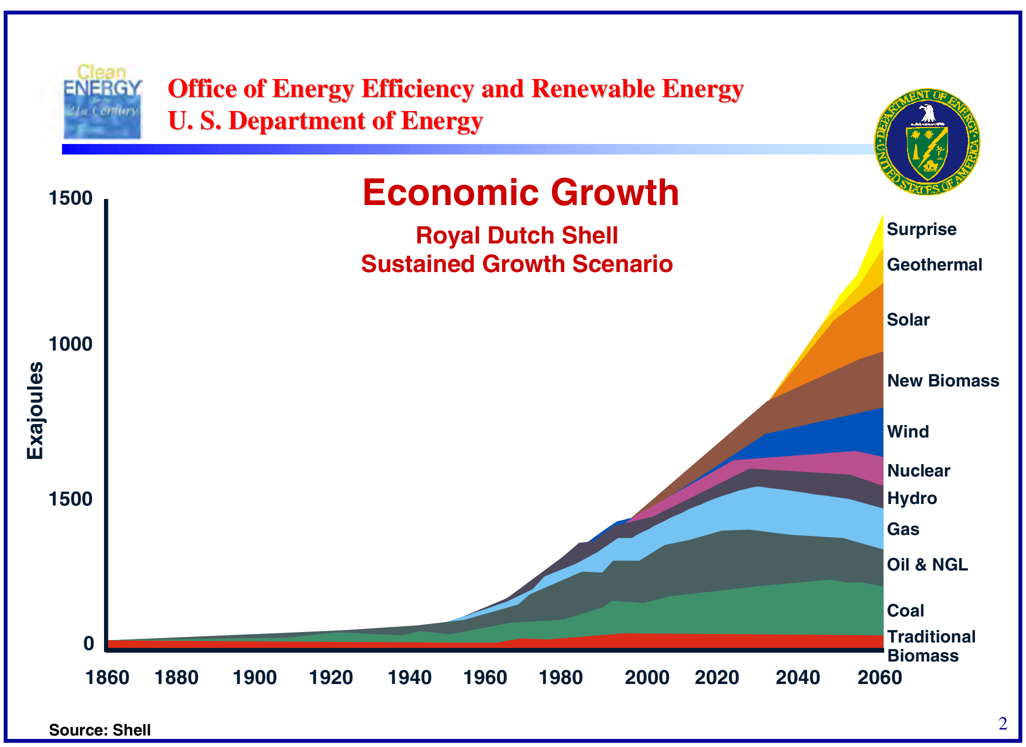


Thank you for inviting me here today.



As shown in the chart, Hawaii is heavily dependent on oil for energy.

(Source: EIA State Energy Data Report 1997, Table 83. Energy Consumption Estimates by Source, Selected Years 1960-1997, Hawaii.)



This is how Shell expects world energy needs to grow and to be met over the next several decades. Note the projected decline in oil and natural gas and the increase in renewable energy, particularly solar.

Note that they've even got "surprise" there up at the top, to account for some kind of technological breakthrough.

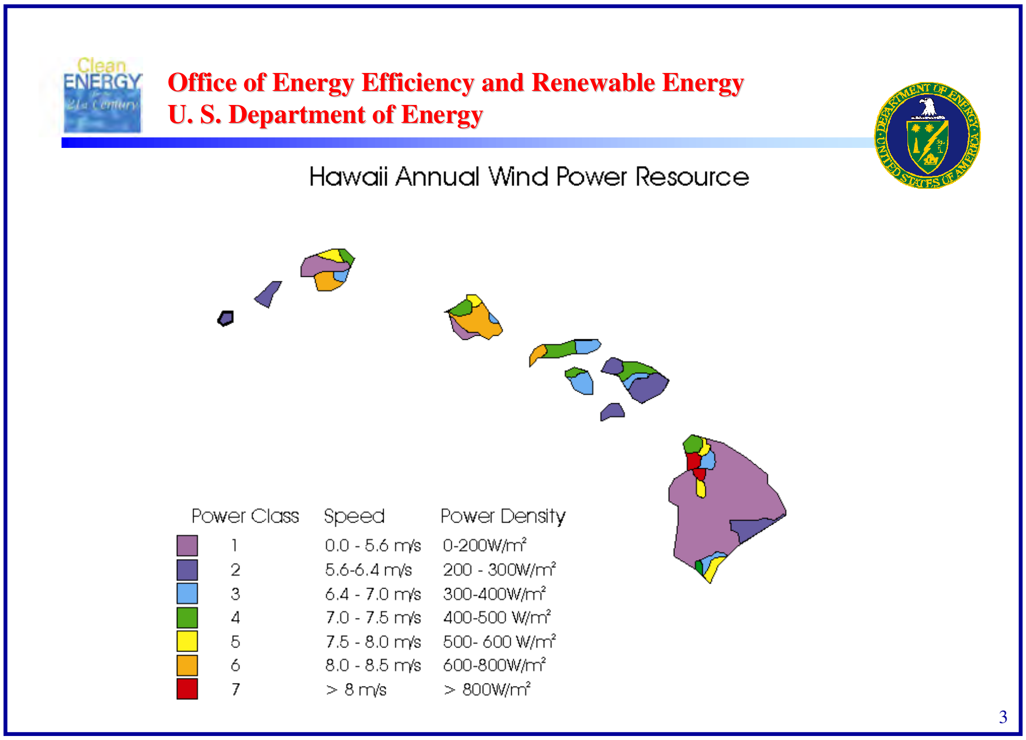
Wind

Hawaii has a significant wind resource.

The teal and green areas are class 3 and 4, which are fair to good resources with wind speeds that range from 14.3 to 16.8 mph.

The orange areas are excellent wind resources, with wind speeds measuring between 16.8 and 17.9 mph, mostly on the crests of ridges.

The red areas have outstanding wind speeds, between 17.9 and 19.7 mph. (Wind speeds are at heights of 50 m. Source: http://www.NREL.gov/wind/usmaps.html)

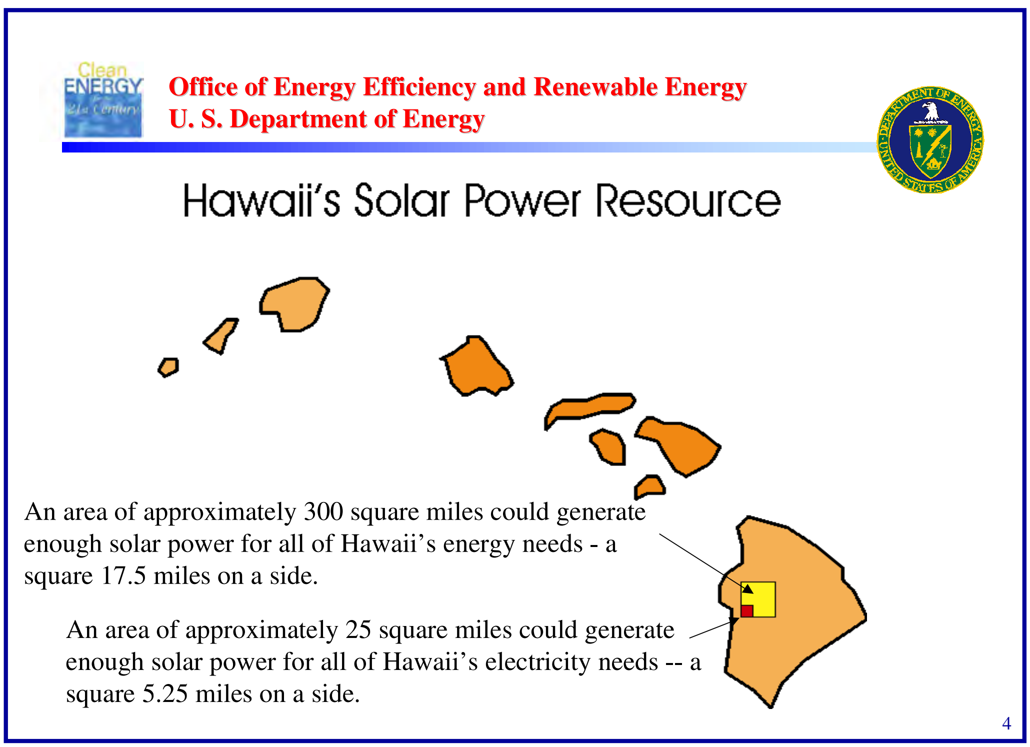


Solar

Almost 90% of the country receives between 6 and 8 kWh/m2 per day, plenty for effective use of PV.

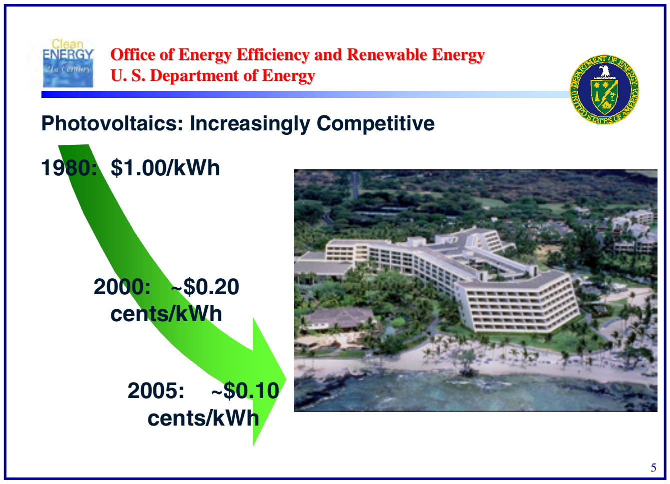
All of Hawaii is in the 6 to 8 range.

A relatively small square just 5.25 miles on a side could generate the equivalent of all of your electricity use -- with PV operating at just 10% efficiency.



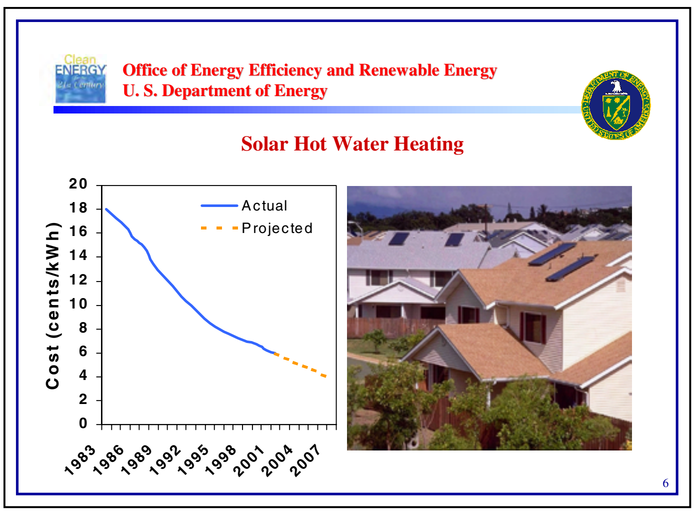
A square just 17.6 miles on a side could supply the equivalent of all of your energy use. It wouldn't even have to be on land -- a floating square this size would do the trick, or an area broken up into a few thousand roof-size systems. You're already on the way with 8,516 roofs.

The amount of sunlight available in a certain place each year allows us to calculate how much energy can be converted into electricity. There is approximately 2 to 3 megawatt hours per year of sunlight on each square meter of the U.S., depending on location. In total the U.S. receives $2.4X10^{16}$ kWh of electricity per year, more than 10,000 times our annual energy use. Resource is average daily solar radiation per month, annual average for a 2-axis flat-plate PV system. On an average day, the U.S. receives approximately 5 to 9 kW for each square meter of exposed area. Las Vegas, for example, receives 9.7 kWh/m2; Boston receives approximately 5.3. Using a distributed approach with systems installed on buildings, vacant land, and parking lots the same result could be achieved with PV in every state. (Source: NREL Resource Assessment Program, www.rredc.nrel.gov/solar)

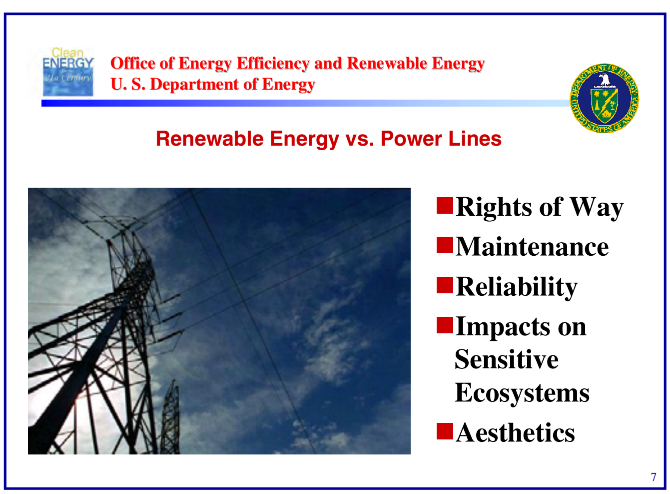


Here's the rooftop photovoltaic system on the Mauna Lani hotel.

Photovoltaics are becoming increasingly cost competitive.



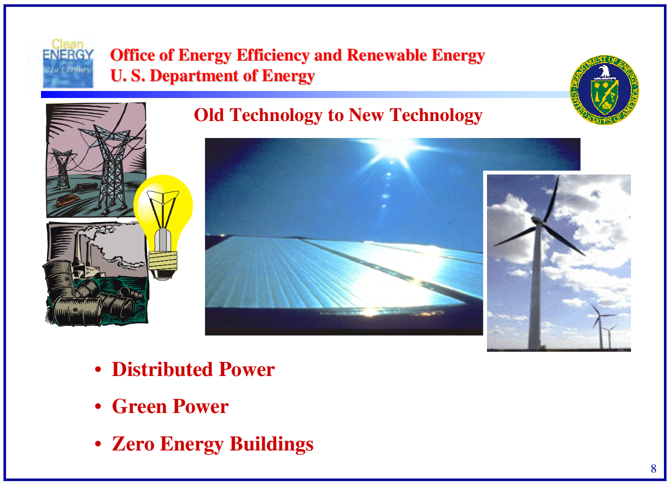
In partnership with the Hawaiian Electric Company, the U.S. Navy installed 136 solar water-heating systems on residences in its Moanalua Terrace family housing project. Each system offsets about 1.7 tons of carbon dioxide, 8.2 pounds of sulfur dioxide, and 11.2 pounds of nitrogen oxide every year. Funding to help pay for the project was provided by the U.S. Department of Energy Federal Energy Management Program, which helps agencies reduce their costs, increase energy efficiency, use renewable energy, and conserve water.



Power Lines...

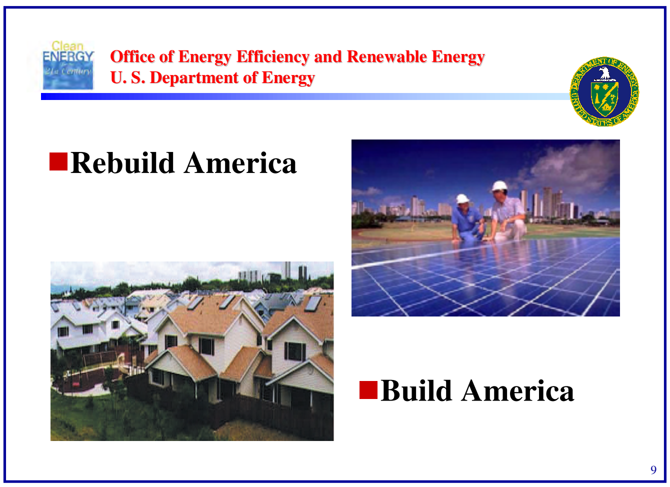
Utilities spend millions of dollars to chop down trees and spray herbicides in order to build power lines. It costs billions more to maintain power lines and their rights of way.

Many renewable energy technologies can be placed on-site in sensitive areas where power lines would be inappropriate.



There is an ongoing shift from old technology to new technology. The old technology was central station power, with power lines. The new technologies include distributed generation, green power, and zero energy buildings.

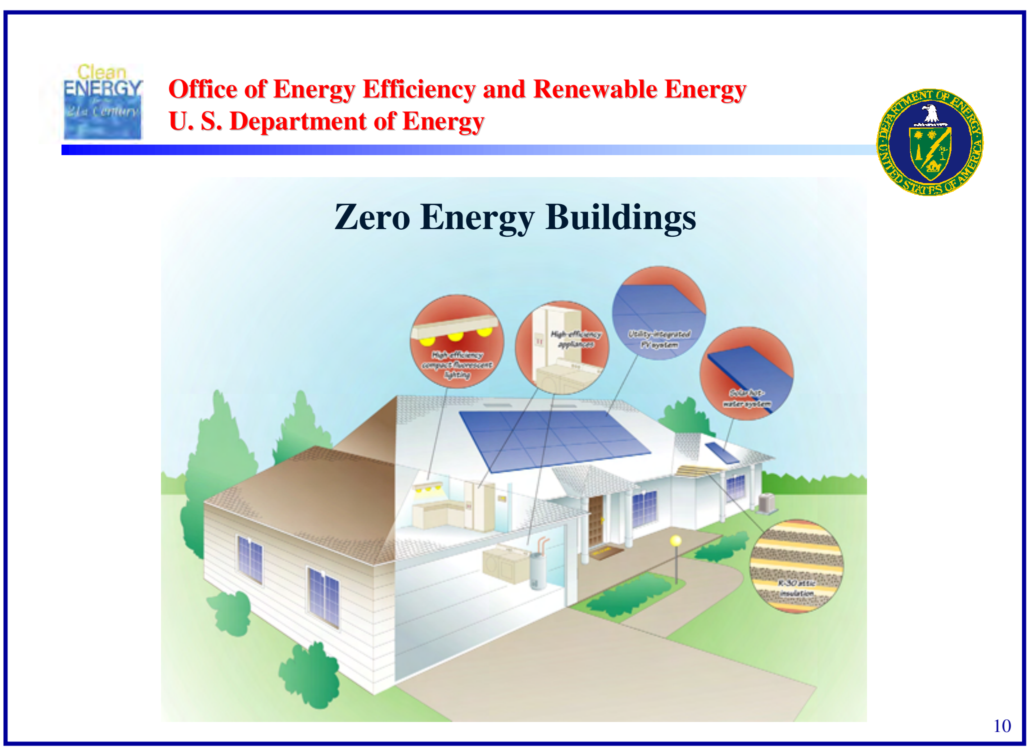
Whole-Building Approach



Rebuild America – 300 partnerships to date; Retrofits of 510 million sf; saving 10.8 trillion Btu and $170 million/year.

Right side: Hawaiian Electric Company (HECO) and its subsidiaries launched the Sun Power for Schools program in late 1996. The program is a green pricing program that forms a three-way partnership between the utilities, the State of Hawaii Department of Education, and electric utility customers. In July 1997, Sun Power for Schools made its first installation, a two-kilowatt PV system installed on the roof of the Kaimuki High School gymnasium. In addition to the Kaimuki High School installation, the Sun Power for Schools program has installed a number of other PV systems on schools on Oahu, Maui and Hawaii.

Build America – Industry-led, cost-shared program to use systems engineering to reduce energy use, construction time, and construction waste by as much as 50%. Lower left: Moanalua Terrace.



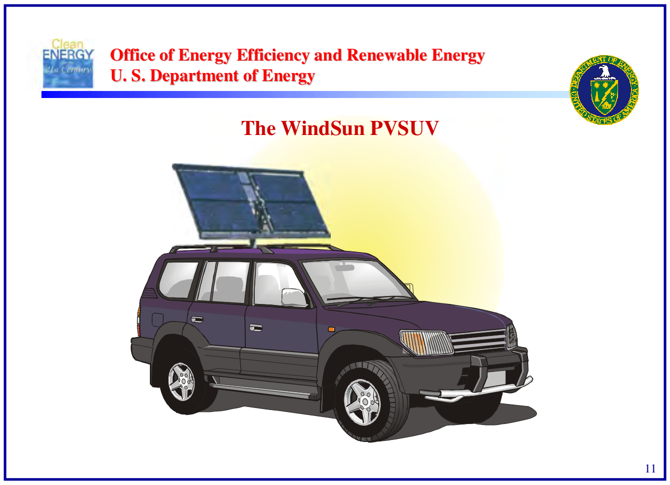
Solar Buildings Vision

By the year 2020, there will be constructed, in the United States, a significant number of buildings that:

- meet their own energy needs by utilizing solar or other renewable resources,
- have no on-site or off-site carbon emissions,
- reduce utility peak electrical demand,
- optimize the health and productivity of their occupants, and
- provide energy security from natural disasters and extended power outages.

The Opportunity:

Several DOE and electric utility energy efficiency programs carried out in the 1990s have demonstrated cost-effective new buildings with 60%–80% overall annual energy savings compared with energy-code compliant base case buildings. Continuing improvements in the energy performance of building enclosures, glazings, lighting systems, HVAC systems, controls, and office equipment can further reduce new building energy requirements. With reduced building loads, solar technologies can offer the opportunity to achieve “zero net annual energy use” in new buildings. In fact, some zero net energy (ZNE) buildings have already been completed; however, the challenge is to achieve cost-effective and affordable ZNE buildings. Clearly, widespread construction of ZNE buildings would also contribute significantly to U.S. economic and environmental health.



And here's the answer for transportation. (Just kidding.)

Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Million Solar Roofs Goals

- Create approximately 70,000 new high-tech jobs by 2010
- Slow greenhouse gas emissions by using clean energy from the sun
- Keep the U.S. companies competitive in the world market

12

Million Solar Roofs Initiative

- Announced by President Clinton, June 26, 1997, in address to United Nations Session on Environment and Development
- Announcement of Million Solar Roofs by Energy Secretary Peña, June 27, 1997
- White House directs agencies to prepare plans and information on programs they can use to support the Initiative
- Made into a line item in FY99 Appropriations

Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Million Solar Roofs Technologies

- Photovoltaics
  - Residential .5 kW
  - Schools and Churches 1 kW
  - Commercial 2 kW
- Solar Thermal Water Heating
  - Residential domestic 1 kW or 20 ft^2
  - Residential pool heating 100 ft^2
  - Commercial domestic 2.0 kW or 40 ft^2
  - Commercial pool heating 400 ft^2
- Solar Thermal Space Heating
  - 4.0 kW or 100 ft^2

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Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Million Solar Roofs Fundamentals

- Bottom-up: State and Local Partnerships
- Top-down: Federal Programs and Barrier Removal Activities
- State, Local and Federal Cooperation
- Flexibility, Innovation and Adaptation

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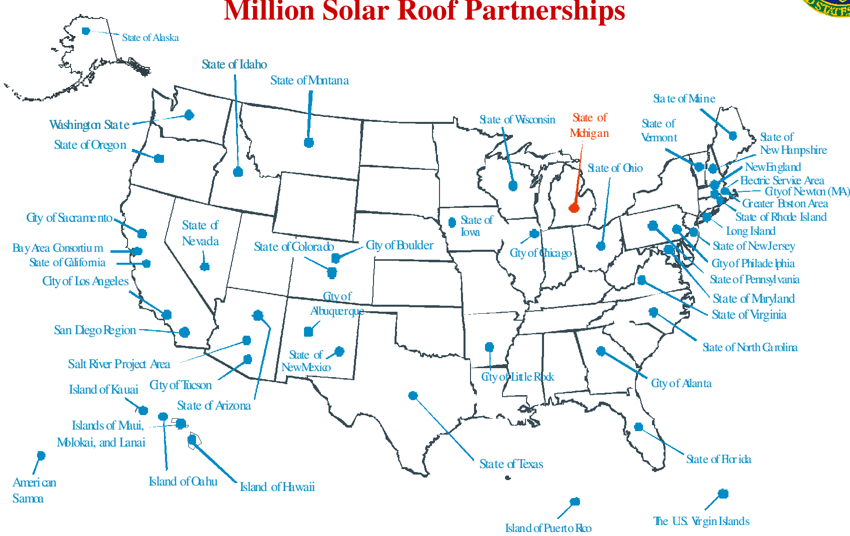
Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Million Solar Roof Partnerships



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Office of Energy Efficiency and Renewable Energy
U. S. Department of Energy

Million Solar Roofs Accomplishments

- 48 State and Local Partnerships
- 1,044,000 Preliminary Pledges
- 110,000 Systems Installed
- 2,100 Federal Systems Installed
- $3 million in FY 2001
- Positive Inspector General Report

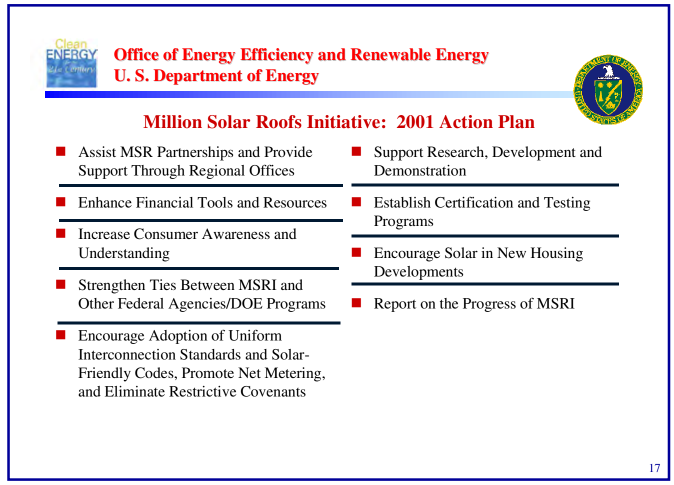
16

When choosing the best energy resource becomes the criteria, renewable energy will win easily. Poll after poll for nearly two decades now has shown a strong public preference for renewable energy.

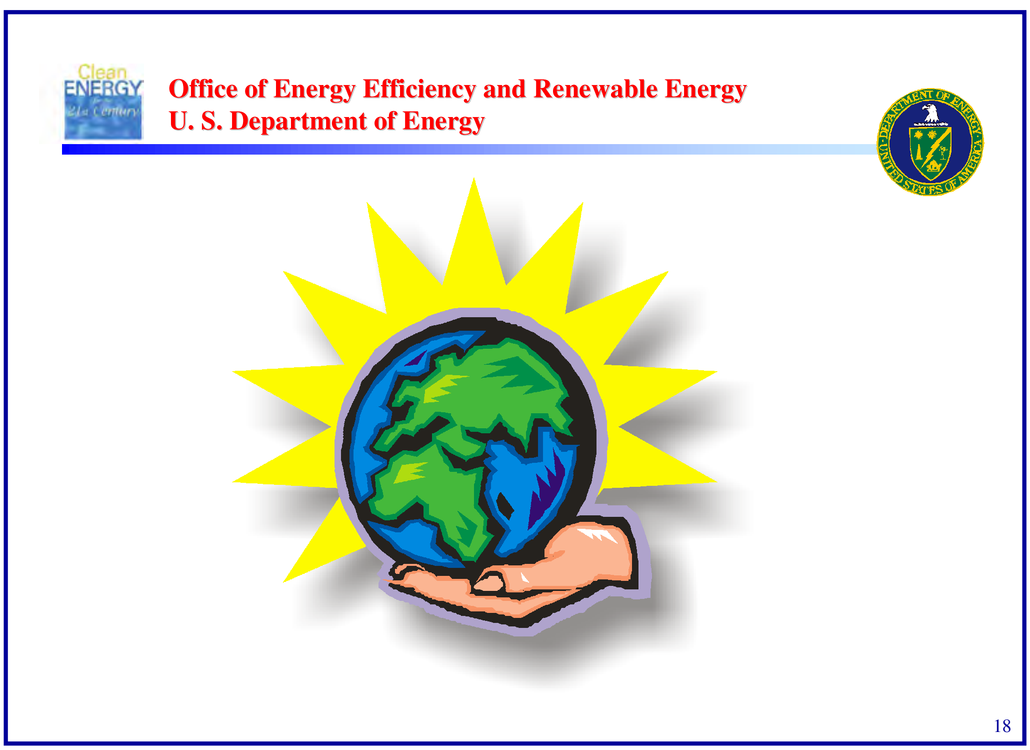
MSR is a bellwether indicator of community support. We now have 48 MSR partners, pulled together in just 3 short years.

Partnerships are the heart of the MSR Initiative. DOE and the national labs help out with technical advice, a little seed money, and a network for sharing problems, solutions, and success stories so that each partnership can benefit from the collective experience.

- We expect that over the next 20 years the world's installed electricity capacity will double. Today that is about 3 million megawatts. That means another 3 million megawatts by 2020. That will be going to condition and light buildings, heat water, and run appliances that could be served by PV, solar thermal, or passive solar technologies.



- Renewable energy does create jobs and economic growth, just like we said it would.
- The number of states with renewable portfolio standards or systems benefits charges for renewable energy now stands at 27. That represents billions of dollars available for renewable energy development.
- In addition to providing money to the economy through industry growth, it's also saving us money, and even more importantly helping the environment.
- The signs of change are becoming obvious. Over the next few years the nature of how consumers buy electricity will be changed radically by utility restructuring.
- Consumers are learning more about where their power comes from and that they have choices.
- Wind Powering America is getting strong support from farmers in the Midwest, who are realizing that leasing some of their land to harvest the wind is good for their rural economies.
- Change and disruption are becoming the rule in the new economy, not the exception.



Arithmetic, Population, and Energy

Dr. Albert Bartlett

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Dr. Bartlett is a retired Professor of Physics. He joined the faculty of the University of Colorado in Boulder in September 1950. His B.A. degree in physics is from Colgate University and his M.A. and Ph.D. degrees in physics are from Harvard University. In 1978 he was national president of the American Association of Physics Teachers. He is a Fellow of the American Physical Society and of the American Association for the Advancement of Science. In 1969 and 1970 he was the elected Chair of the four-campus Faculty Council of the University of Colorado.

In the late 1950s Al was an initiator of the citizens' effort to preserve open space in Boulder, and this ultimately led to the establishment of the City of Boulder's Open Space Program which by 1999 has purchased over 26,000 acres of land to be preserved as public open space. He is a founding member of PLAN-Boulder County, an environmental group for the City and County.

Since the late 1960s he has concentrated on public education on the problems relating to and originating from population growth. More recently he has written on sustainability, examining the widespread misuse of the term, and examining the conditions that are necessary and sufficient for sustainability in any society.

Abstract

This talk examines the arithmetic of steady growth, such as 5% per year, the doubling time for such growth, and the large numbers one gets when steady growth continues over modest periods of time. The examination then turns to what happens when one has steady growth in a finite environment. These concepts are applied to populations and to fossil fuels such as petroleum and coal. A series of recommendations is given for dealing with the problems that are revealed by the very simple arithmetic.

A copy of the original (1978) paper is also included.

Reflections in 1998 on the Twentieth Anniversary of the Paper, "Forgotten Fundamentals of the Energy Crisis"

Albert A. Bartlett
University of Colorado at Boulder

Background

Around 1969, college and university students developed a major interest in the environment and, stimulated by this, I began to realize that neither I nor the students had a good understanding of the implications of steady growth, and in particular, of the enormous numbers that could be produced by steady growth in modest periods of time. On September 19, 1969 I spoke to the students of the pre-medical honor society on "The Arithmetic of Population Growth." Fortunately I kept my notes for the talk, because I was invited to speak to other groups, and I gave the same talk, appropriately revised and enlarged. By the end of 1975 I had given the talk 30 times using different titles, and I was becoming more interested in the exponential arithmetic of steady growth. I started writing short numbered pieces, "The Exponential Function," which were published in *The Physics Teacher*. Then the first energy crisis gave a new sense of urgency to the need to help people to gain a better understanding of the arithmetic of steady growth, and in particular of the shortening of the life expectancy of a non-renewable resource if one had steady growth in the rate of consumption of such a resource until the last of the resource was used.

When I first calculated the Exponential Expiration Time (EET) of U.S. coal for a particular rate of growth of consumption, using Eq. 6, I used my new hand-held electronic calculator, and the result was 44 years. This was so short that I suspected I had made an error in entering the problem. I repeated the calculation a couple of more times, and got the same 44 years. This convinced me that my new calculator was flawed, so I got out tables of logarithms and used pencil and paper to calculate the result, which was 44 years. Only then did I begin to realize the degree to which the lifetime of a non-renewable resource was shortened by having steady growth in the rate of consumption of the resource, and how misleading it is for leaders in business and industry to be advocating growth of rates of consumption and telling people how long the resource will last "at present rates of consumption."

This led to the first version of this paper which was presented at an energy conference at the University of Missouri at Rolla in October 1976, where it appears in the *Proceedings* of the Conference. In reading other papers in the *Proceedings* I came to realize that prominent people in the energy business would sometimes make statements that struck me as being unrealistic and even outrageous. Many of these statements were quoted in the version of the paper that is reprinted here, and this alerted me to the need to watch the public press for more such statements. Fortunately (or unfortunately) the press and prominent people have provided a steady stream of statements that are illuminating because they reflect an inability to do arithmetic and / or to understand the energy situation.

As this is written, I have given my talk on "Arithmetic, Population, and Energy" over 1260 times in 48 of the 50 States in the 28 years since 1969. I wish to acknowledge many constructive and helpful conversations on these topics I have had throughout the 20 years with my colleagues in the Department of Physics, and in particular with Professors Robert Ristinen and Jack Kraushaar, who have written a successful textbook on energy. (*Energy and Problems of a Technical Society*, John Wiley & Sons, New York City, 2nd Ed. 1993)

Reflections on the "Fundamentals" Paper Twenty Years Later

As I read the 1978 paper in 1998, I am pleased to note that the arithmetic that is the core of the paper remains unchanged, and I feel that there are only a few points that need correction or updating.

1) When I derived my Eq. 6 in the Appendix, I was unaware that this equation for the Exponential Expiration Time (EET) had been published earlier by R. T. Robiscoe (his Eq. 4) in an article, "The Effect of Growth Rate on Conservation of a Resource." *American Journal of Physics,* Vol. 41, May 1973, p. 719-720. I apologize for not having been aware of this earlier derivation and presentation of this equation.

2) The world population was reported in 1975 to be 4 billion people growing at approximately 1.9% per year. In 1998 it is now a little under 6 billion people and the growth rate is reported to be around 1.5% per year. The decline in the rate of growth is certainly good news, but the population growth won't stop until the growth rate has dropped to zero.

3) In 1978 I reported that "We are currently importing one-half of the petroleum we use." The data now indicate that, except for brief periods, this could not have been true in 1978. The basis for my statement was a newspaper clipping that said that the U.S. had experienced, in 1976, the first *month* in its history in which more oil was imported than was produced domestically. However, the imported fraction of the oil consumed in the U.S. has risen, and in early 1995 the news said that the calendar year 1994 was the first year in our nation's history when we had to import more oil than we were able to get from our ground ourselves. (*Colorado Daily*, February 24, 1995)

4) The paper reported that by 1973 nuclear reactors (fission) supplied approximately 4.6% of our national electrical power. By 1998 this had climbed to approximately 20% of our electrical power, but no new nuclear power plants have been installed in the U.S. since the 1970s.

5) A table that I wish I had included in the original paper is one that would give answers to questions such as, "If a non-renewable resource would last, say 50 years at present rates of consumption, how long would it last if consumption were to grow say 4% per year?" This involves using the formula for the EET in which the quotient (R / r_0) is the number of years the quantity R of the resource would last at the present rate of consumption, r_0. The results of this simple calculation are shown in Table I.

TABLE I

Lifetimes of non-renewable resources for different rates of growth of consumption. Except for the left column, all numbers are lifetimes in years.

ANNUAL GROWTH RATE	LIFETIME OF RESOURCE IN YEARS						
0%*	**10**	**30**	**100**	**300**	**1000**	**3000**	**10,000**
1%	9.5	26	69	139	240	343	462
2%	9.1	24	55	97	152	206	265
3%	8.7	21	46	77	115	150	190
4%	8.4	20	40	64	93	120	150
5%	8.1	18	36	56	79	100	124
6%	7.8	17	32	49	69	87	107
7%	7.6	16	30	44	61	77	94
8%	7.3	15	28	40	55	69	84
9%	7.1	15	26	37	50	62	76
10%	6.9	14	24	34	46	57	69

** 0% annual growth = "at current rate of consumption"*

Example 1. If a resource would last 300 years at present rates of consumption, then it would last 49 years if the rate of consumption grew 6% per year.

Example 2. If a resource would last 18 years at 5% annual growth in the rate of consumption, then it would last 30 years at present rates of consumption (0% growth).

Example 3. If a resource would last 55 years at 8% annual growth in the rate of consumption, then it would last 115 years at 3% annual growth rate.

6) In the end of Section VIII of the 1978 paper I quoted Hubbert as writing in 1956 that "the peak of production of petroleum" in the U.S. would be reached between 1966 and 1971. The peak occurred in 1970. Hubbert predicted that "On a world scale [oil production] will probably pass its climax within the order of half a century...[2006]" My more recent analysis suggests the year 2004, while Campbell and Laherrere predict that the world peak will be reached before 2010 (*Scientific American*, March 1998, pp. 78-83). Studies by other geologists predict the peak within the first decade of the next century. Hubbert's analysis appears thus far to be remarkably good.

7) The "Fundamentals" paper was followed by a paper titled, "Sustained Availability: A Management Program for Non-Renewable Resources." *American Journal of Physics*, Vol. 54, May 1986, pp. 398-402. This paper makes use of the fact that the integral from zero to infinity of a declining exponential curve is finite. Thus, if one puts production of a non-renewable resource on a declining exponential curve, one can always find a rate of decline such that *the resource will last forever.* This is called "Sustained Availability," which is somewhat analogous to "sustained yield" in agriculture. This paper explores the mathematics of the options that this plan of action can give to a resource-rich nation that wants to divide its production of a resource between domestic use and exports.

8) Many economists reject this sort of analysis which is based on the assumption that resources are finite. A colleague in economics read the paper and later told me that "It is all wrong." When I asked him to point out the specific errors in the paper, he shook his head, saying, "It is all wrong."

9) The original paper dealt more with resources than with population. I feel that it is now clear that population growth is the world's most serious problem, and that the world's most serious population problem is right here in the U.S. The reason for this is that the average American has something like 30 to 50 times the impact on world resources as does a person in an underdeveloped country. (A.A. Bartlett, *Wild Earth*, Vol. 7, Fall 1997, pp. 88-90)

We have the jurisdiction and the responsibility needed to permit us to address our U.S. population problem, yet many prefer to focus their attention on the population problems in other countries. Before we can tell people in other countries that they must stop their population growth, we must accept the responsibility for working to stop population growth in the United States, where about half of our population growth is the excess of births over deaths and the other half is immigration, legal plus illegal. This leads me to offer the following challenge:

> *Can you think of any problem, on any scale, from microscopic to global, whose long-term solution is in any demonstrable way, aided, assisted, or advanced by having larger populations at the local level, the state level, the national level, or globally?*

Horror Stories

Here are more recent horror stories to add to those that were recounted in the original paper.

1) *The Rocky Mountain News* of October 6, 1993 reported that: Shell Oil Co. said "... it planned to spend $1.2 billion to develop the largest oil discovery in the Gulf of Mexico in the past 20 years. The discovery ... has an estimated ultimate recovery in excess of 700 million barrels of oil and gas." The 700 million barrels of oil sounds like a lot -- until you note that at that time the U.S. consumption was 16.6 million barrels / day, so that this "largest oil discovery in the Gulf of Mexico in the past 20 years" would supply the needs of the U.S. for only 42 days!

2) The headline in the *Wall Street Journal* for July 18, 1986 proclaimed that "U.S. Oil Output Tumbled in First Half as Alaska's Production Fell Nearly 8%." In the body of the story we read that the chief economist for Chevron Corporation observes that, "The question we can't answer yet is whether this is a new trend or a quirk." The answer to his question is that it is neither; it is an old trend! It is exactly what one expects as one goes down the right side of the Hubbert Curve.

3) Another headline on the front page of the *Wall Street Journal* (April 1, 1997) said: "Four Decades Later, Oil Field Off Canada is Ready to Produce. Politics, Money and Nature Put Vast Deposit on Ice; Now It Will Last 50 Years: Shot in the Arm for U.S." In the body of the story we read that:

The Hibernia field, one of the largest oil discoveries in North American in decades, should deliver its first oil by year end. At least 20 more fields may follow, offering well over one billion barrels of high-quality crude and promising that a steady flow of oil will be just a quick tanker-run away from the energy-thirsty East Coast.

Total U.S. oil consumption in 1996 was about 18 million barrels a day. Do the long division and one sees that the estimated "one billion barrels of high-quality crude" will supply the needs of the U.S. for just 56 days! This should be compared with the "50 Years" in the headline.

4) In the *Prime Time Monthly Magazine* (San Francisco, September 1995) we find an article, "Horses Need Corn" by the famous radio news broadcaster Paul Harvey. He emphasizes the opportunity we have to make ethanol from corn grown in the U.S. and then to use the ethanol as a fuel for our cars and trucks: "Today, ethanol production displaces over 43.5 million barrels of imported oil annually, reducing the U.S. trade balance by $645 million. . . For as far ahead as we can see, the only inexhaustible feed for our high horsepower vehicles is corn."

There are two problems with this:

A) The 43.5 million barrels must be compared with the annual consumption of motor gasoline in the U.S. In 1994 we consumed 4.17 billion barrels of motor vehicle gasoline. (Annual Energy Review, 1994, DOE / EIA 0384(94), p. 159) The ethanol production is seen to be approximately 1 % of the annual consumption of gasoline by vehicles in the U.S. So one would have to multiply corn production by a factor of about 100 just to make the numbers match. An increase of this magnitude in the farm acreage devoted to the production of corn for ethanol would have profound negative dietary consequences. *Editor's note: new technologies allow ethanol to be made from "hemicellulosic" materials currently wasted, such as corn stover, rice stalks, waste paper, and yard and wood wastes. Although corn is still the primary feedstock used today, it is not the only (or even preferred) feedstock envisioned for the future.*

B) It takes energy (generally diesel fuel) to plow the ground, to fertilize the ground, to plant the corn, to take care of the corn, to harvest the corn, and then more energy is needed to distill the corn to get ethanol. So it turns out that in the conventional production of ethanol, the finished gallon of ethanol contains less energy than was used to produce it! It's an energy loser! The net energy of this "energy source" is negative! *Editor's note: although the net energy balance of ethanol production from corn was negative in the 1970s and early 1980s, modern ethanol production is significantly more efficient, and now has a positive net energy balance. Ethanol production from other feedstocks, such as molasses or hemicellulosic materials, has an even greater positive net energy balance. As the author has said in numerous presentations, "don't let others do your thinking for you." If this issue is of interest to you, look into it further.*

5) The Clinton administration, in a "Draft Comprehensive National Energy Strategy" (February 1998) talks about America's oil as being "abundant," (pg. 4) and it advocates "promoting increased domestic oil ... production" (pg. 2) to reverse this downward trend in U.S. oil production. The peak of the Hubbert Curve of oil production in the U.S. was reached in 1970 and we are now well down the right side of the Curve. The Draft Strategy calls for "stabilization of domestic oil production" (pg. 12) which is explained in "Strategy 1" (pg. 12) "By 2005, first stop and then reverse the decline in domestic oil production." The Hubbert Curve rises and falls in a manner like that of a Gaussian Error Curve, and once one is over the peak, one can put bumps on the downhill side, but except for such "noise," the trend after the peak is always downhill. A large national effort might reverse the decline in U.S. oil production for a year or two, but it hardly plausible to propose to "stabilize" domestic oil production for any extended period of time. It almost seems as though the U.S. Department of Energy has not studied the works of Hubbert, Campbell & Laherrere, Ivanhoe, Edwards, Masters and other prominent petroleum geologists.

