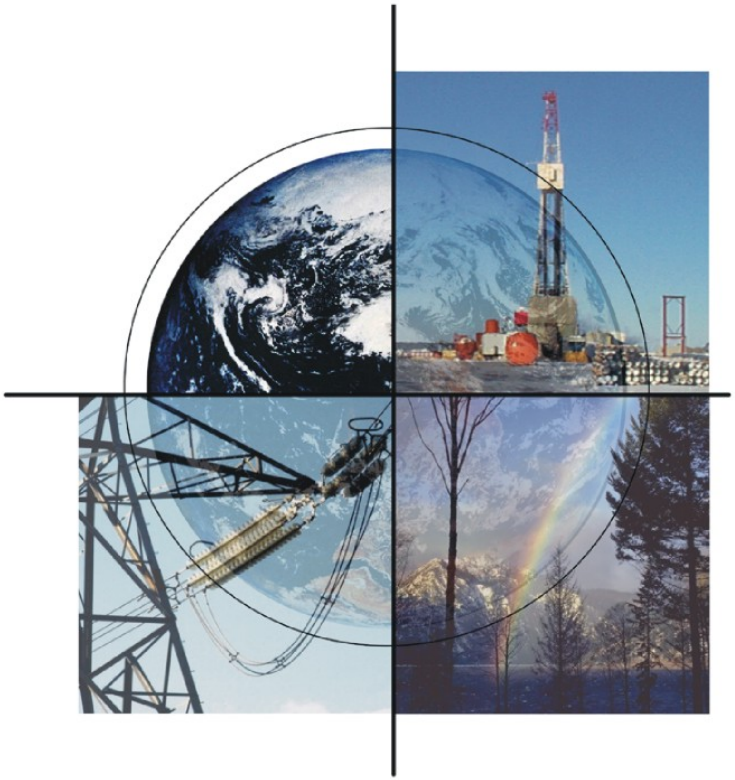
Systems Analysis Supporting the Carbon Sequestration Technology Roadmap



Second National Conference on Carbon Sequestration

May 6, 2003

Scott M. Klara, NETL

Jared Ciferno, SAIC

Phil DiPietro, Energetics, Inc.

Sequestration Program Goals

Develop Technology Options for GHG Management That...

- **Are safe and environmentally acceptable**
- **Result in**
  - < 10% increase in cost of energy services (< $10/tonne CO_2 avoided) for capture, transport, & storage
  - With Measurement, Monitoring & Verification protocols for assurance of permanent storage
- **Global Climate Change Initiative**
  - Contribute to reducing carbon intensity by 18% by 2012
  - Provide portfolio of commercially ready technologies for 2012 assessment

Cost Performance Goals

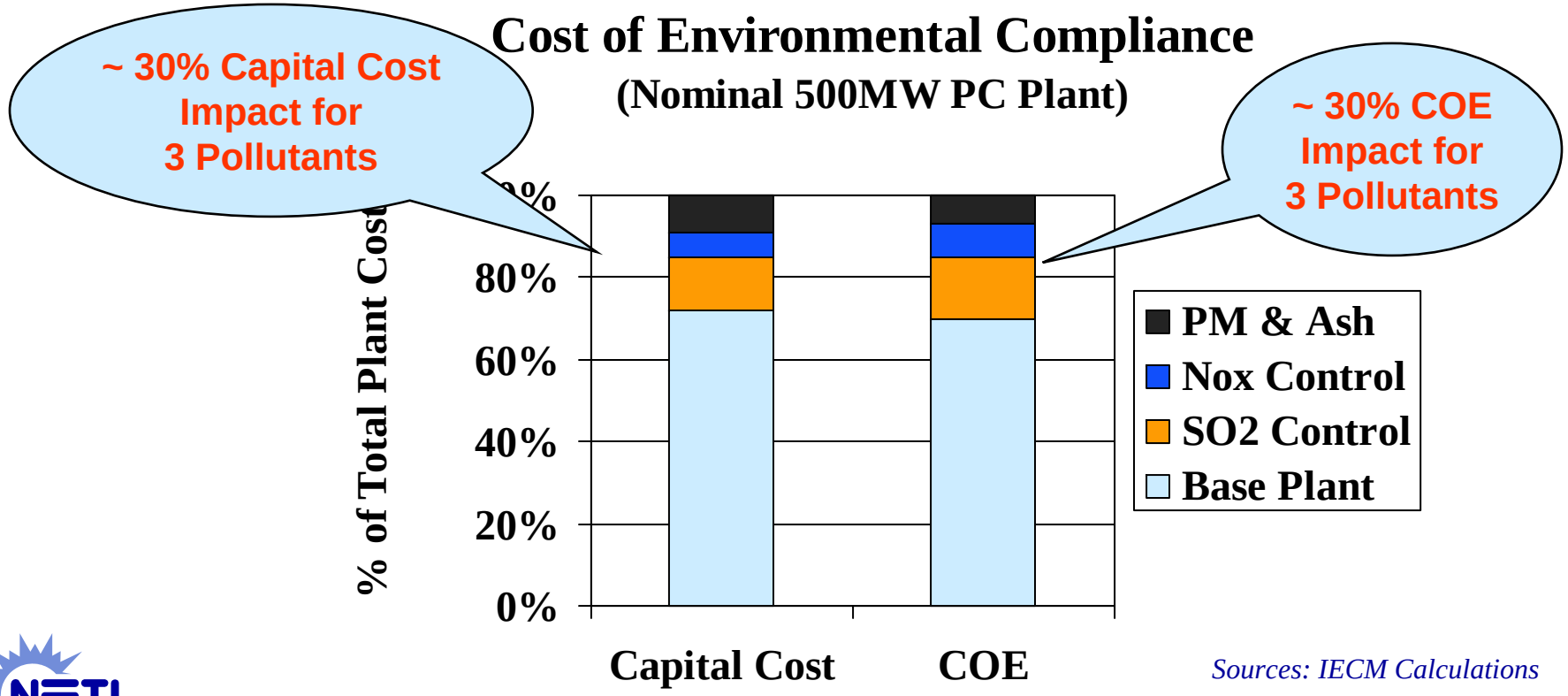
Year	COE Penalty IGCC Plants (% Increase)	COE Penalty PC