Forgotten Fundamentals of the Energy Crisis

(1978)

Albert A. Bartlett
University of Colorado at Boulder

"Facts do not cease to exist because they are ignored," Aldous Huxley.

I. INTRODUCTION[1]

The energy crisis has been brought into focus by President Carter's message to the American people on April 18 and by his message to the Congress on April 20, 1977. Although the President spoke of the gravity of the energy situation when he said that it was "unprecedented in our history," his messages have triggered an avalanche of critical responses from national political and business leaders. A very common criticism of the President's message is that he failed to give sufficient emphasis to increased fuel production as a way of easing the crisis. The President proposed an escalating tax on gasoline and a tax on the large gas guzzling cars in order to reduce gasoline consumption. These taxes have been attacked by politicians, by labor leaders, and by the manufacturers of the "gas guzzlers" who convey the impression that one of the options that is open to us is to go ahead using gasoline as we have used it in the past.

We have the vague feeling that Arctic oil from Alaska will greatly reduce our dependence on foreign oil. We have recently heard political leaders speaking of energy self-sufficiency for the U.S. and of "Project Independence." The divergent discussion of the energy problem creates confusion rather than clarity, and from the confusion many Americans draw the conclusion that the energy shortage is mainly a matter of manipulation or of interpretation. It then follows in the minds of many that the shortage can be "solved" by congressional action in the manner in which we "solve" social and political problems.

Many people seem comfortably confident that the problem is being dealt with by experts who understand it. However, when one sees the great hardships that people suffered in the Northeastern U.S. in January 1977 because of the shortage of fossil fuels, one may begin to wonder about the long-range wisdom of the way that our society has developed.

What are the fundamentals of the energy crisis?

Rather than travel into the sticky abyss of statistics it is better to rely on a few data and on the pristine simplicity of elementary mathematics. With these it is possible to gain a clear understanding of the origins, scope, and implications of the energy crisis.

II. BACKGROUND

When a quantity such as the rate of consumption of a resource (measured in tons per year or in barrels per year) is growing at a fixed percent per year, the growth is said to be exponential. The important property of the growth is that the time required for the growing quantity to increase its size by a fixed fraction is constant. For example, a growth of 5 % (a fixed fraction) per year (a constant time interval) is exponential. It follows that a constant time will be required for the growing quantity to double its size (increase by 100 %). This time is called the doubling time T_2 , and it is related to P, the percent growth per unit time by a very simple relation that should be a central part of the educational repertoire of every American.

$$T_2 = 70 / P$$

As an example, a growth rate of 5 % / yr will result in the doubling of the size of the growing quantity in a time $T_2 = 70 / 5 = 14$ yr. In two doubling times (28 yr) the growing quantity will double twice (quadruple) in size. In three doubling times its size will increase eightfold ($2^3 = 8$); in four doubling times it will increase sixteenfold ($2^4 = 16$); etc. It is natural then to talk of growth in terms of powers of 2.

III. THE POWER OF POWERS OF TWO

Legend has it that the game of chess was invented by a mathematician who worked for an ancient king. As a reward for the invention the mathematician asked for the amount of wheat that would be determined by the following process: He asked the king to place 1 grain of wheat on the first square of the chess board, double this and put 2 grains on the second square, and continue this way, putting on each square twice the number of grains that were on the preceding square. The filling of the chessboard is shown in Table I. We see that on the last square one will place 2^{63} grains and the total number of grains on the board will then be one grain less than 2^{64}.

How much wheat is 2^{64} grains? Simple arithmetic shows that it is approximately 500 times the 1976 annual worldwide harvest of wheat? This amount is probably larger than all the wheat that has been harvested by humans in the history of the earth! How did we get to this enormous number? It is simple; we started with 1 grain of wheat and we doubled it a mere 63 times!

Exponential growth is characterized by doubling,
and a few doublings can lead quickly to enormous numbers.

The example of the chessboard (Table I) shows us another important aspect of exponential growth; *the increase in any doubling is approximately equal to the sum of all the preceding growth!* Note that when 8 grains are placed on the 4th square, the 8 is greater than the total of 7 grains that were already on the board.

Table I.
Filling the squares on the chessboard

Square Numbers	Grains on the Square	Total Grains Thus Far
1	1	
2	2	
3	4	
4	8	15
5	16	31
6	32	63
7	64	127
64	2^{63}	$2^{64} - 1$

The 32 grains placed on the 6th square are more than the total of 31 grains that were already on the board. Covering any square requires one grain more than the total number of grains that are already on the board.

On April 18, 1977 President Carter told the American people, "And in each of these decades (the 1950s and 1960s), more oil was consumed than in all of man's previous history combined."

We can now see that this astounding observation is a simple consequence of a growth rate whose doubling time is $T_2 = 10$ yr (one decade). The growth rate which has this doubling time is $P = 70/10 = 7\%$ / yr.

When we read that the demand for electrical power in the U.S. is expected to double in the next 10-12 yr we should recognize that this means that the quantity of electrical energy that will be used in these 10-12 yr will be approximately equal to the total of all of the electrical energy that has been used in the entire history of the electrical industry in this country! *Many people find it hard to believe that when the rate of consumption is growing a mere 7 % / yr, the consumption in one decade exceeds the total of all of the previous consumption.*

Populations tend to grow exponentially. The world population in 1975 was estimated to be 4 billion people and it was growing at the rate of 1.9 % / yr. It is easy to calculate that at this low rate of growth the world population would double in 36 yr, the population would grow to a density of 1 person / m2 on the dry land surface of the earth (excluding Antarctica) in 550 yr, and the mass of people would equal the mass of the earth in a mere 1,620 yr! Tiny growth rates can yield incredible numbers in modest periods of time! Since it is obvious that people could never live at the density of 1 person / m^2 over the land area of the earth, it is obvious that the earth will experience zero population growth. The present high birth rate and / or the present low death rate will change until they have the same numerical value, and this will probably happen in a time much shorter than 550 years.

A recent report suggested that the rate of growth of world population had dropped from 1.9 % / yr to 1.64 % / yr.[2] Such a drop would certainly qualify as the best news the human race has ever had! The report seemed to suggest that the drop in this growth rate was evidence that the population crisis had passed, but it is easy to see that this is not the case. The arithmetic shows that an annual growth rate of 1.64 % will do anything that an annual rate of 1.9 % will do; it just takes a little longer. For example, the world population would increase by one billion people in 13.6 yr instead of in 11.7 years.

Compound interest on an account in the savings bank causes the account balance to grow exponentially. One dollar at an interest rate of 5 % / yr compounded continuously will grow in 500 yr to 72 billion dollars and the interest at the end of the 500th year would be coming in at the magnificent rate of $114 / s. If left untouched for another doubling time of 14 yr, the account balance would be 144 billion dollars and the interest would be accumulating at the rate of $228 / s.

It is very useful to remember that steady exponential growth of n % / yr for a period of 70 yr (100 ln2) will produce growth by an overall factor of 2^n. Thus where the city of Boulder, Colorado, today has one overloaded sewer treatment plant, a steady population growth at the rate of 5 % / yr would make it necessary in 70 yr (one human lifetime) to have $2^5 = 32$ overloaded sewer treatment plants!

Steady inflation causes prices to rise exponentially. An inflation rate of 6 % / yr will, in 70 yr, cause prices to increase by a factor of 64! If the inflation continues at this rate, the $0.40 loaf of bread we feed our toddlers today will cost $25.60 when the toddlers are retired and living on their pensions!

It has even been proven that the number of miles of highway in the country tends to grow exponentially.[1(e),3]

The reader can suspect that the world's most important arithmetic is the arithmetic of the exponential function. *One can see that our long national history of population growth and of growth in our per-capita consumption of resources lie at the heart of our energy problem.*

IV. EXPONENTIAL GROWTH IN A FINITE ENVIRONMENT

Bacteria grow by division so that 1 bacterium becomes 2, the 2 divide to give 4, the 4 divide to give 8, etc. Consider a hypothetical strain of bacteria for which this division time is 1 minute. The number of bacteria thus grows exponentially with a doubling time of 1 minute. One bacterium is put in a bottle at 11:00 a.m. and it is observed that the bottle is full of bacteria at 12:00 noon. Here is a simple example of exponential growth in a finite environment. This is mathematically identical to the case of the exponentially growing consumption of our finite resources of fossil fuels. Keep this in mind as you ponder three questions about the bacteria:

(1) When was the bottle half-full? Answer: 11:59 a.m.!

(2) If you were an average bacterium in the bottle, at what time would you first realize that you were running out of space?

Answer: There is no unique answer to this question, so let's ask, "At 11:55 a.m., when the bottle is only 3 % filled (1 / 32) and is 97 % open space (just yearning for development) would you perceive that there was a problem?" Some years ago someone wrote a letter to a Boulder newspaper to say that there was no problem with population growth in Boulder Valley. The reason given was that there was 15 times as much open space as had already been developed. When one thinks of the bacteria in the bottle one sees that the time in Boulder Valley was 4 min before noon! See Table II.

Table II. The last minutes in the bottle.		
11:54 a.m.	1/64 full (1.5%)	63/64 empty
11:55 a.m.	1/32 full (3%)	31/32 empty
11:56 a.m.	1/16 full (6%)	15/16 empty
11:57 a.m.	1/8 full (12%)	7/8 empty
11:58 a.m.	1/4 full (25%)	3/4 empty
11:59 a.m.	1/2 full (50%)	1/2 empty
12:00 noon	full (100%)	0% empty

Suppose that at 11:58 a.m. some farsighted bacteria realize that they are running out of space and consequently, with a great expenditure of effort and funds, they launch a search for new bottles. They look offshore on the outer continental shelf and in the Arctic, and at 11:59 a.m. they discover three new empty bottles. Great sighs of relief come from all the worried bacteria, because this magnificent discovery is three times the number of bottles that had hitherto been known. The discovery quadruples the total space resource known to the bacteria. Surely this will solve the problem so that the bacteria can be self-sufficient in space. The bacterial "Project Independence" must now have achieved its goal.

(3) How long can the bacterial growth continue if the total space resources are quadrupled?
Answer: Two more doubling times (minutes)! See Table III.

James Schlesinger, Secretary of Energy in President Carter's Cabinet recently noted that in the energy crisis "we have a classic case of exponential growth against a finite source."[4]

Table III. The effect of the discovery of three new bottles.	
11:58 a.m.	Bottle No. 1 is one quarter full.
11:59 a.m.	Bottle No. 1 is half-full.
12:00 noon	Bottle No. 1 is full.
12:01 p.m.	Bottles No. 1 and 2 are both full.
12:02 p.m.	Bottles No. 1, 2, 3, 4 are all full.
Quadrupling the resource extends the life of the resource by only two doubling times! When consumption grows exponentially, enormous increases in resources are consumed in a very short time!	

V. LENGTH OF LIFE OF A FINITE RESOURCE WHEN THE RATE OF CONSUMPTION IS GROWING EXPONENTIALLY

Physicists would tend to agree that the world's mineral resources are finite. The extent of the resources is only incompletely known, although knowledge about the extent of the remaining resources is growing very rapidly. The consumption of resources is generally growing exponentially, and we would like to have an idea of how long resources will last. Let us plot a graph of the rate of consumption r(t) of a resource (in units such as tons / yr) as a function of time measured in years. The area under the curve in the interval between times t = 0 (the present, where the rate of consumption is r_0) and t = T will be a measure of the total consumption C in tons of the resource in the time interval. We can find the time T_e at which the total consumption C is equal to the size R of the resource and this time will be an estimate of the expiration time of the resource.

Imagine that the rate of consumption of a resource grows at a constant rate until the last of the resource is consumed, whereupon the rate of consumption falls abruptly to zero. It is appropriate to examine this model because this constant exponential growth is an accurate reflection of the goals and aspirations of our economic system. Unending growth of our rates of production and consumption and of our Gross National Product is the central theme of our economy and it is regarded as disastrous when actual rates of growth fall below the planned rates. Thus it is relevant to calculate the life expectancy of a resource under conditions of constant rates of growth. Under these conditions the period of time necessary to consume the known reserves of a resource may be called the exponential expiration time (EET) of the resource. The EET is a function of the known size R of the resource, of the current rate of use r_0 of the resource, and of the fractional growth per unit time k of the rate of consumption of the resource. The expression for the EET is derived in the Appendix where it appears as Eq. (6). This equation is known to scholars who deal in resource problems[5] but there is little evidence that it is known or understood by the political, industrial, business, or labor leaders who deal in energy resources, who speak and write on the energy crisis and who take pains to emphasize how essential it is to our society to have continued uninterrupted growth in all parts of our economy. The equation for the EET has been called the best-kept scientific secret of the century.[6]

VI. HOW LONG WILL OUR FOSSIL FUELS LAST?

The question of how long our resources will last is perhaps the most important question that can be asked in a modern industrial society. Dr. M. King Hubbert, a geophysicist now retired from the United States Geological Survey, is a world authority on the estimation of energy resources and on the prediction of their patterns of discovery and depletion. Many of the data used here come from Hubbert's papers.[7 - 10] Several of the figures in this paper are redrawn from figures in his papers. These papers are required reading for anyone who wishes to understand the fundamentals and many of the details of the problem.

Let us examine the situation in regard to production of domestic crude oil in the U.S. Table IV gives the relevant data. *Note that since one-half of our domestic petroleum has already been consumed, the "petroleum time" in the U.S. is 1 minute before noon!*

Table IV.
United States crude oil (lower 48 states).

Ultimate total production (Ref. 7)	190
Produced to 1972	96.6
Percent of ultimate total production produced to 1972 (Ref.7)	50.8%
Annual production rate 1970	3.29

Units are 10^9 barrels (1 barrel = 42 U.S. gal. = 158.98 L).

Figure 1 shows the historical trend in domestic production (consumption) of crude oil. Note that from 1870 to about 1930 the rate of production of domestic crude oil increased exponentially at a rate of 8.27% / yr with a doubling time of 8.4 yr. If the growth in the rate of production stopped and the rate of production was held constant at the 1970 rate, the remaining U.S. oil would last only (190 - 96.6) / 3.29 = 28 yr!

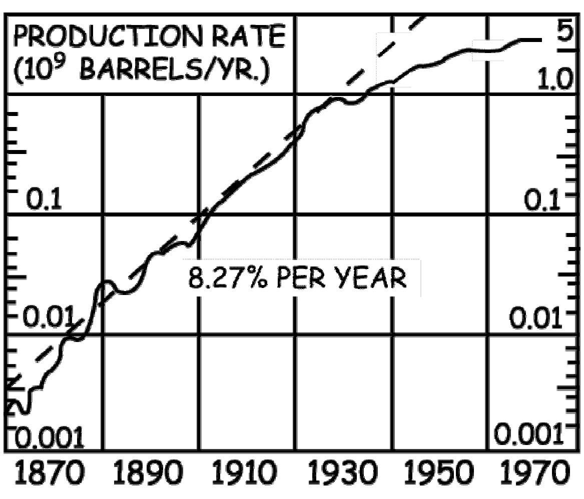

***Fig. 1**. History of U.S. crude oil production (semilogarithmic scale).*
Redrawn from Hubbert's Fig. 12, Ref. 7.

We are currently importing one-half of the petroleum we use. If these imports were completely cut off and if there was no growth in the rate of domestic consumption above the 1970 rate, our domestic petroleum reserves would last only 14 yr! The vast shale oil deposits of Colorado and Wyoming represent an enormous resource. Hubbert reports that the oil recoverable under 1965 techniques is 80 x 10^9 barrels, and he quotes other higher estimates. In the preparation of Table V, the figure 103.4 x 10^9 barrels was used as the estimate of U.S. shale oil so that the reserves used in the calculation of column 4 would be twice those that were used in the calculation of column 3. This table makes it clear that *when consumption is rising exponentially, a doubling of the remaining resource results in only a small increase in the life expectancy of the resource.*

A reporter from CBS News, speaking about oil shale on a three-hour television special feature on energy (August 31, 1977) said, "Most experts estimate that oil shale deposits like these near Rifle, Colorado, could provide more than a 100-yr supply." This statement should be compared with the figures given in column 4 of Table V. This comparison will serve to introduce the reader to the disturbing divergence between reassuring statements by authoritative sources and the results of simple calculations.

Anyone who wishes to talk about energy self-sufficiency for the United States (Project Independence) must understand Table V and the simple exponential calculations upon which it is based.

Table V.

Exponential expiration time (EET) in years of various estimates of U.S. oil reserves for different rates of growth of annual production. Units are 10^9 barrels. This table is prepared by using Eq. (6) with $r_0 = 3.29 \times 10^9$ barrels/yr. Note that this is domestic production which is only about one half of domestic consumption!

Col.1 (%)	Col.2 (yr)	Col.3 (yr)	Col.4 (yr)
Percent annual growth rate	*Lifetime (EET) of the resource which is calculated using R = 190 - 96.6 = 93.4 as the estimated oil remaining in the lower 48 states.*	*Lifetime (EET) calculated using R = 93.4 + 10 to include the Alaskan oil.*	*Lifetime (EET) calculated using R = 93.4 + 10 + 103.4 = 206.8 to include Alaskan oil and a hypothetical estimate of U.S. oil shale.*
Zero	28.4	31.4	62.8
1%	25.0	27.3	48.8
2%	22.5	24.4	40.7
3%	20.5	22.1	35.3
4%	19.0	20.4	31.4
5%	17.7	18.9	28.4
6%	16.6	17.7	26.0
7%	15.6	16.6	24.1
8%	14.8	15.7	22.4
9%	14.1	14.9	21.1
10%	13.4	14.2	19.9

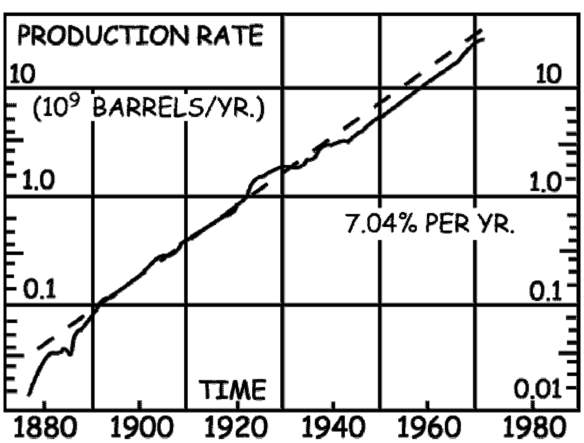

Fig. 2. *History of world crude oil production (semilogarithmic scale).*
Redrawn from Hubbert's Fig. 6, Ref. 7.

Table VI gives statistics on world production of crude oil. Figure 2 shows the historical trend in world crude oil production. Note that from 1890 to 1970 the production grew at a rate of 7.04% / yr, with a doubling time of 9.8 yr. It is easy to calculate that the world reserves of crude oil would last 101 yr if the growth in annual production was halted and production in the future was held constant at the 1970 level. Table VII shows the life expectancy (EET) of world crude oil reserves for various rates of growth of production and shows the amount by which the life expectancy is extended if one adds world deposits of oil shale. Column 4 is based on the assumption that the available shale oil is four times as large as the value reported by Hubbert. Note again that the effect of this very large hypothetical increase in the resource is very small.

Table VI. World crude oil data.	
Ultimate total production (Ref.7)	1952
Produced to 1972	261
Percent of total production produced to 1972 (Ref. 7)	13.4%
Annual Production rate 1970	16.7
Units are 10^9 barrels. Note that a little more than 1/8 of the world's oil has been consumed. *The "world petroleum time" is between 2 and 3 min before noon, i.e. we are between 2 and 3 doubling times from the expiration of the resource.*	

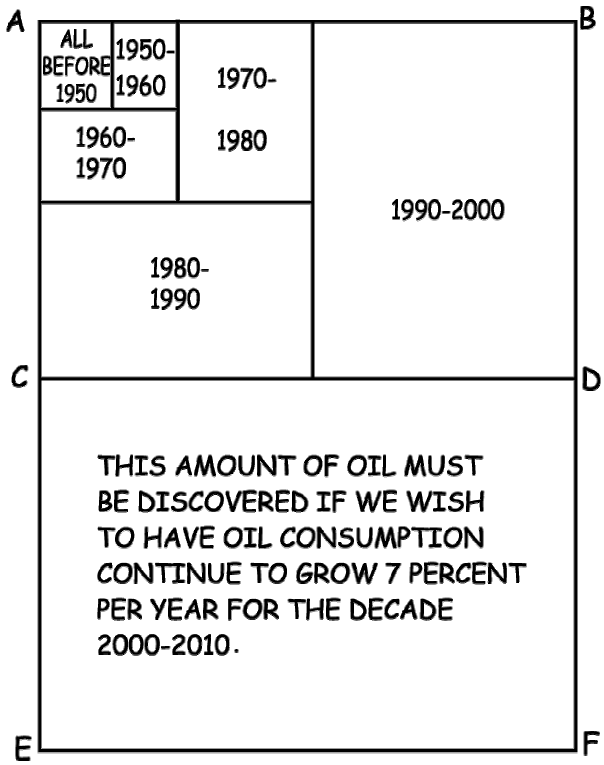

Fig. 3. *This graphical model from Mario Iona can be used to represent this growth.*[11]

When consumption grows 7% / yr the consumption in any decade is approximately equal to the sum of all previous consumption as can be seen by the areas representing consumption in successive decades.

The rectangle ABDC represents all the known oil, including all that has been used in the past, and the rectangle CDFE represents the new discoveries that must be made if we wish the 7 % / year growth to continue one decade, from the year 2000 to 2010!

From these calculations we can draw a general conclusion of great importance. *When we are dealing with exponential growth we do not need to have an accurate estimate of the size of a resource in order to make a reliable estimate of how long the resource will last.*

Table VII.
Life expectancy in years of various estimates of world oil reserves for different rates of growth of annual production. Units are 10^9 barrels. This table is prepared by using Eq. (6) with r0 = 16.7 x 10^9 barrels / yr.

Col. 1 (%)	Col. 2 (yr)	Col. 3 (yr)	Col. 4 (yr)
Percent annual growth rate of production	*Lifetime (EET) of the resource calculated using r = 1691 as the estimate of the amount of the remaining oil.*	*Lifetime (EET) calculated using R = 1691 + 190 = 1881 representing crude oil plus oil shale.*	*Lifetime (EET) calculated using R = 1691 + 4(190) = 2451 which assumes that the amount of shale oil is 4 times the amount which is known now.*
Zero	101.0	113.0	147.0
1%	69.9	75.4	90.3
2%	55.3	59.0	68.5
3%	46.5	49.2	56.2
4%	40.5	42.6	48.2
5%	36.0	37.8	42.4
6%	32.6	34.1	38.0
7%	29.8	31.2	34.6
8%	27.6	28.8	31.8
9%	25.7	26.8	29.5
10%	24.1	25.1	27.5

A friend recently tried to reassure me by asserting that there remained undiscovered under our country at least as much oil as all we have ever used. Since it has been about 120 yr since the first discovery of oil in this country, he was sure that the undiscovered oil would be sufficient for another 120 yr. I had no success in convincing him that if such oil was found it would be sufficient only for one doubling time or about a decade.

As the reader ponders the seriousness of the situation and asks, "What will life be like without petroleum?" the thought arises of heating homes electrically or with solar power and of traveling in electric cars. A far more fundamental problem becomes apparent when one recognizes that modern agriculture is based on petroleum-powered machinery and on petroleum-based fertilizers. This is reflected in a definition of modern agriculture: "Modern agriculture is the use of land to convert petroleum into food."

Item: We have now reached the point in U.S. agriculture where we use 80 gallons of gasoline or its equivalent to raise an acre of corn, but only nine hours of human labor per crop acre for the average of all types of produce.[12]

Think for a moment of the effect of petroleum on American life. Petroleum has made it possible for American farms to be operated by only a tiny fraction of our population; only 1 American in 26 lived on a farm in 1976. The people thus displaced from our farms by petroleum-based mechanization have migrated to the cities where our ways of life are critically dependent on petroleum. The farms without the large number of people to do the work are also critically dependent on petroleum-based mechanization. The approaching exhaustion of the domestic reserves of petroleum and the rapid depletion of world reserves will have a profound effect on Americans in the cities and on the farms. It is clear that agriculture as we know it will experience major changes within the life expectancy of most of us, and with these changes could come a major further deterioration of world-wide levels of nutrition. The doubling time (36 - 42 yr) of world population (depending on whether the annual growth rate is 1.9 % or 1.64 %) means that we have this period of time in which we must double world food production if we wish to do no better than hold constant the fraction of the world population that is starving. This would mean that the number starving at the end of the doubling time would be twice the number that are starving today. This was put into bold relief by David Pimentel of Cornell University in an invited paper at the 1977 annual meeting of AAPT-APS (Chicago, 1977):

> As a result of overpopulation and resource limitations, the world is fast losing its capacity to feed itself... More alarming is the fact that while the world population doubled its numbers in about 30 years the world doubled its energy consumption within the past decade. Moreover, the use of energy in food production has been increasing faster than its use in many other sectors of the economy.

It is possible to calculate an absolute upper limit to the amount of crude oil the earth could contain. We simply assert that the volume of petroleum in the earth cannot be larger than the volume of the earth. The volume of the earth is 6.81×10^{21} barrels, which would last for 4.1×10^{11} yr if the 1970 rate of consumption of oil held constant with no growth. The use of Eq. (6) shows that if the rate of consumption of petroleum continued on the growth curve of 7.04 % / yr of Fig. 2, this earth full of oil will last only 342 yr!

It has frequently been suggested that coal will answer the U.S. and world energy needs for a long period in the future. What are the facts?

Table VIII shows data on U.S. coal production that are taken from several sources. Figure 4 shows the history of coal production in the U.S. Note that from 1860 to 1910, U.S. coal production grew exponentially at 6.69 % / yr (T_2 = 10.4 yr). The production then leveled off at 0.5×10^9 tons / yr which held approximately constant until 1972 whereupon the rate started to rise steadily. Coal consumption remained level for 60 yr because our growing energy demands were met by petroleum and natural gas. In early 1976 the annual coal production goals of the U.S. government were 1.3 billion tons for 1980 and 2.1 billion tons for 1985. The 1976 production is now reported to have been 0.665 billion tons and the current goal is to raise annual production to a billion tons by 1985.[13] From these data we can see that the Ford administration's goals called for coal production to increase on the order of 10 % / yr while the Carter administration is speaking of growth of production of approximately 5 % / yr.

Table VIII. United States coal resource.	
Ultimate total production (Ref. 7)	
High estimate	1486
Low estimate	390
Produced through 1972 (My estimate from Hubbert's Fig. 22)	50
Percent of ultimate production produced through 1972	
Percent of high estimate	3%
Percent of low estimate	13%
Coal resource remaining	
High estimate	1436
Low estimate	340
Annual production rate, 1972	0.5
Rate of export of coal, 1974	0.06
Annual production rate, 1974	0.6
Annual production rate, 1976	0.665
Units are 10^9 metric tons.	

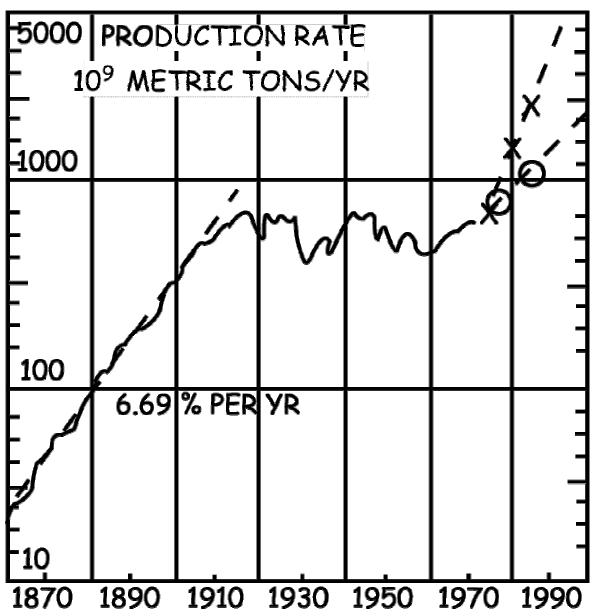

Fig. 4. *History of U.S. coal production (semilogarithmic scale). Redrawn from Hubbert's Fig. 10, Ref. 7.*

In the upper right, the crosses in the steep dashed curve show the coal production goals of the Ford Administration, and the circles in the lower dashed curve show the production goals of the Carter Administration.

From the close of the American Civil War to about the year 1910, coal production grew at a steady rate of 6.69% / yr. If this growth rate had continued undiminished after 1910, the small estimate of the size of U.S. coal reserves would have been consumed by about 1967 and the larger estimate of the size of the reserves would have been consumed by about the year 1990!

Table IX shows the expiration times (EET) of the high and the low estimates of U.S. coal reserves for various rates of increase of the rate of production as calculated from the equation for the EET [Eq. (6)]. If we use the conservative smaller estimate of U.S. coal reserves we see that the growth of the rate of consumption will have to be held below 3 % / yr if we want coal to last until our nation's tricentennial. If we want coal to last 200 yr, the rate of growth of annual consumption will have to be held below 1 % / yr! One obtains an interesting insight into the problem if one asks how long beyond the year 1910 could coal production have continued on the curve of exponential growth at the historic rate of 6.69 % / yr of Fig. 4. The smaller estimate of U.S. coal would have been consumed around the year 1967 and the large estimate would have expired around the year 1990. Thus it is clear that the use of coal as an energy source in 1978 and in the years to come is possible only because the growth in the annual production of coal was zero from 1910 to about 1972!

VII. WHAT DO THE EXPERTS SAY?

Now that we have seen the facts let us compare them with statements from authoritative sources. Let us look first at a report to the Congress.

> It is clear, particularly in the case of coal, that we have ample reserves.... We have an abundance of coal in the ground. Simply stated, the crux of the problem is how to get it out of the ground and use it in environmentally acceptable ways and on an economically competitive basis... At current levels of output and recovery these reserves can be expected to last more than 500 years.[14]

Here is one of the most dangerous statements in the literature. It is dangerous because news media and the energy companies pick up the idea that "United States coal will last 500 years" while the media and the energy companies forget or ignore the important caveat with which the sentence began, "At current levels of output . . ." The right-hand column of Table IX shows that at zero rate of growth of consumption even the low estimate of the U.S. coal resource "will last over 500 years." However, it is absolutely clear that the government does not plan to hold coal production constant "at current levels of output."

Table IX.
Lifetime in years of United States coal (EET). The lifetime (EET) in years of U.S. coal reserves (both the high and low estimate of the U.S.G.S.) are shown for several rates of growth of production from the 1972 level of 0.5 ($x10^9$) metric tons per year.

		High Estimate (yr)	Low Estimate (yr)
ANNUAL GROWTH RATE	Zero	2872	680
	1%	339	205
	2%	203	134
	3%	149	102
	4%	119	83
	5%	99	71
	6%	86	62
	7%	76	55
	8%	68	50
	9%	62	46
	10%	57	42
	11%	52	39
	12%	49	37
	13%	46	35

> Coal reserves far exceed supplies of oil and gas, and yet coal supplies only 18 % of our total energy. To maintain even this contribution we will need to increase coal production by 70 % by 1985, but the real goal, to increase coal's share of the energy market will require a staggering growth rate.[15]

While the government is telling us that we must achieve enormous increases in the rate of coal production, other governmental officials are telling us that we can increase the rate of production of coal *and* have the resource last for a very long time.

> The trillions of tons of coal lying under the United States will have to carry a large part of the nation's increased energy consumption, says (the) Director of the Energy Division of the Oak Ridge National Laboratories. He estimated America's coal reserves are so huge, they could last "a minimum of 300 years and probably a maximum of 1000 years."[16]

Compare the above statement of the life expectancy of U.S. coal reserves with the results of very simple calculations given in Table IX.

In the three-hour CBS television special on energy (August 31, 1977) a reporter stressed the great efforts that are being made to increase the rate of production of U.S. coal, and he summarized the situation in these words, "By the lowest estimate, we have enough (coal) for 200 years. By the highest, enough for more than a thousand years."

Again, compare the above statement with the results of simple calculations shown in Table IX.

While we read these news stories we are bombarded by advertisements by the energy companies which say that coal will last a long time at present rates of consumption and which say at the same time that we must dramatically increase our rate of production of coal.

> At the rate the United States uses coal today, these reserves could help keep us in energy for the next two hundred years . . . Most coal used in America today is burned by electric power plants (which) consumed about 400 million tons of coal last year. By 1985 this figure could jump to nearly 700 million tons.[17]

Other advertisements stress just the 500 years (no caveat): "We are sitting on half the world's known supply of coal -- enough for over 500 years."[18] Some ads stress the idea of self-sufficiency without stating for how long a period we might be self-sufficient. "Coal, the only fuel in which America is totally self-sufficient."[19] Other ads suggest a deep lack of understanding of the fundamentals of the exponential function.

> Yet today there are still those who shrill (sic) for less energy and no growth... Now America is obligated to generate more energy - not less - merely to provide for its increasing population... With oil and gas in short supply, where will that energy come from? Predominately from coal. The U.S. Department of the Interior estimates America has 23 % more coal than we dreamed of, 4,000,000,000,000 (trillion!) tons of it. Enough for over 500 years. (The non-sentences are in the original.)[20]

A simple calculation of the EET based on a current production rate of 0.6×10^9 tons / yr shows that the growth in the rate of production of coal can't exceed 0.8 % / yr if the ad's 4×10^{12} tons of coal is to last for the ad's 500 yr. However, it should be noted that the 4×10^{12} tons cited in the ad is 2.8 times the size of the large estimate of U.S. coal reserves and is 12 times the size of the small estimate of U.S. coal reserves as cited by Hubbert.

When we view the range of creative information that is offered to the public we cannot wonder that people are confused. We may *wish* that we could have rapid growth of the rate of consumption and have the reserves of U.S. coal last for a large number of years, but very simple calculations are all that is needed to prove that these two goals are incompatible. At this critical time in our nation's history we need to shift our faith to calculations (arithmetic) based on factual data and give up our belief in Walt Disney's First Law: "Wishing will make it so."[21]

On the broad aspects of the energy problem we note that the top executive of one of our great corporations is probably one of the world's authorities on the exponential growth of investments and compound interest. However, he observes that "the energy crisis was made in Washington." He ridicules "the modern-day occult prediction" of "computer print-outs" and warns against extrapolating past trends to estimate what may happen in the future. He then points out how American free-enterprise solved the great "Whale Oil Crisis" of the 1850s. With this single example as his data base he boldly extrapolates into the future to assure us that American ingenuity will solve the current energy crisis if the bureaucrats in Washington will only quit interfering.[22] It is encouraging to note that the person who made these statements in 1974, suggesting that the energy crisis was contrived rather than real, has now signed his name on an advertisement in *Newsweek Magazine* (Sept. 12, 1977) saying that, "Energy is not a political issue. It's an issue of survival. Time is running out." However, the same issue of Newsweek Magazine carried two advertisements for coal which said: "We've limited our use of coal while a supply that will last for centuries sits under our noses... Coal _can provide our energy needs for centuries to come."

Carefully read this ad by the Edison Electric Institute for the Electric Companies telling us that: "There is an increasing scarcity of certain *fuels*. But there is no scarcity of *energy*. There never *has* been. There never *will* be. There never *could* be. Energy is inexhaustible." (Emphasis is in the original.)[23] We can read that a professor in a school of mining technology offers "proof" of the proposition: "Mankind has the right to use the world's resources as it wishes, to the limits of its abilities . . ."[24]

We have the opening sentence of a major scientific study of the energy problem: "The United States has an abundance of energy resources; fossil fuels (mostly coal and oil shale) adequate for centuries, fissionable nuclear fuels adequate for millennia and solar energy that will last indefinitely."[25] We can read the words of an educated authority who asserts that there is no problem of shortages of resources: "It is *not* true that we are running out of resources that can be easily and cheaply exploited without regard for future operations." His next sentence denies that growth is a serious component of the energy problem, "It is *not* true that we must turn our back on economic growth"(emphasis is in the original). Three sentences later he says that there may be a problem: "We must face the fact that the well of nonrenewable natural resources is not bottomless."[26] He does suggest that lack of "leadership" is part of the problem.

We have a statement by Ralph Nader, "The supply of oil, gas, and coal in this country is enormous and enough for hundreds of years. It is not a question of supply but a question of price and profits, of monopolies and undue political influence."[27]

Expert analysis of the problem can yield unusual recommendations. We have the opening paper in an energy conference in which a speaker from a major energy company makes no mention of the contribution of growth to the energy crisis when he asserts that: "The core of the energy problem both U.S. and worldwide [is] our excessive dependence on our two scarcest energy resources - oil and natural gas." For him continued growth is not part of the problem, it is part of the solution! *More* energy must be made available at a higher rate of growth than normal - in the neighborhood of 6 percent per year compared to a recent historical growth rate of 4 percent per year.[28]

The patient is suffering from cancer, and after a careful study, the doctor prescribes the remedy; give the patient more cancer. Here is a second case where cancer is prescribed as the cure for cancer. The National Petroleum Council in its report to the energy industry on the energy crisis: observed that "Restrictions on energy demand growth could prove (to be) expensive and undesirable. . . The Council 'flatly rejected' any conservation-type measures proposing instead the production of more energy sources domestically and the easing of environmental controls."[29]

Study this statement carefully: "Energy industries agree that to achieve some form of energy self-sufficiency the U.S. must mine all the coal that it can."[30] The plausibility of this statement disappears and its real meaning becomes apparent when we paraphrase it: "The more rapidly we consume our resources, the more self-sufficient we will be." David Brower has referred to this as the policy of "*Strength through Exhaustion*." [31] This policy has many powerful adherents. For example, on the three-hour CBS television special on energy (Aug. 31, 1977) William Simon, energy adviser to President Ford said: "We should be "trying to get as many holes drilled as possible to get the proven (oil) reserve . . ."

Is it in the national interest to get and use these reserves as rapidly as possible? We certainly get no sense of urgency from the remarks of the Board Chairman of a major multinational energy corporation who concludes the discussion "Let's Talk Frankly About Energy" with his mild assessment of what we must do. "Getting on top of the energy problem won't be easy. It will be an expensive and time-consuming task. It will require courage, creativeness and discipline . . ."[32]

If one searches beyond the work of Hubbert for an indication of others who understand the fundamental arithmetic of the problem one finds occasional encouraging evidence.[33] However, when one compares the results of the simple exponential calculations with news stories, with statements from public officials, and with assertions in advertisements of the energy companies it is hard to imagine that this arithmetic is widely understood.

VIII. A WORD OF CAUTION

We must note that these calculations of the EET of fossil fuels are not predictions of the future. They simply give us first-order estimates of the life expectancies of known quantities of several fuels under the conditions of steady growth which our society and our government hold sacred. These estimates are emphasized as aids to understanding the consequences of any particular growth scenario that the reader may want to consider or to evaluate.

The rate of production of our mineral resources will not rise exponentially until the EET is reached and then plunge abruptly to zero, as modeled in these calculations and as shown in curve A of Fig. 5 even though our national goals are predicated on uninterrupted growth.

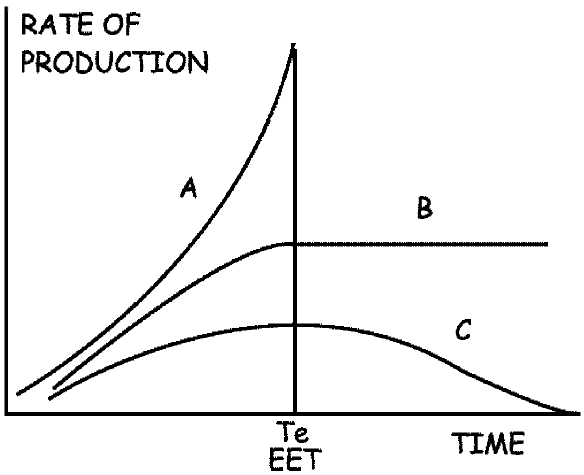

Fig. 5. *Three patterns of growth. Curve A represents steady exponential growth in the rate of production of a non-renewable resource until the resource is exhausted at T_e, the exponential expiration time (EET). The area under the curve from the present (t = 0) to t = T_e is equal to the known size of the resource. Curve C represents Hubbert's model of the way in which the rate of production of a nonrenewable resource rises and falls. This model is based on studies of the rate of use of resources which have been nearly completely consumed. The area under the curve from the present to t = infinity is equal to the size of the resource. Curve B represents the rate of production of a renewable resource such as agricultural or forest products, where a constant steady-state production can be maintained for long periods of time provided this production is not dependent on the use of a nonrenewable resource (such as petroleum) whose production is following a curve such as C.*

The rate of production of our nonrenewable mineral resources will not follow the classical S-shaped transition from an early period of exponential growth to a horizontal curve representing a constant rate of production, curve B. Such a curve can be achieved in the production of renewable resources such as food, forest products, or the production of solar energy, provided the rate of production of the renewable resource is not dependent on fossil fuels. Reference has already been made to the dependence of modern agriculture on petroleum, and as long as this dependence continues, the curve of agricultural production would be expected to follow curve C, (the curve for nonrenewable petroleum) rather than curve B. Although the rate of production of mineral resources has been growing exponentially, one knows that at some time in the future the resource will be exhausted and the rate of production will return to zero. The past history, this one future datum and a careful study of the rate versus time of production of resources that have expired has led Dr. M. King Hubbert to the conclusion that the rate of production of a nonrenewable resource will rise and fall in the symmetrical manner of a Gaussian error curve as shown in curve C of Fig. 5. When he fits the data for U.S. oil production in the lower 48 states to a curve such as C, Hubbert finds that we are now just to the right of the peak. We have used one-half of the recoverable petroleum that was ever in the ground in the U.S. and in the future the rate of production can only go downhill. However, our national demand for petroleum has continued to grow exponentially and the difference between our demands and our production has been made up by imports. Bold initiatives by the Congress could temporarily reverse the trend and could put a small bump on the downhill side of the curve. Alaskan oil can put a little bump on the downhill side of the curve. The downhill trend on the right side of the curve was noted clearly by Deputy Energy Secretary John O'Leary under the headline, "U.S. Energy 'Disaster' Inevitable by 1985,"[34]

> Although U.S. oil and gas production hit their peak several years ago and are declining by about 8 percent per year, O'Leary said, the nation has avoided serious problems by using more foreign oil...We are walking into a disaster in the next three or four years with our eyes wide open.

The most dramatic conclusion that Hubbert draws from his curve for the complete cycle of U.S. oil production is that the consumption of the central 80 % of the resource will take place in only 67 yr! It is very sobering to face the downhill side of the curve and to note that in the past the rise in our annual per capita consumption of energy has gone hand-in-hand with the increase of our standard of living. It is more sobering to note the close coupling between our production of food and our use of petroleum. It is even more sobering to note that on March 7, 1956 (over 22 years ago) Dr. Hubbert, addressing the conference in San Antonio, Texas, of a large group of petroleum engineers and geologists said:

> According to the best currently available information, the production of petroleum and natural gas on a world scale will probably pass its climax within the order of half a century, while for both the United States and for Texas, the peaks of production can be expected to occur within the next 10 or 15 years. (i.e., between 1966 and 1971)

Pazik tells[33] of the shock this statement and the related analysis caused in oil industry circles and he tells about the efforts that were made by the "experts" to ignore this and the other results of the analysis made by Hubbert.

IX. WHAT DO WE DO NOW?

The problems are such that we have rather few options. All of the following points are vital:

(i) We must educate all of our people to an understanding of the arithmetic and consequences of growth, especially in terms of the earth's finite resources. David Brower has observed that, "The promotion of growth is simply a sophisticated way to steal from our children."

(ii) We must educate people to the critical urgency of abandoning our religious belief in the disastrous dogma that "growth is good," that "bigger is better," that "we must grow or we will stagnate," etc., etc. We must realize that growth is but an adolescent phase of life which stops when physical maturity is reached. If growth continues in the period of maturity it is called obesity or cancer. Prescribing growth as the cure for the energy crisis[28, 29] has all the logic of prescribing increasing quantities of food as a remedy for obesity. *The recent occasion of our nation's 200th anniversary would be an appropriate time to make the transition from national adolescence to national maturity.*

(iii) We must conserve in the use and consumption of everything. We must outlaw planned obsolescence. We must recognize that, as important as it is to conserve, the arithmetic shows clearly that large savings from conservation will be wiped out in short times by even modest rates of growth. For example, in one or two dozen years a massive federal program might result in one-half of the heat for the buildings where we live and work being supplied by solar energy instead of by fossil fuels. This would save 10 % of our national use of fossil fuels, but this enormous saving could be completely wiped out by two years of 5 % growth. Conservation alone cannot do the job! The most effective way to conserve is to stop the growth in consumption.

As we consider the absolute urgency of conservation we must recognize that some powerful people are hostile to the concept of conservation. One of our great multinational oil companies has advertised that conservation is: "Good for you - but not if there's too much." And in the same ad they noted that: "Conservation does no harm."[35]

In his message to the American people President Carter proposed a tax on large "gas guzzling" cars. General Motors Chairman Thomas Murphy had the following reaction to this proposal to conserve energy:

Murphy calls the excise tax on big cars, coupled with rebates on small cars "one of the most simplistic irresponsible and short-sighted ideas ever conceived by the hip-shooting marketeers of the Potomac."[36]

Big labor is hostile to this same conservation measure. Leonard Woodcock, President of the United Auto Workers said of the tax: "I respectfully suggest that the proposal is wrong. It is not properly thought through and should be withdrawn."[37]

Congress is not enthusiastic about conservation: "Look for Senate leaders on both sides of the aisle - including Chairman Russell Long of the Finance Committee and Minority Leader Howard Baker - to gang up on Carter's energy package. The two influential lawmakers want more stress on the production of oil, not so much on conservation."[38]

Closer to home we can note that our governors don't show much enthusiasm for conservation: "The nation's governors told President Carter that the federal government is placing too much emphasis on conservation and not enough on developing new resources."[39]

With all this influential opposition one can see how difficult it will be to launch major national programs of energy conservation.

(iv) We must recycle almost everything. Except for the continuous input of sunlight the human race must finish the trip with the supplies that were aboard when the "spaceship earth" was launched.

(v) We must invest great sums in research (a) to develop the use of solar, geothermal, wind, tidal, biomass, and alternative energy sources; (b) to reduce the problems of nuclear fission power plants; (c) to explore the possibility that we may be able to harness nuclear fusion. These investments must not be made with the idea that if these research programs are successful the new energy sources could sustain growth for a few more doubling times. The investments must be made with the goal that the new energy sources could take over the energy load in a mature and stable society in which fossil fuels are used on a declining exponential curve as chemical raw materials and are not used as fuel for combustion. One great area of responsibility of our community of scientists and engineers is vigorous pursuit of research and development in all these areas. These areas offer great opportunity to creative young people.

Perhaps the most critical things that we must do is to decentralize, and consequently humanize, the scale and scope of our national industrial and utility enterprises.[40]

(vi) We must recognize that it is exceedingly unscientific to promote ever-increasing rates of consumption of our fuel resources based on complete confidence that science, technology, and the economics of the marketplace will combine to produce vast new energy resources as they are needed. Note the certainty that characterizes this confidence.

Coal could help fight a rear-guard action to provide time for scientific breakthroughs which will move the world from the fossil fuel era of wood, gas, oil, and coal to the perpetual energy era of infinitely renewable energy resources.[41] The supply (of coal) is adequate to carry the U.S. well past the transition from the end of the oil and gas era to new, possibly not discovered sources of energy in the 2000s.[42]

There seems to be an almost complete absence of the caution that would counsel us to stop the growth of our national energy appetite until these "unlimited energy resources" are proven to be capable of carrying the national energy load. We must recognize that it is not acceptable to base our national future on the motto "When in doubt, gamble."

Fusion is most commonly mentioned as being an unlimited energy source. The optimism that leads some people to believe that fusion power will be ready whenever it is needed should be balanced against this opening statement in a report on fusion from MIT. "Designing a fusion reactor in 1977 is a little like planning to reach heaven: theories abound on how to do it, and many people are trying, but no one alive has ever succeeded."[43]

If the generation of electric power from fusion was achieved today, we could ask how long would it then be before fusion could play a significant role in our national energy picture. The time-constant for the replacement of one major energy source by another can be estimated from the fact that the first nuclear fission reactor was operated in December 1942. Even though the recent growth of nuclear energy in the U.S. has been spectacular, it was not until around 1972 that annual energy consumption equaled our annual energy consumption from firewood! By 1973 nuclear energy had climbed to the point where it supplied 1.3 % of our U.S. total annual energy consumption and 4.6 % of our electrical power.[44] Thus in 31 years nuclear energy has grown to provide only a small fraction of our energy needs. Had there been no growth of our national electrical needs since 1942, today's nuclear plants would be supplying 41 % of our national electrical power.

(vii) We can no longer sit back and deplore the lack of "leadership" and the lack of response of our political system. In the immortal words of Pogo "We have met the enemy, and they's us." We are the leaders, we are vital parts of the political system and we have an enormous responsibility.

The arithmetic makes clear what will happen if we hope that we can continue to increase our rate of consumption of fossil fuels. Some experts suggest that the system will take care of itself and that growth will stop naturally, even though they know that cancer, if left to run its natural course, always stops when the host is consumed. My seven suggestions are offered in the spirit of *preventive* medicine.

X. CONCLUSION

The preceding calculations are offered as guideposts which must be understood by those who would deal constructively with the energy crisis. The role and limitations of science in analyzing and in solving our problems was beautifully expressed by Gustav Lebon (1841-1931).

> "Science has promised us truth; an understanding of such relationships as our minds can grasp. It has never promised us either peace or happiness."

Perhaps the most succinct conclusion that is indicated by the analysis above is taken from the immortal words of Pogo, "The future ain't what it used to be!" The American system of free enterprise has flourished for 200 years with spectacular achievements. Until recently it flourished in a world whose energy resources were essentially infinite. Whenever one fossil fuel came into short supply, another could always be found to take its place. We are now close enough that we can see the end of the world's total supply of fossil fuels. The challenge that we must meet is set forth clearly in the question, "Can free enterprise survive in a finite world?" President Carter observed (April 18, 1977) that: "If we fail to act soon we will face an economic, social, and political crisis that will threaten our free institutions." (See Fig. 6)

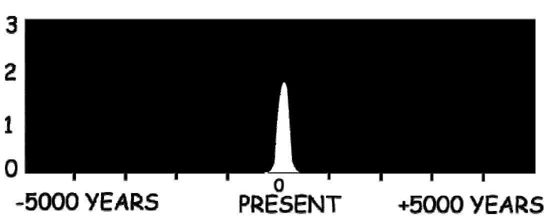

Fig. 6. *The delta function in the darkness. Redrawn from Hubbert's Fig. 69, Ref. 7. The epoch of the world's use of its fossil fuels is shown on a time scale of human history from 5000 yr ago to 5000 yr in the future. The vertical axis is the rate of consumption of fossil fuels measured in units of* 10^{14} *kW h / yr. The vertical scale is a linear scale.*

XI. A POSTSCRIPT FOR SCIENCE TEACHERS

For decades physics teachers throughout the world have discussed the RC circuit and the decay of radioactive atoms and have thus introduced the simple differential equation that gives rise to exponential decay of the charge on the capacitor or of the number of remaining radioactive nuclei. These provide a wonderful opportunity for us to digress and to point out that exponential arithmetic has great value outside of these two special examples in physics and to show our students that exponential arithmetic is probably the most important mathematics they will ever see. It is especially important for students to see how the change in the sign of the exponent can make an enormous difference in the behavior of the function. But we will need to do more. We must integrate the study of energy and of the exponential arithmetic into our courses as has been done, for example, in one new text.[44] In addition, we have an even larger task. As science teachers we have the great responsibility of participating constructively in the debates on growth and energy. We must be prepared to recognize opinions such as the following, which was expressed in a letter to me that was written by an ardent advocate of "controlled growth" in our local community: "I take no exception to your arguments regarding exponential growth. I don't think the exponential argument is valid on the local level."

We must bring to these debates the realism of arithmetic and the new concept of precision in the use of language. We must convey to our students the urgency of analyzing all that they read for realism and precision. We must convey to our students the importance of making this analysis even though they are reading the works of an eminent national figure who is writing in one of the world's most widely circulated magazines. (The emphasis in the following quotations is in the original.

> The simple truth is that America has an abundance of energy resources... An estimated 920 *trillion* cubic feet of natural gas still lies beneath the United States. Even at present consumption rates, this should last at least 45 years... About 160 *billion* barrels of oil still lie below native ground or offshore. That's enough to last us into the next century at present rates of consumption.[45]

When students analyze these statements they can see that the first statement is false if "abundance" means "sufficient to continue currently accepted patterns of growth of rates consumption for as long as one or two human lifetimes." An evaluation of the second and third statements show that they are falsely reassuring because they suggest the length of time our resources will last under the special condition of no growth of the rates of use of these resources. The condition of no growth in these rates is absolutely contrary to the precepts of our national worship of growth. It is completely misleading to introduce the results of "no growth:" unless one is advocating "no growth."

If it is true that our natural gas reserves will last 45 yr at present rates of consumption ($R / r_0 = 45$ yr), then Eq. (6) shows that this amount of gas would last only 23.6 yr at an annual growth rate of 5 % / yr, and only 17 yr at an annual growth rate of 10 % / yr. When the third statement is analyzed one sees that the given figure of 160×10^9 barrels of reserves is roughly 60 % larger than Hubbert's estimate. This amount would last 49 yr if oil was produced at the 1970 rate of 3.3×10^9 barrels / yr, held constant with no growth. However, our domestic consumption is now roughly twice the rate of domestic production, *so this amount of oil would satisfy domestic needs for only about 25 yr if there was no growth in these domestic needs.* If $R / r_0 = 25$ yr, then Eq. (6) shows that this amount of oil would last only 16.2 yr if production grew 5 % / yr and only 12.5 yr if it grew 10 % / yr.

We can conclude that the author is probably advocating growth in the rate at which we use fossil fuels from the following imprecise statement, "The fact is that we must produce more energy." Therefore the author's statements about the life expectancy of resources at current rates of use are irrelevant. When they are offered as reassurance of the lack of severity of our energy problem they are dangerously and irresponsibly misleading.

Students should be able to evaluate the same author's statement about coal, "At least 220 *billion* tons of immediately recoverable coal - awaits mining in the United States." This "could supply our energy needs for several centuries." Students can see that the size of the coal reserves given by the author is significantly smaller than either of the two estimates given by Hubbert. They can see that it is imprecise and meaningless to suggest how long a resource will last if one says nothing about the rate of growth of production. In addition to encouraging our students to carry out their responsibility to analyze what they read, we must encourage them to recognize the callous (and probably careless) inhumanity of a prominent person who is perhaps in his fifties,[45] offering reassurance to younger readers to the effect, "don't worry, we have enough petroleum to last into the next century," The writer is saying that "There is no need for you to worry, for there is enough petroleum for the rest of my life." Can we accept the urgings of those who advocate unending expansion and growth in the rates of consumption of our fossil fuel resources and who say "Why worry, we have enough to last into the next century."

We must give our students an appreciation of the critical urgency of evaluating the vague, imprecise, and meaningless statements that characterize so much of the public debate on the energy problem. The great benefits of the free press place on each individual the awesome responsibility of evaluating the things that he or she reads. Students of science and engineering have special responsibilities in the energy debate because the problems are quantitative and therefore many of the questions can be evaluated by simple analysis.

Students must be alert not only to the writings in the popular press but to the writings in college textbooks. In the bookstore of a school of engineering I purchased a book that was listed for one of the courses, possibly in political science. Here are a few interesting statements from the book:[46]

> Our population is not growing too rapidly, but much too slowly... To approach the problem ("the population scare") from the standpoint of numbers per se is to get the whole thing hopelessly backward... Our coal supply alone, for example, is sufficient to power our economy for anywhere for 300 to 900 years - depending on the uses to which it is put - while gas and oil and coal together are obviously good for many centuries... So whatever the long-term outlook for these energy sources, it is obvious (that) natural shortage cannot account for the present energy crunch.

Dr. Hubbert, speaking recently, noted that we do not have an energy crisis, we have an energy shortage. He then observed that *the energy shortage has produced a cultural crisis.*

We must emphasize to our students that they have a very special role in our society, a role that follows directly from their analytical abilities. It is their responsibility (and ours) to become the great humanists.

Note added in proof:

Two incredible misrepresentations of the life expectancy of U.S. coal reserves have been called to my attention recently. *Time* (April 17, 1978, p.74) said:

> Beneath the pit heads of Appalachia and the Ohio Valley, and under the sprawling strip mines of the West, lie coal seams rich enough to meet the country's power needs for centuries, *no matter how much energy consumption may grow*." (emphasis added)

In reply to my letter correcting this, *Time* justified their statement by saying that they were using the Citibank estimate of U.S. coal reserves which is larger than the estimate used by Hubbert.

A beautiful booklet, "Energy and Economic Independence" (Energy Fuels Corporation of Denver, Denver, 1976) said: "As reported by *Forbes* magazine, the United States holds 437 billion tons of known (coal) reserves. That is equivalent to 1.8 trillion barrels of oil in British Thermal units, *or enough energy to keep 100 million large electric generating plants going for the next 800 years or so.*" (emphasis added) This is an accurate quotation from *Forbes*, the respected business magazine (December 15, 1975, p.28). Long division is all that is needed to show that 437×10^9 tons of coal would supply our 1976 production of 0.665×10^9 tons per year for only 657 years, and we probably have fewer than 500 large electric generating plants in the U.S. today. This booklet concluded, "Your understanding of the facts about 'energy and economic independence' issue is of great importance."

A very thoughtful comment on fusion was made to me recently by a person who observed that it might prove to be the worst thing that ever happened to us if we succeed in using nuclear fusion to generate electrical energy because this success would lead us to conclude that we could continue the unrestrained growth in our annual energy consumption to the point (in a relatively few doubling times) where our energy production from the unlimited fusion resource was an appreciable fraction of the solar power input to the earth. This could have catastrophic consequences.

Richard Stout, columnist for the *New Republic*, noted (*Time*, March 27, 1978, p.83) that in America, "We consume one third of all the energy, one third of the food and enjoy one half of the world's income. Can a disparity like this last? I think that much of the news in the next 50 years is going to turn on whether we yield to the inevitable graciously or vindictively."

ACKNOWLEDGEMENTS

A great deal of correspondence and hundreds of conversations with dozens of people over six years have yielded many ideas, suggestions, and facts which I have incorporated here. I offer my sincere thanks to all who have helped.

APPENDIX

When a quantity such as the rate $r(t)$ of consumption of a resource grows a fixed percent per year, the growth is exponential:

$$r(t) = r_0 e^{kt} = r_0 2^{t/T2} \qquad (1)$$

where r_0 is the current rate of consumption at $t = 0$, e is the base of natural logarithms, k is the fractional growth per year, and t is the time in years. The growing quantity will increase to twice its initial size in the doubling time $T_2$where:

$$T_2\,(\text{yr}) = (\ln 2) / k \;»\; 70 / P \qquad (2)$$

and where P, the percent growth per year, is $100k$. The total consumption of a resource between the present ($t = 0$) and a future time T is:

$$C = \{T \ to \ 0\} \quad r(t)\,dt \qquad (3)$$

The consumption in a steady period of growth is:

$$\text{C} = \text{r}_0 \{T \ to \ 0\} \quad e^{kt}\,dt = (r_0 / k)(e^{kt} - 1) \qquad (4)$$

If the known size of the resource is R tons, then we can determine the exponential expiration time (EET) by finding the time T_e at which the total consumption C is equal to R:

$$R = (r_0 / k)(e^{kTe} - 1) \qquad (5)$$

We may solve this for the exponential expiration time T_e where:

$$\text{EET} = T_e = (1/k) \ln(kR / r_0 + 1) \qquad (6)$$

This equation is valid for all positive values of k and for those negative values of k for which the argument of the logarithm is positive.

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1. This paper is based on a series of articles, "The Exponential Function" which is appearing in *The Physics Teacher:*
(a) Vol. 14, p. 393 (Oct. 1976); (b) Vol. 14, p. 485 (Nov. 1976); (c) Vol. 15, p. 37 (Jan. 1977); (d) Vol. 15, p. 98 (Mar. 1977); (e) Vol. 15, p. 225 (Apr. 1977); (f) Vol. 16, p. 23 (Jan. 1978); (g) Vol. 16, p. 92 (Feb. 1978); (h) Vol. 16, p. 158 (Mar. 1978). An early version of this paper was presented at the Third Annual UMR-MEC Conference on Energy, held at the University of Missouri at Rolla, Oct. 12-14, 1976, and appears in the volume of the *Proceedings of the Conference*. The early version, or minor revisions of it have been published in *Not Man Apart* published by Friends of the Earth: July / Aug. 1977, Vol. 7, No. 14 pp. 12-13; *The Vermillion Flycatcher* (Tucson,

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REPRINTINGS

This paper has been rewritten and reprinted many times in the 20 years since it was first published.

The paper was enlarged and was published in: *Mineral & Energy Resources*, Colorado School of Mines, Golden, Colorado; Part I, Vol. 22, Sept. 1979, pp. 1-46; Part II, Vol. 22, Nov. 1979, pp. 1-9; Part III, Vol. 23, Jan. 1980, pp. 1-10.

The enlarged version was also published in the *Journal of Geological Education*, Vol. 28, Jan. 1980, pp. 4-35.

The paper was rewritten as a chapter in the book, *Perspectives on Energy* by L.C. Ruedisili and M.W. Firebaugh, Third Edition, Oxford University Press, New York City, 1982.

The paper was reprinted in *New Trends in Physics Teaching*, Vol. IV, 1984, pp. 20-37 by the United Nations Educational Scientific and Cultural Organization in Paris, France.

Short versions of this paper have been printed as essays in introductory physics textbooks by Halliday & Resnick, Serway, and Tipler. Other authors of physics texts have written chapters or sections in their texts using these applications of exponential arithmetic.

The paper has been reprinted in full or abridged in over 30 different publications or proceedings, and was translated into Spanish for publication in Mexico.

I adapted the paper to data on energy in Canada, and it was published as "Forgotten Fundamentals of the Energy Crisis: A Canadian Perspective," by the Industrial Energy Division of the Ministry of Energy, Mines, and Resources of the Federal Government of Canada, Ottawa, Canada, May 1986.

This paper was listed as one of ten "memorable papers" for the year 1978 that was included in a list of "Memorable papers from the *American Journal of Physics, 1933-1990*" R.H. Romer, American Journal of Physics, Vol. 59, March 1991, p. 205.

The paper was included in the "*Physics Teachers' CD-ROM Toolkit*" published by the University of Nebraska, 1993.

Video copies of Dr. Bartlett's lecture are available from University of Colorado Television; Academic Media Services; Campus Box 379; Boulder, CO 80309-0379; (303) 492-1857.

Additional and Updated Information

Understanding the Concept (and Effect of) Constant Growth

THE GREATEST SHORTCOMING OF THE HUMAN RACE IS OUR INABILITY TO UNDERSTAND THE EXPONENTIAL FUNCTION!

If it takes a fixed length of time to grow five percent, then it follows that it takes a longer fixed length of time to grow by one hundred percent.

This longer time is called THE DOUBLING TIME.

We can calculate the doubling time.

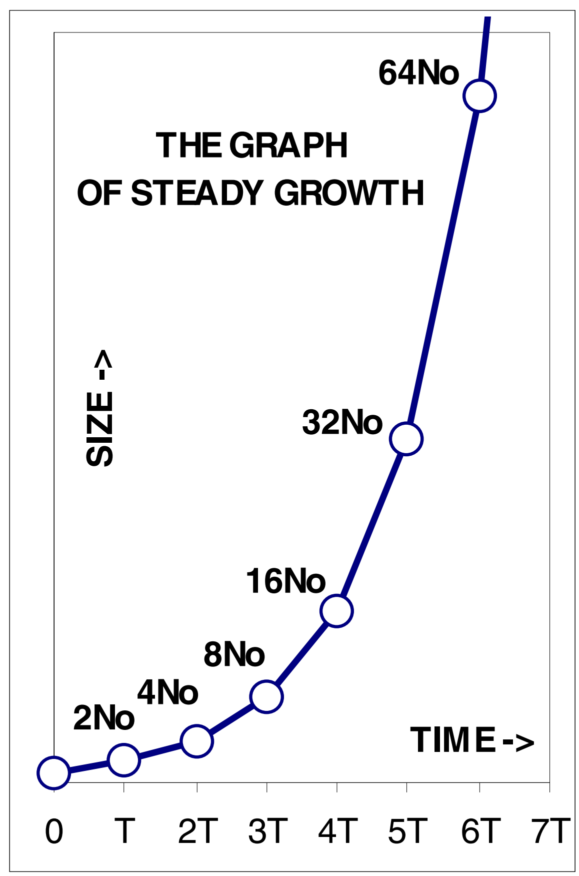
$$T_2 = \frac{\mathbf{70}}{\text{(PERCENT GROWTH PER UNIT TIME)}}$$

Thus a growth rate of **5%** per year has a doubling time of

$T_2 = 70 / 5 =$ **14 years**

Where did the 70 come from?

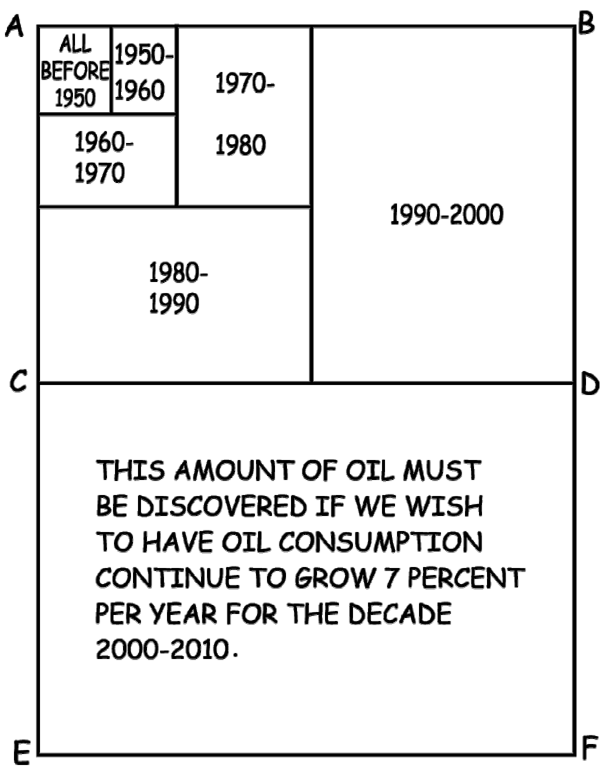
$70 \sim 100 \ln 2 = 69.3$



THE GROWTH IN ANY DOUBLING TIME

IS GREATER THAN

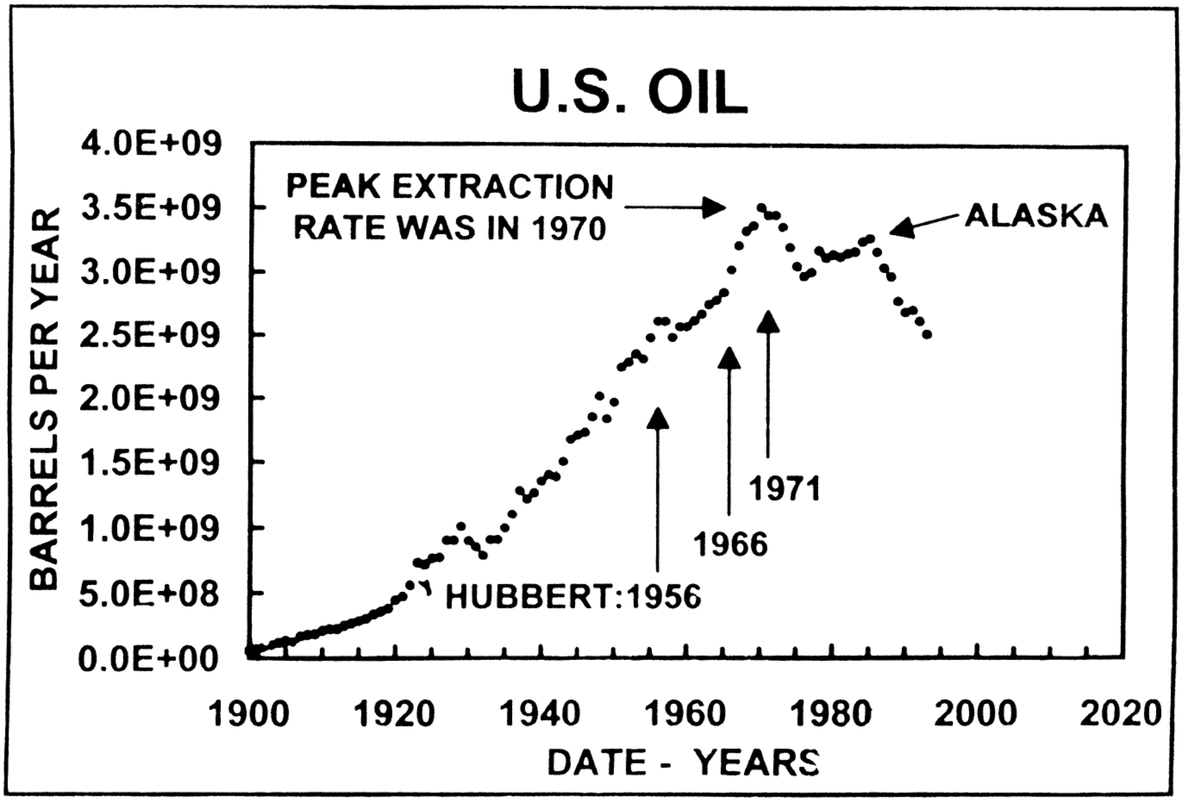
THE TOTAL OF ALL THE PRECEDING GROWTH!



So, if growth in energy demand is 7% per year, the doubling time is ten years.

If that rate of growth is maintained, we will need AS MUCH ENERGY in the next ten years as has been used from the beginning of the history of energy use UNTIL NOW.

Oil Reserves in the United States



A A BARTLETT   DISK 7   USOIL3.XLC   Chart4

Market News

ALERTS   February 17, 1999 10:2[illegible] AM E

Headlines   Market News Index

02/17 10:00 U.S. lower 48-state Jan oil output hits 50-yr low

WASHINGTON, Feb 17 (Reuters) - U.S. crude oil production in the lower 48 states during January sank to 4.8 million barrels per day (bpd), the lowest level in more than 50 years and down 6 percent from a year ago, the American Petroleum Institute said Wednesday.

In its monthly energy statistical report, the API said January oil production in Alaska, which accounted for one-fifth of total U.S. production was down 15 percent from last year to just 1.1 million bpd

ROCKY MOUNTAIN NEWS OCT. 6, 1993

NATION

Shell pumps funds into gulf

Shell Oil Co. said Tuesday it planned to spend $1.2 billion to develop the largest oil discovery in the Gulf of Mexico in the past 20 years. The discovery, called Mars, has an estimated ultimate recovery in excess of 700 million barrels of oil and gas. The find is 71.5% owned by Houston-based Shell and 28.5% owned by BP Exploration, a unit of British Petroleum Co. Plc. Shell, part of the Anglo-Dutch giant Royal Dutch/Shell Group, said production should begin in late 1996 and is expected to reach a peak daily rate of 100,000 barrels of oil and 110 million cubic feet of gas.

U.S. CONSUMES (1991) 16.6 MB/D
HOW LONG WOULD THIS LAST?

$$\frac{700\ MB}{16.6\ MB/D} = 42\ DAYS$$

THE WALL STREET JOURNAL.

★ ★ ★ INTERNET ADDRESS: http://wsj.com THURSDAY, JULY 18, 1996 WESTERN EDITION DENVER, COLORADO

U.S. Oil Output Tumbled in First Half As Alaska's Production Fell Nearly 8%

BY ANNE REIFENBERG
Staff Reporter of THE WALL STREET JOURNAL

U.S. crude oil output fell sharply in the first half of the year, with production from Alaska's enormous fields taking an unexpected, nearly 8% tumble, the American Petroleum Institute reported.

One consequence was another jump in the amount of imported petroleum used by Americans to 52% from 49% of total consumption.

The nation's production of oil has been tracking downward for more than a decade. But industry analysts were surprised by the rate of decline recorded in the first six months of 1996: 3.1%, more than double the 1.5% rate in the same period of 1995. And the number of oil-well confirmations, a barometer of the explorations and production sector's health, also slipped abruptly -- by 18% -- even though crude was selling for about $2 a barrel more this spring than last.

"With prices like that, it's not as if people wouldn't have been trying to get oil out of the ground," said Ken Haley, chief economist for Chevron Corp. in San Francisco. "The question we can't answer yet is whether this is a new trend or a quirk."

The petroleum institute, which keeps statistics for the industry, had thought the exploration-and-production boom in the Gulf of Mexico would compensate for sluggish activity in the continental U.S. "But what's going on in the Gulf isn't enough to completely offset the decline onshore in the lower 48," said Ed Murphy, the institute's chief economist, "and certainly not enough to make up for Alaska production falling off so very, very quickly."

Alaska's prolific North Slope fields, among the biggest in the world, were discovered nearly 30 years ago. The Slope's output peaked in 1988, at about two million barrels a day. "The only thing that companies can do in Alaska is try to slow the rate of decline," said Peter Jacquette, an energy analyst with WEFA Group in Eddystone, Pa.

FROM THE WORK OF
DR. M. KING HUBBERT

WORLD CRUDE OIL CONSUMPTION

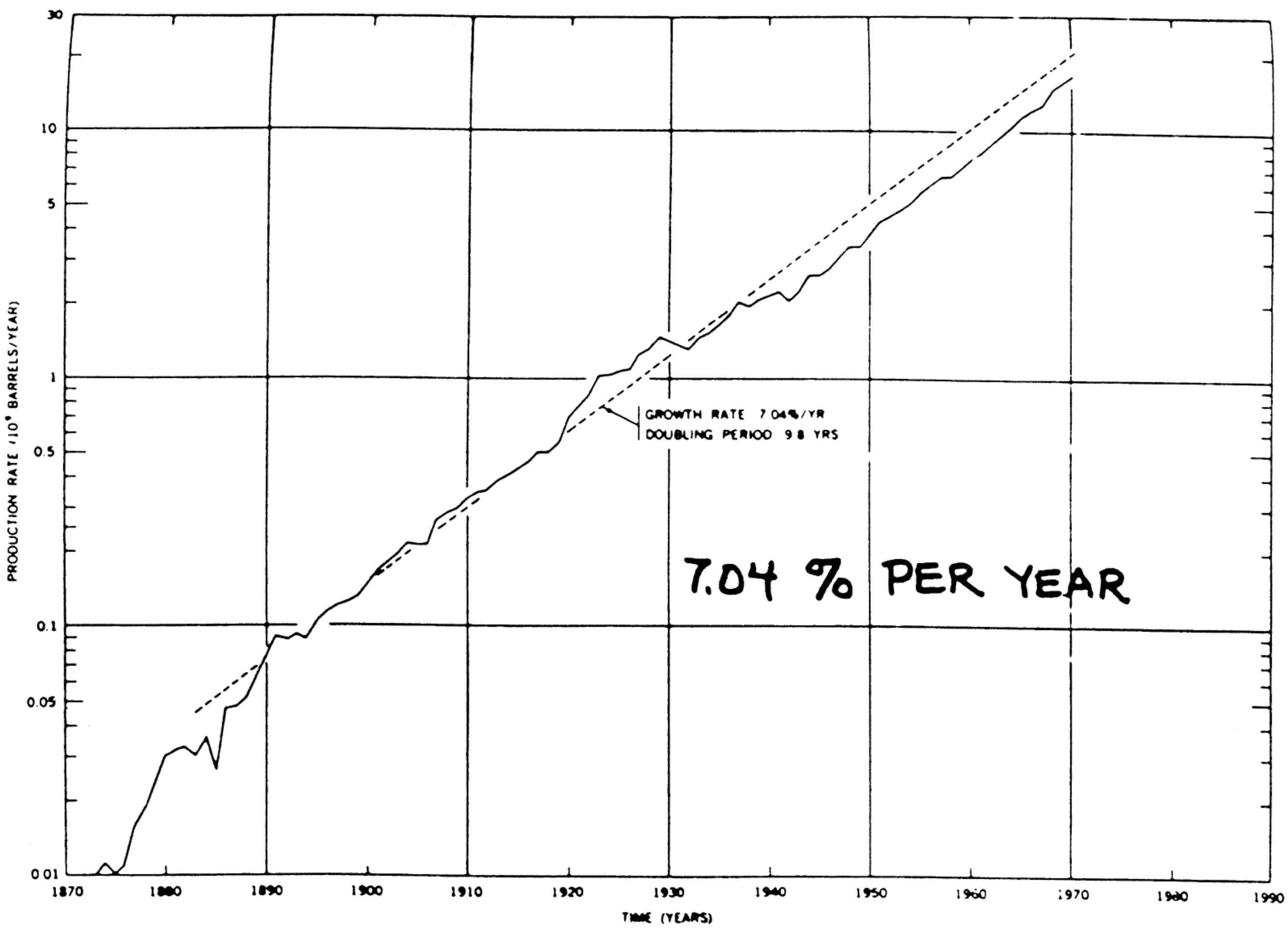
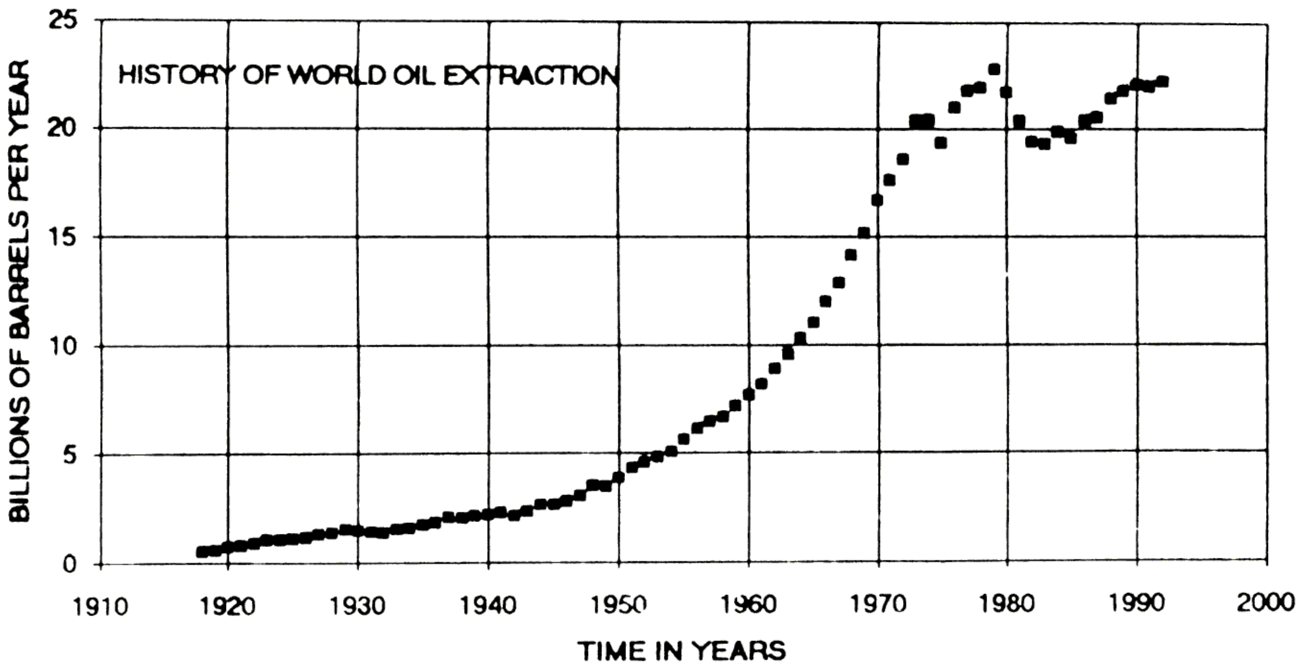


FIGURE 6. – World crude-oil production. (Semilogarithmic scale.)


HISTORY OF WORLD OIL EXTRACTION
BILLIONS OF BARRELS PER YEAR
0
5
10
15
20
25
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
TIME IN YEARS

Here is an example
of the policy of
"**<u>STRENGTH THROUGH EXHAUSTION</u>**."

William Simon, Energy Advisor to
U.S. President Gerald Ford:

"We should be trying to get as many holes drilled as possible to get the proven (oil) reserve."

CBS Television
August 31, 1977

Commenting on a scientific analysis that was done by petroleum geologists,

M.A. Adelman, Emeritus Professor of Economics at M.I.T., said:

"This analysis is a piece of foolishness."

"The world will never run out of oil, not in 10,000 years."

Fortune
November 22, 1999, Pg. 194

We have non-scientists telling us
that petroleum reserves
are greater
than ever before in history,

and we have geologists
telling us that we are finding
only one new barrel of oil
for every four barrels
we pump from the ground.

WHAT'S GOING ON?

YOU CANNOT

LET OTHERS

DO YOUR

THINKING

FOR YOU!

From *THE WALL STREET JOURNAL*:

"Four Decades Later, Oil Field Off Canada Is Ready to Produce

Politics, Money, and Nature Put Vast Deposit on Ice;
Now, It Will Last 50 Years

'Shot in the Arm for U.S.'

… The Hibernia field, one of the largest oil discoveries in North America in decades, should deliver its first oil by year end. At least 20 more fields may follow, offering well over one billion barrels of high-quality crude and promising that a steady flow of oil will be just a quick tanker-run away from the energy-thirsty East Coast."

April 1, 1997

USE LONG DIVISION:

U.S. CONSUMPTION (1994) $18X10^6$ BARRELS/DAY

$$\frac{1 \times 10^9 \text{ BARRELS}}{18 \times 10^6 \text{ B/D}} = \textbf{56 DAYS not "50 years"}$$

Dr. Julian Simon

Formerly Professor of Economics and Business Administration, University of Illinois

And in 1992, Professor of Business Administration, University of Maryland, and Adjunct Scholar of the Heritage Foundation:

Writing about oil from many sources (including biomass), Simon says,

"Clearly there is no meaningful limit to this source except the sun's energy…"

"but even if our sun were not as vast as it is, there may well be other suns elsewhere."

The Ultimate Resource
Princeton University Press, 1981, Page 49.

Coal Reserves in the United States

DATA FOR U.S. COAL

"Annual Energy Review: 1991," U.S. Department of Energy, pgs. 109, 189

Coal Demonstrated Reserve Base:

$R = 4.7 \times 10^{11}$ tons*

*"about one-half of the demonstrated reserve base of coal in the United States is estimated to be recoverable."

$R = 2.4 \times 10^{11}$ tons

Extraction Rates

1971 $r_0 = 5.6 \times 10^8$ tons/yr

1991 $r_0 = 9.9 \times 10^8$ tons/yr

Average Rate of Growth

2.86% per year

LIFE EXPECTANCY OF U.S. COAL

Growth Rate	Recoverable	Reserve Base
8% per year	37 Years	46 Years
7	41	50
6	45	56
5	51	64
4	59	75
3	70	91
2.86*	**72**	**94**
2	87	117
1	121	174
0	236	473

* Avg. growth rate 1971-1991

Data from "Annual Energy Review: 1991," U.S. Department of Energy, pgs. 109, 189

"We spent about $25 billion for imported oil last year," Beall* said, adding that any reduction in the dependence on imported oil could be greatly aided by increased use of coal.

He estimated that America's coal reserves are so huge they could last "a minimum of 300 years and probably a maximum of 1000 years."

*Director of the Energy Division of the Oak Ridge National Laboratories

Boulder Daily Camera
July 5, 1975

COMPARE THIS TO THE "LIFE EXPECTANCY OF U.S. COAL," ABOVE.

"By the lowest estimate, we have enough (coal) for 200 years, by the highest, enough for more than a thousand years."

CBS reporter Wagner
CBS Television
Special Program on Energy
August 31, 1977

HOW DOES THIS STATEMENT HOLD UP WHEN COMPARED TO THE FACTS?

NEWSWEEK MAGAZINE

In a cover story on energy (July 16, 1979) said that "at present rates of consumption" we have enough coal for "666.5 years."

DOES THAT MEAN THERE IS ENOUGH COAL FOR OVER 600 YEARS?

Don't believe any prediction
of the life expectancy of a non-renewable resource
until you have confirmed
the prediction
by repeating the calculation.

COROLLARY

The more optimistic the prediction
the greater is the probability
that it is based
on faulty arithmetic
or on no arithmetic at all.

THE DENVER POST

ON THE WEB
The Denver Post Online
denverpost.com

Century's forecast: Hot

Much of U.S. may go winterless before 2099

By H. Josef Hebert
The Associated Press

WASHINGTON — Alpine meadows will disappear, along with many coastal wetlands and barrier islands. Cities will be hotter and more humid. Ski runs will be scarcer, the demand for air conditioners will increase and scientists probably will have to combat a resurgence in insect-borne diseases such as malaria.

That is the weather forecast for the late 21st century, when average U.S. temperatures will have risen by 5 to 10 degrees.

In much of America, winter may disappear, limiting outdoor activities such as skiing.

Warmer weather will reduce the mountain snowpack, curtailing the summer runoff that feeds irrigation across much of the West and complicating water management.

But more rain is predicted for the arid Southwest. That could bring new vegetation — and more flash floods — to desert lands. Tree, fish and animal species will migrate northward everywhere.

Four years in the making, the report reflects the most ambitious

■ **DRY:** The Southeast is in the grip of a drought the likes of which some states have not seen in generations **/16A**

A dozen government agencies and hundreds of scientists, in and out of government, worked on "Climate Change in America." It will be released next week and later presented to Congress, which asked for the assessment a decade ago.

The Associated Press obtained a draft of the report's summary.

"Based on the best available information, most Americans will experience significant impacts" from Earth's warming, the report concludes. Among the findings:

■ Entire ecosystems may shift northward as temperatures increase.

■ The alpine meadows of the Rocky Mountains most likely will disappear.

■ Forests in the Southeast may break into "a mosaic of forests, savannas and grasslands," and sugar maples could disappear from Northeastern forests.

■ Ocean levels will rise, causing wetlands, marshes and barrier is-

JUNE 9, 2000 P.1A

100-year forecast sees cities going winterless

CLIMATE from Page 1A

lands to disappear or — when the geography allows — be forced inland.

■ The Great Lakes are predicted to decline because of increased evaporation.

■ Some coastal cities, faced with higher sea levels and more frequent storm surges, may have to redesign and adapt water, sewer and transportation systems. The study does not try to put a price tag on such improvements.

Some critics have charged that the report paints too dismal a picture and plays down potential benefits of warming — increased crop yields and warmer winters that may make life more pleasant in some areas, for example.

The document acknowledges "a complex mix of positive and negative impacts" if, as most climate scientists predict, pollution in the atmosphere raises temperatures worldwide by an average of 4 to 9 degrees over the next 100 years.

An early draft of the summary was attacked in December as having "an extreme, alarmist tone" on predicting impact on human health. The summary has been revised with more emphasis on the uncertainties of such predictions.

Nevertheless, the study says higher temperatures and increased rainfall are likely to worsen air pollution, saddle large cities with more frequent and severe heat waves, and lead to the spread of waterborne or insect-carrying diseases including malaria in the Southeast.

But warming also bring positive results, the study says.

Trees will grow faster, and the amount of timber in America's forests — especially hardwoods — will increase steadily through the century.

Farmers will be able to grow more crops, although both in agriculture and forestry there could be increased possibilities of pests and fire.

the small society **by Brickman**

Ruby Hargrave

Executive Director, Honolulu Community Action Program

Honolulu Community Action Program

The Honolulu Community Action Program, Inc. (HCAP), a 501(c)(3) entity, has been operating since September 1965. HCAP is a creation of the Economic Opportunity Act of 1964. In 1980, our funding came under the Federal Community Services Block Grant, administered by the State. The goal of the agency is to provide opportunities to low-income families on Oahu to become self-sufficient.

It is a federal mandate that the CAP agencies be governed by a tri-partite board. HCAP has a 30-member policymaking board, which consists of one-third resident sector, one-third private, and one-third public. The resident and private sector representatives may serve for five consecutive years, stay off for one year, and serve another five for a total of 10 years. The public sector does not have a term limitation.

Over its 35 years existence, HCAP has operated a variety of programs addressing the needs of the very young, the youth, families, and the senior population. According to Pacific Business News, HCAP operates the largest preschool program "Head Start" in the State of Hawaii. Kamehameha Schools ranks second.

Employment readiness, job placement, business development, agricultural training and education, welfare-to-work, community planning/ leadership development, and youth employment are some of the programs HCAP operates.

The program you may be most interested in is our energy program. In 1977, HCAP received a federal demonstration grant of $409,747 which was used to provide energy conservation and consumer education. The thrust was to help the low income families decrease their utility cost. We partnered with Hawaii Job Corps to fabricate and install solar water heater panels for about 124 low income homeowners.

We were responsible to recruit and certify for eligibility, provide energy education, and purchase new hot water heaters. Under the tutelage of Irwin Shimada, Job Corps students fabricated and installed the solar panels on 124 homes. We had some interesting results as the program progressed. Several of the private, local solar companies were hiring our student fabricators and installers.

During the monitoring of the program, we found families who celebrated their utility savings by purchasing electrical appliances they didn't have before. We talked to the families and broached the idea of giving back to the program pot a portion of the their utility savings as a result of the solar installation. The donation was entirely voluntary. About 45 families participated in the pay back program. Approximately, half of them paid for the entire cost of the solar system. The funds were used for repairs that occurred at a later date. As a matter of fact, HCAP honored a repair request several years ago.

We had hoped to receive future funding so we could continue the program but the federal government changed their focus and established the Weatherization Assistance Program providing smaller grants to install water heater jackets and timers. Later they included heat pumps, which was done through a bid process with private vendors.

In 1996, the U. S. Department of Energy added solar hot water heating systems to the Weatherization Assistance Program. The same year, the Island of Kauai and Hawaii were awarded a small grant to install solar systems, in addition to heat pumps, timers and jackets. The following year, Maui and Oahu received their grant. Oahu received $65,800, which allowed for 10 solar systems. This grant also included the cost of heat pumps, timers and jackets.

This year, HCAP's weatherization grant is $33,219 to provide installation of 15 water heater jackets, 8 water heater timers, and 6 solar systems.

In 1980, the U. S. Department of Energy introduced the Low Income Home Energy Assistance Program (LIHEAP). Families would apply for a pre-determined amount toward their utility bill if they were in a shut-off or about to be shut-off situation. The program, however, has since been revised to include a pre-determined amount for **credit** toward the utility bill.

Currently, the Department of Human Services administers LIHEAP statewide. HCAP is contracted to do recruitment and certification. Applicants are allowed to apply for either Energy Crisis Intervention or Energy Credit with Hawaiian Electric Company or the Gas Company. The program is conducted annually for one month, usually in the month of June. Although the program does not conserve energy, the families find relief in their utility cost.

Our LIHEAP contract states that HCAP is responsible to refer individuals to and coordinate with any other existing federal, state or local low income energy program. When processing LIHEAP applications, we do provide information on the Weatherization Assistance Program. If the applicant is interested, we have them complete an application for an energy device.

The State's allocation for year 2000 is $1,252,186.00. Last year, the allocation was $1,159,827. The outer island Community Action Agencies are also contract by the State to do recruitment and certification. Administrative cost to the CAP agencies is based on performance.

This summer, President Clinton released emergency funds from the LIHEAP budget to pay for utilities in the mainland states that were suffering from high heat. During the winter, the states will be awarded subsidies towards alleviating their high cost for heating.

HCAP feels investing in solar systems would benefit low income families on a continuing basis through energy conservation, which results in a decrease in utility bills. The federal government allows the states to use up to 15% of their LIHEAP allocation towards providing other energy saving devices to low income families to reduce their energy cost. The Hawaii State Plan does not include this option. With the rising cost of fuel, the State should look into providing other energy saving devices, in addition to providing relief to families on their utility bills.

Terrence R. George

Chief Program Officer, Consuelo Foundation

Solar Water Systems Benefit the Working Poor Three Different Ways: A Case Study of Consuelo Foundation's Self-Help Housing Initiative in Waianae, Oahu

Prepared for the
Energy Efficiency Policy Symposium
November 9, 2000

Consuelo Foundation: History and Community-Building Approach

Consuelo Zobel Alger was born into one of the Philippines' wealthiest families, the Zobel de Ayala family. In 1988, just two years prior to Consuelo's death in her adopted home of Hawaii, the Consuelo Zobel Alger Foundation was incorporated as a nonprofit, private operating foundation. Consuelo Foundation envisions communities in Hawaii and the Philippines in which disadvantaged children, women and families achieve dignity, self-esteem and self-sufficiency resulting in renewed hope for those who have lost it and hope to those who have never had it. The Foundation's mission is to operate or support programs in Hawaii and the Philippines that improve the quality of life of disadvantaged children, women and families. Jeffrey N. Watanabe chairs the Foundation's six-member board, while Patti J. Lyons is the founding President and Chief Executive Officer.

Using a small professional staff with offices in Manila and Waianae and headquarters in Honolulu's Chinatown, the Foundation works to fulfill Consuelo's vision. In Hawaii, the Foundation currently pursues three broad programmatic goals:

1. To strengthen children and families through community development and asset building;

2. To reduce the incidence of child abuse and neglect by strengthening parent-infant bonding among families at risk; and

3. To improve women's status and opportunities.

Roughly three-fourths of our activities occur in the Philippines and one-fourth in Hawaii. In some cases we directly run our own programs; in others, we contract with other organizations to manage activities that help fulfill our mission. A very small number of grants is also made. Since Consuelo Foundation's resources are modest in comparison to its programmatic goals, we focus on a limited number of program strategies and projects within these broad goals. A report on the Foundation's activities is published annually and is available on request.

Before she died in 1990, Consuelo made it clear that she wanted her Foundation to pay particular attention to native Hawaiians, though not to the exclusion of work with people of other ethnicities. Our staff leadership – who had a long history of social work on the Leeward Coast -- began to survey the needs of Hawaiians. We found that affordable housing and safe neighborhoods were major concerns. Children live in families, and families live in communities. Without strengthening those communities, we would be unable to help children and their families forge better futures. Therefore, we decided to make community development our central approach in Hawaii.

Our community development approach is comprehensive rather than piecemeal, preventive rather than palliative, and long-term rather than short-term. We also take an assets approach rather than a deficit approach to community building. In other words, we look for what is right in families and communities and seek to deepen that, rather than looking for what is wrong and seeking to treat that. We also believe that communities everywhere contain the talent and potential to solve their own problems if they adhere to common values and if they receive the kind of support they need to strengthen their capacity to work together. Our work, therefore, is in essence the building of capacities: in individuals, in families, and in communities.

Self-Help Housing Project in Waianae

By far the largest Consuelo Foundation project in Hawaii, **Ke Aka Ho'onā** is a values-driven community in Waianae, Oahu built since 1993 through self-help construction. The Foundation's goal is not simply to increase the supply of affordable housing, but to build an intentional community of low-income working families with children who wish to live in a nurturing neighborhood free from violence and substance abuse. Each year, between 8 and 17 families build their homes together in one group, without knowing which home would be theirs until the end of construction. Volunteers and professional construction staff are kept to a minimum. This approach gives families more pride in ownership, more skills to do their own home repair, and more cohesion as a group of future neighbors. Families secure a mortgage of less than $60,000 for the home, while agreeing to buy their fee within 30 years of moving in.

As of this date, 63 single-family homes have been completed. Currently, 12 duplex homes are being built by 12 low-income families. By May 2001, 75 families will have completed their homes. The Foundation's staff based at the neighborhood's Community Center manage the recruitment and selection of homebuilders, help families through the building process, and offer a range of activities for families. These include outings for children and their parents, a small-grants program to assist children and adults in furthering their education, computer classes, and a 14-week family-strengthening program run by the Coalition for a Drug-Free Hawaii. A similar project for another 32 families will begin next year elsewhere in Waianae on Hawaiian Homestead land.

House Design and Construction Method

Both the duplex units and the single-family homes have three bedrooms, two baths, and a carport; internal living area is 1,127 and 1,104 square feet, respectively. Designed by architects at Group 70, both home models are of high quality yet can be built by inexperienced self-help builders over a period of nine to ten months' worth of weekends, under the supervision of our general contractor, Trim Line Contractors. The double-wall, post-on-pier homes have stepped wooden landing entries in both the front and the rear of the house. At the rear is a laundry area located on a concrete slab and enclosed by sliding wooden doors. The laundry area contains a laundry tray, solar water heater storage tank with timer, and all necessary hookups for a washer and dryer.

All eight increments at Ke Aka Ho´onā have roof-mounted solar water heating units, with ground-mounted solar water heater storage tank with timer. Since 1998, these units have been built to Hawaiian Electric Company (HECO) standards necessary for the provision of a $1,000 to $1,500 rebate.

Consuelo Foundation believes strongly in making the home construction a true self-help process as much as possible. Virtually the only tasks handled by professional subcontractors rather than the builders are: installing carpets, plumbing systems, and wiring for electricity, telephone, and cable TV; and pouring concrete for driveways and carports. Each family must provide two builders to work from 7 am to 5:30 pm every Saturday and Sunday until the homes are completed. No one knows in advance which house and lot will be theirs. Instead, all homes are built together by all the builders. Only when all homes are completed does the Foundation hold a lottery to determine who gets which house. Each builder agrees in the sales contract to accept whichever house is drawn for their family. The Foundation has found that this process builds unity among the future neighbors and ensures uniformly high quality of house construction.

Home Financing

The families selected to build these homes have incomes between 40 and 80 percent of the area median income. In other words, these are the working poor, who have worked hard to stay off welfare but who barely make enough money to get ahead. They are construction workers, janitors, part-time teachers, secretaries, bus drivers, and nurses' aides. Some were homeless and jobless at previous points in their lives, but all families now have low but steady incomes. Most importantly, they have a desire to have a home of their own in a safe, drug-free, violence-free neighborhood in which neighbors give back to each other.

To keep the house sales price low for these families, Consuelo Foundation pays the entire cost of the general contractors' and subs' labor and of reimbursable expenditures. Reimbursables include such items as ladders, chipping guns, saws, and the cost of hauling away refuse and surface material. We also enroll families in the HomeStart Individual Development Account (IDA) program of the Federal Home Loan Bank of Seattle, through American Savings Account. Each family in this program starts a modest savings account during the construction period. At the end of construction, every dollar saved by the family is matched 3-for-1 by the HomeStart program, and the total amount goes to reduce closing costs and the mortgage principal. Families can save a maximum of $1,667 to generate a $5,000 match, which means that $6,667 goes toward paying off the principal and mortgage. The result is far lower monthly P&I repayment rates.

Consuelo Foundation provides its own interim home construction financing. Permanent home financing is provided through American Savings Bank. The special program we have arranged with American Savings Bank requires no down payment other than the builders' sweat equity, no points, and no private mortgage insurance. Minimal closing costs are rolled into the 25-year fixed rate mortgage. The loan is set not on the appraised value of the home (which would be too high for our builders to qualify for) but on the cost of materials used to build the home. Therefore, home sales prices are below $60,000 for homes that could sell for twice that price.

Three Ways Families Reap Financial Benefits from their Solar Systems

1. Income Tax Credit. Ever since our first homes were completed in 1994 and each year since them, Ke Aka Ho´onā's annual group of new homebuilders has benefited from the Hawaii Energy Conservation Income Tax Credit. Consuelo Foundation pays the tax preparation fee for these families for the first year that they reside at Ke Aka Ho´onā so they can fully avail of the tax benefits of home ownership. For most families, this results in a much-needed income tax refund that they use to improve their homes, save for their children's education, and provide for their families' other needs.

2. Solar Energy. In 1998, the families of Increment Five at Ke Aka Ho´onā learned about HECO's special solar energy credit program. They alerted the Foundation to this opportunity. Ever since then, we have made sure that our solar water systems meet all HECO standards. Thanks to the rebates from HECO, we are able to reduce the purchase price for each new home (initially by $1,500 and now by $1,000) because we pass the entire rebate on to the homeowners. We are extremely grateful to Hawaiian Electric for their flexibility and for their support of our low-income homebuilders.

3. Lower Electricity Bills. Waianae is arguably one of the sunniest spots on the island of Oahu. As a result, our solar systems do virtually all the work in heating water for the households at Ke Aka Ho´onā. The resultant savings on electricity bills is dramatic. For examples, all 17 families of our most recent increment, who moved into their new homes in May 2000, reported last week that their electricity bills are significantly lower than was the case in the homes and apartments where they used to live. One resident told me that his family's bill dropped from $200 per month to $70 per month. For families that need to stretch every dollar to meet their monthly household needs, this savings has tremendous meaning.

In conclusion, it is my hope that Hawaiian Electric Company and the State of Hawaii continue to implement policies and programs that maximize the incentives for families to use alternative energy sources for their household energy needs.

Cully Judd

Member, Board of Directors, Hawaii Solar Energy Association

Solar in Hawaii

Good afternoon. My name is Cully Judd and I represent the Hawaii Solar Energy Association, or HSEA. Founded in 1978, the HSEA is a professional trade association composed of twenty-five solar and plumbing contractors, wholesale distributors, manufacturers, and electric utilities.

It is my privilege today to comment on what I consider one of Hawaii's most successful public-private sector partnerships. I refer to the synergy between the legislative and administrative branches of our government, and our renewable energy service providers, the ranks of which now include our electric utilities, in achieving Hawaii's clearly stated energy policy objectives relative to the development and commercialization of solar and other renewable energy technologies.

Since 1976, the year our legislature enacted Hawaii's energy conservation income tax credits (ECITC), our lawmakers have consistently supported a levelized playing field that allows renewable energy technologies to have a fair chance of success against heavily subsidized, polluting, and until very recently, dirt cheap fossil fuels. The State's buy down of clean, but higher initial cost energy technologies, has lead to the installation of over 70,000 solar water heating systems and thousands of solar electric power systems in Hawaii. There are now more residential solar water heaters per capita in Hawaii than any other state in the nation.

Hawaii's progress in commercializing renewable energy technologies has been based, for the most part, on consistent and predictable state energy policy. The cornerstone of this policy, and the fulcrum that leverages private sector investment in renewables, is the ECITC. Hawaii has a strong and growing renewable energy industry and infrastructure for two simple reasons: We have a state legislature historically committed to clean energy development and to the reduction of Hawaii's dependence upon imported oil and coal to generate electricity, and we have an energy conservation income tax credit.

Under guidelines established during a protracted Integrated Resource Planning Process, and at the behest of our Public Utilities Commission, Hawaii's largest electric utility companies have begun providing additional financial incentives for the installation of solar water heating systems. Hawaiian Electric, Maui Electric and Hawaii Electric Light Co. now sponsor the largest and most successful utility solar water heating programs in the country. The energy savings and demand reduction benefits from these solar systems help to defer the construction of costly new generation capacity for years. The cost-effectiveness of these programs and their long-term viability is directly linked to the continuation of the ECITC. Our utilities need a high level of customer participation and satisfaction for their demand-side management programs to remain cost effective. The ECITC is the mechanism that continues to ensure both of these core requirements.

The State of Hawaii ECITC remains the glue that holds all these pieces, coalitions, industries and partnerships together. The HSEA is supportive of innovative solutions to our energy problems in Hawaii, but it is our fundamental belief that nothing has been or will be as successful, simple, cost effective or widely accepted by businesses and consumers alike as the ECITC.

Dave Waller

Manager, Energy Services, Hawaiian Electric Company

HECO's Energy $olutions Program: Partnership that Creates and Supports Local Businesses

HECO *Energy$olutions* Program: Partnership That Creates and Supports Local Businesses

Dave Waller, Manager

Energy Services Department
Hawaiian Electric Company

Outline of Presentations

- Program Background
- Critical Success Factors
- Government - Utility Partnership
- Thermal Storage

Hawaiian Electric Company 2

Critical Success Factors

- Challenge: Ensure Quality Product
- Response: Developed Comprehensive Uniform Standards and Specifications

Hawaiian Electric Company 4

Program Background

- HECO's Residential DSM Program Kicked-off in 1996
- Rebate for Residential Solar Water Heating Systems Available on Oahu, Maui, Molokai, Lanai and Hawaii
- Over 12,000 Systems Have Been Installed Under This Program Since 1996

Hawaiian Electric Company 3

Critical Success Factors

- Challenge: Encourage Financially Sound Contractors to Provide Solar Systems
- Response: Nearly 50 Participating Solar Contractors Are Involved

Hawaiian Electric Company 5

Critical Success Factors

- Challenge: Ensure Quality of Installations
- Response: 100% Inspection of All Solar System Installed

Hawaiian Electric Company 6

Critical Success Factors

- **Challenge:** Provide Financial Incentives to Reduce Up-Front Cost of the Solar System
- **Response:** Provide Utility Rebates and Support State Tax Credits

Hawaiian Electric Company 7

Critical Success Factors

- **Challenge:** Ensure Energy Savings Are Achieved
- **Response:** HECO Conducts Independent Evaluations of Program Results

Hawaiian Electric Company 8

Critical Success Factors

- **Challenge:** Develop Customer Awareness
- **Response:** Mass Media Advertising Campaign

Hawaiian Electric Company 9

HECO Marketing Efforts

- Television
- Radio
- Newspaper
- Magazine
- Special Events
- Consumer Lines
- Bill Inserts
- Direct Mail
- Consumer Lines

Hawaiian Electric Company 10

HECO Government Partnerships

- State of Hawaii & DBEDT
- U.S Dept. of Energy (DOE)
- U.S. Dept. of Defense (DOD)
- U.S. Environmental Protection Agency (EPA)

Hawaiian Electric Company 11

State of Hawaii Partnership & DBEDT

- Joint Energy Awareness and Educational Programs With DBEDT
- Seminars
- Rebuild America

Hawaiian Electric Company 12

HECO Leads the Nation in the Million Solar Roofs Initiative

DOE Partnership

- Million Solar Roofs Registry
  - Over 80% of the Nation's Register Solar Roofs Are in Hawaii
  - Over 75% of the Nation's Federal Solar Roofs Are in Hawaii
- With Support of the DOE, We Have:
  - Held Solar Fest 2000 in May
  - Developing Education Curriculum for Sun Power for Schools and Smart Schools Programs

HECO Is an Energy Star Ally

Hawaiian Electric Company, Inc.
Giving you the power

EPA Partnership

- HECO Has Brought the Energy Star Homes Program to Hawaii
- Qualifying Homes Are Eligible for Energy Star Loans at Lower Cost Than Conventional Loans
- Recruited Five Energy Star Mortgage Lenders and Eight Energy Star Builders

Energy Star Lending Institutions

Bank of Hawaii

Countrywide HOME LOANS Easy. Really.

American Savings Bank An HEI Company

North American Mortgage Company A Dime Company

First Hawaiian Bank

Private Developers Offering Solar

- Schuler
  - Waikele Classics
  - Waikele Celebrations
  - Kapolei Knolls
- Gentry
  - Terazza
- Stanford Carr Development
  - Iwalani

Low-to-Moderate Income Housing Projects

- Consuelo Algier Foundation
  - Waianae Self-Help Homes
- Department of Hawaiian Homelands
  - Kalawahine Streamside & Kapolei Villages
- Housing & Community Development Corp. of Hawaii
  - Maili II & Kalihi Valley Homes
- Waimanalo Self-Help Housing

Hawaiian Electric Company 19

Successes in Thermal Storage At Iolani

Hawaiian Electric Company 20

Successes in Thermal Storage At Iolani

- DBEDT Grant & Electric Power Research Institute Funding
- HECO Project Management
- Project Financing
- Success at Iolani Has Lead to Other Thermal Storage Projects

Hawaiian Electric Company 21

Conclusions

Fundamental Choices For Hawaii

- Should We Continue To:
  - Lead in Solar Water Heating
  - Make Wise Energy Investments
  - Create Positive Economic Value, Jobs and Encourage Small Businesses
- If We Do, Continuation of the Tax Credits Is Essential

Hawaiian Electric Company 22

Ray Starling

President
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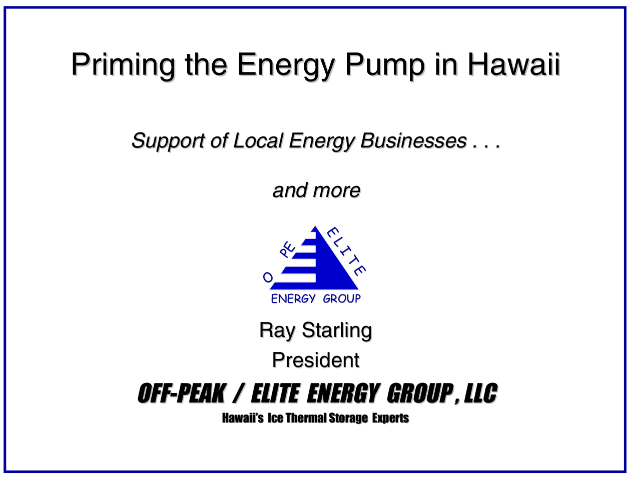
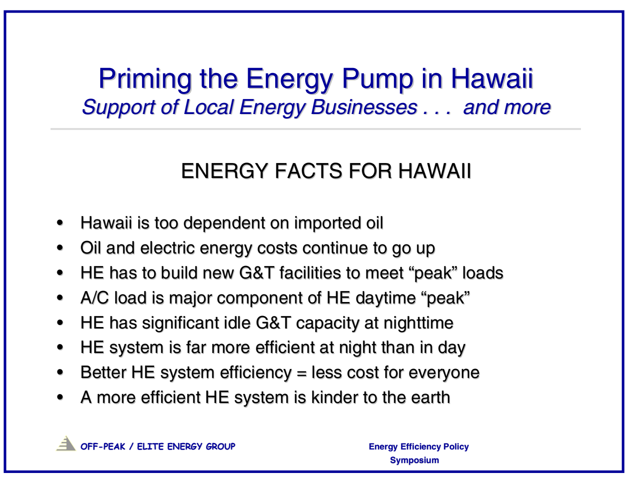
Priming the Energy Pump in Hawaii

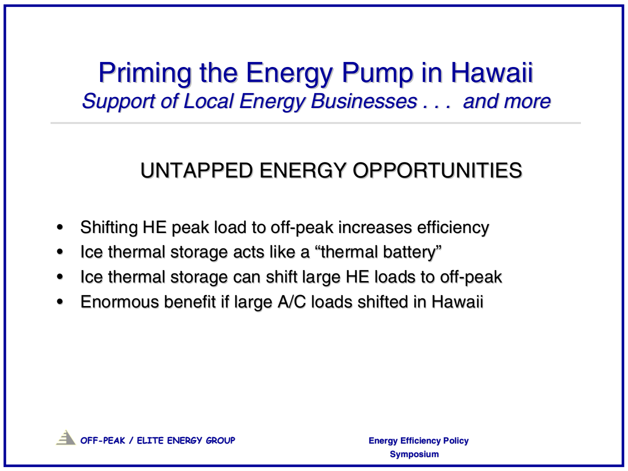


OFF-PEAK / ELITE ENERGY GROUP, LLC is a small energy business in Hawaii that designs, builds and operates ice thermal storage systems for commercial air conditioning. We have installed and now operate three full ice systems in Honolulu, Maryknoll High School, Aiea Medical Building and Market City Shopping Center. We have another full ice system under construction at Mid-Pacific Institute scheduled for completion in December 2000.



These are some of the basic Energy Facts that we live with in Hawaii. These Facts not only describe the fundamental energy problems that we face, but also give a hint at where to look for solutions to those problems.

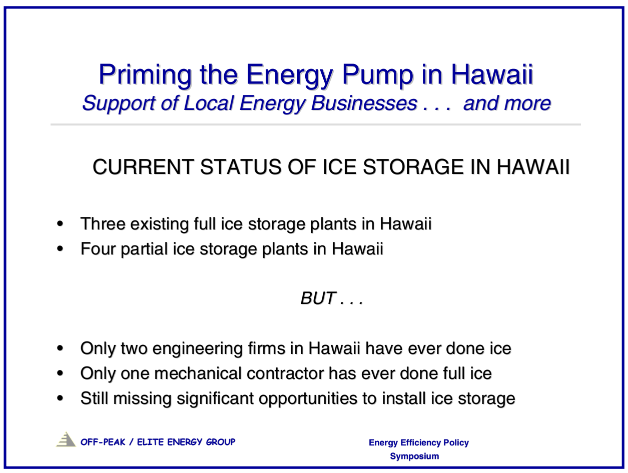
- Hawaii is much too dependent on imported oil.
- Oil and electric energy costs continue to go up at alarming rates.
- Hawaiian Electric companies in the islands have to build new generation and transmission facilities to meet "peak" loads.
- Peak electric loads usually occur during the day as a result of air conditioning loads.
- Hawaiian Electric companies have significant idle generation and transmission capacity at nighttime (i.e., 1200MW daytime vs. 400MW nighttime at HECO).
- The Hawaiian Electric system efficiency is far more efficient at nighttime than in daytime due to availability of the most efficient equipment on the HE system.
- Better Hawaiian Electric efficiency results in lower electric cost for everyone using electricity on the HE system.
- A more efficient HE system is also much kinder to the earth, with less fossil fuel use, lower air emissions and less greenhouse gases.



Anytime an electric load can be shifted from on-peak to off-peak, our energy problems are reduced, HECO's entire system efficiency is improved, fossil fuel use is reduced, air pollution is reduced, global warming is slowed, the need for new generators and transmission lines is reduced and the cost of electricity for everyone on the HE system is reduced.

Ice thermal storage has a unique ability to shift very large electric loads from on-peak to off-peak times. By using the "battery" effect of ice storage, we can make and store ice at night (when generation costs are *low* and system efficiencies are *high*) and use that ice for cooling during the day (when generation costs are *high* and system efficiencies are *low*).

Because ice thermal storage in Hawaii is almost non-existent, this leaves a vast untapped opportunity to shift electric load, save wasted energy and reduce energy costs.

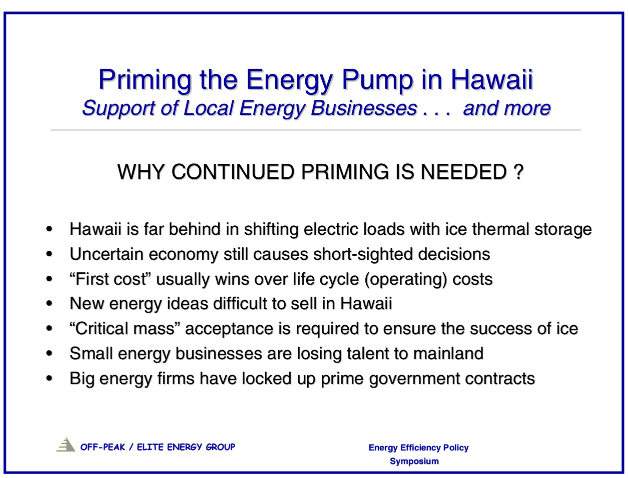


There are only 7 ice thermal storage facilities operating in all of Hawaii, with 6 of them built in the last 4 years.

Only two engineering firms in Hawaii have ever attempted to design an ice system and only one Hawaii mechanical contractor has ever constructed a full ice system.

More importantly, because of ignorance, fear and short-sightedness, many new conventional air conditioning systems are being installed each day in Hawaii without any serious consideration of ice thermal storage as an alternative.

As a practical matter, once a new conventional system is installed, that new electric load will be a burden on the ECO's system "peak" for the next 20-25 years, costing us all. By comparison, ice thermal storage takes this burden off the electric system for the next 20-25 years.



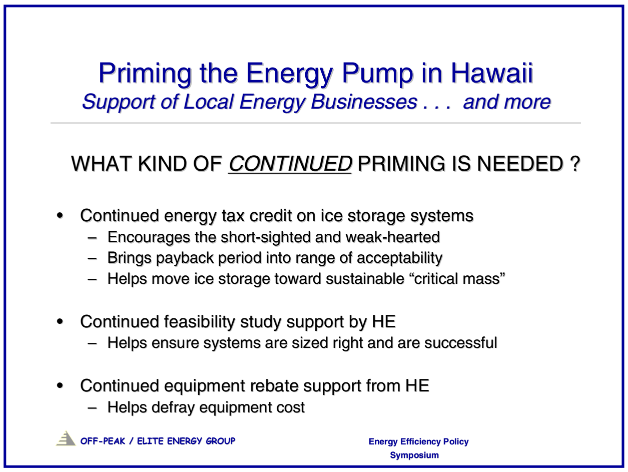
Because ignorance, fear and shortsightedness are still keeping Hawaii from enjoying the many benefits of ice thermal storage, continued priming of energy pump is needed, at least until ice gains more widespread acceptance.

The rest of the world is much farther along than Hawaii in its use of ice thermal storage. Pictures at the end of this slide series will show what the rest of the world is doing with ice storage technology.

Hawaii's uncertain economy still causes short-sighted decisions when building owners are faced with large investments for capital equipment. The higher "first cost" of ice thermal storage systems compared with conventional A/C systems leads many building owners to choose the less expensive conventional system, when the ice system would save much more in energy costs over its life than the conventional system. In fact, the ice storage system will actually save enough from electric load shifting over its life to pay for itself; the conventional system will never save anything from load shifting.

Additionally, new energy ideas like ice thermal storage are difficult to sell in Hawaii. In particular, design engineers and architects have a built in bias towards the conventional A/C systems that they are used to and understand. They are generally not willing to take a chance on a new technology. The fact that ice thermal storage is practically non-existent in Hawaii is testament to this reluctance.

In order for ice storage to become successful, a certain "critical mass" of acceptance is necessary. Continued priming of the energy pump is absolutely essential to achieving that critical mass of acceptance. Small energy firms have lost talent to the mainland because energy conservation efforts in Hawaii have diminished in the difficult economy of the 90s. Big energy firms have locked up prime government contracts, leaving nothing for small energy firms.

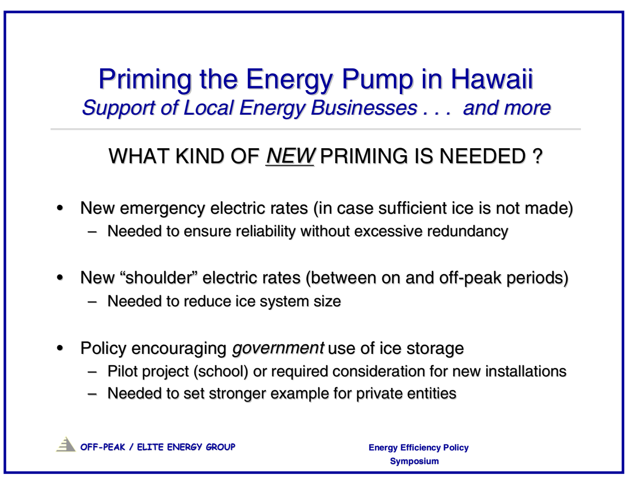


Existing energy pump priming has been very helpful in getting ice thermal storage started in Hawaii, but this needs to continue until a time when ice thermal storage has gained a sustainable "critical mass".

Energy tax credits make the additional capital cost of ice thermal storage systems tolerable when compared to conventional systems. Payback periods are brought within the range of acceptability when compared to conventional systems. This has encouraged the first adventurers to give ice a try. It is essential that these tax credits remain in place until ice gains more widespread use in Hawaii.

Feasibility studies conducted before installation of ice systems are essential to proper system design and sizing. HE support for feasibility studies has insured that detailed analysis is accomplished. This has led to a very good record of adequate design of ice systems in Hawaii. This program also needs to be continued until the design/engineering of ice storage systems is second nature for design professionals.

Likewise, equipment rebates are essential to encouraging initial use of ice thermal storage, before general acceptance is obtained. This program should be continued.

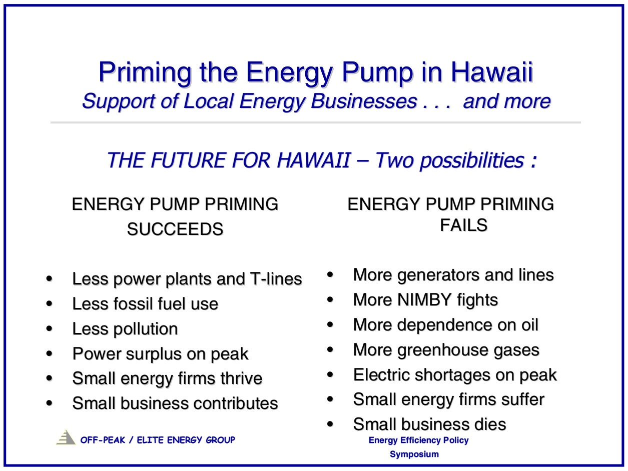


Three kinds of NEW priming would help the cause of ice thermal storage:

1. New emergency electric rates are needed to avoid excessive (and expensive) redundancy. These rates would allow for running of off-peak ice chillers during peak periods without unreasonable penalty if sufficient ice was not made during the off-peak ice-making period due to equipment problems.

2. New shoulder electric rates (medium cost rates between off and on-peak) would greatly reduce the size and expense of equipment needed to most effectively shift electric load.

3. Finally, policies encouraging government use of ice storage would be very helpful in setting a good public example of support for this "earth friendly" technology.



The future of Hawaii's energy policy can take two radically different paths, one leading to a successful priming of the energy pump and the other leading to a failure to adequately prime the energy pump.

Each path has dramatically different results as shown, making this a very important issue for Hawaii. Which results do you want to see?

Glenn Ching

Director of Finance, Iolani School

Being Cool at Iolani School

My thanks to the State Department of Business, Economic Development & Tourism for this opportunity to share Iolani School's experience with thermal (ice) storage air conditioning systems.

As background information, Iolani School is a K-12 college preparatory independent school with an enrollment of about 1800 students and 260 full-time employees. The 23-acre campus, Iolani's home since the mid-fifties, is located near the Ala Wai Canal.

This afternoon, I would like to expound on a formula which summarizes our experience, i.e. engineering solutions + economic incentives = project feasibility.

Engineering Solutions

We have sought engineering solutions to address operational needs in concert with our long-range plans. Presently, all 125 of our classrooms are air-conditioned. We believe that the overall physical environment of an educational institution affects teaching, student learning, and school pride.

We also recognize that the maintenance of our learning environment must be cost effective as well. The school is willing to invest in long term cost effective solutions. It is important for us to scrutinize costs as tuition is based on costs. With tuition covering about 70% of the cost to educate a student, it is our priority to accomplish our educational mission yet be cognizant of the tuition impact on our parents.

In 1994, about 50% of our Lower School classrooms needed air-conditioning. We were looking for a cost-effective solution to bring cooling relief to 15 classrooms, notably K-1, 5^{th} and 6^{th} grades. Hawaiian Electric (HECO) proposed an ice storage air-conditioning system. We were initially skeptical, as there was only one other ice storage air-conditioning system in existence in the State. It was located at the old Hawaiian Airlines terminal. The technology intrigued us and we pursued the proposal with HECO's project manager, Paul Fetherland.

The key engineering features centered on making ice during off-peak hours (9p.m.-5a.m.) and pumping ice water to the classrooms during the school day. The ice tanks complemented the chiller such that chiller capacity was lower than if we had a conventional one. Ice storage basically shifted a portion of our electrical energy demand. Pumping ice water to the classrooms utilizes less energy than running a chiller compressor.

From HECO's view, more widespread use of ice storage systems which utilizes available off peak capacity would make more peak capacity available. This would alleviate costly buildup of power infrastructure to meet peak demand.

An economic analysis was done to compare the operating costs of a conventional, ice storage, and split system types of air-conditioning. Although conventional and ice storage systems have a higher initial capital cost than split systems, the overall life cycle operational costs were lower for the ice system based on present values of anticipated cash flows.

Economic Incentives

An integral part of the analysis included the economic incentives provided.

Since ice storage shifts part of the energy demand to off peak hours, Iolani qualified under HECO's Rider M tariff which provides an adjustment in billing demand. Consequently electrical operating costs were lower than for conventional and split systems.

The State offered a 50% tax energy credit for thermal (ice) systems. This effectively cut the initial capital costs in half. Since Iolani School is a non-profit corporation, the application of this tax credit was accomplished through leasing. Consequently the Lower School project was financed through First Hawaiian Leasing which utilized the tax and depreciation credits. The resultant lease payments over the five-year lease term totaled less than the initial principal.

As a demonstration project a one-time grant totaling $200,000 was available from the State Department of Business and Economic Development (DBEDT) and the Electric Power Research Institute (EPRI) and applied to the Lower School project.

Feasible Projects

The Lower School ice storage system was completed in the Fall of 1995. This project received an Excellence Award for the design by HECO's mechanical engineer subcontractor, Cedric Chong and Associates. Here we see where engineering solutions + economic solutions = feasible projects.

This equation was applied again in 1997 and 1998 in the Upper School where ice tanks were retrofitted to existing chillers. The operational need was to replace window air-conditioning units to reduce noise levels, improve reliability, consolidate these individual units to a more "central" plant concept, and to add more chilling capacity to air condition the Student Center and cafeteria.

In the Upper School, off peak tariffs were applied and the leasing through First Hawaiian Leasing was done to realize the tax advantages of the 50% tax energy credit and depreciation.

Presently the school saves about $24,000 in electrical costs due to the off peak tariff rate. Through HECO's rebate program, the school has received rebates for lighting retrofits, conversion to electronic ballasts in its buildings, occupancy sensors in bathrooms, and use of variable speed drive motors. Windows have been tinted to reduce glare into the classrooms and to keep classrooms cooler. HECO also introduced us to the use of ultraviolet lights in air-conditioning ducts to kill mold. This had led to cleaner condenser coils requiring less maintenance and has increased air-conditioning efficiency. Plant personnel have visited us from hotels and hospitals seeking to adopt this technology. We continue to seek energy related savings through solar and heat recovery systems as the long-term outlook for petroleum is projected in the mid to high twenties per barrel.

Iolani is presently moving forward with Project 1 of its 1997 Campus Master Plan developed by Belt Collins which entails a multi purpose building (housing about four floors of parking and the Maintenance Department) and an adjacent classroom building. Under a Utilities Master Plan prepared by Fukunaga & Associates, the operational long-range goal is to consolidate the current three "regional" air-conditioning plants into a single ice storage system. A phasing plan has been established to pick up air-conditioning loads campus wide over a 20-year period. Besides Project 1, the Campus Plan entails building improvements in Lower School, a new Student Center and Theater, and a library addition. All of these building improvements will be "looped" together with a degree of back-up capacity.

HECO and the design team led by Group 70 (which is the Campus Master Plan Project 1 architect) are designing a chiller plant which would maximize off peak tariff allowances, allowable tax energy credits, and HECO rebate incentives for building day-lighting features and motors. In conjunction with this, engineering reviews are being conducted to streamline the campus electrical grid for metering purposes.

The impact of these economic incentives will weigh heavily in the building decision process which has a projected start date in June 2002 with an estimated completion date in late 2003. The expiration of the energy tax credits on June 30, 2003 will occur during construction.

Conclusion

ENGINEERING SOLUTIONS + ECONOMIC INCENTIVES = FEASIBLE PROJECTS

From an overall view, without economic incentives, the marketability and feasibility of engineering solutions such as ice storage would be in jeopardy especially since the energy tax credits expire on June 30, 2003.

Tax incentives work. Planning an energy efficient plant takes capital funding and years to implement, and in Iolani's case, it needs to be phased in over 20 years. The seemingly short-term nature of expirations and extensions of these tax credits adds uncertainties to companies which want to invest in their future as well as to those whose livelihood depends on supplying the necessary energy saving devices. We encourage the Legislature to take the long-term view so that infrastructure plans can be made without guessing what may happen to tax credits.

Iolani School is appreciative of the efforts of the Legislature and Hawaiian Electric Company in providing such incentives which have helped Iolani School derive cost effectiveness in its educational mission.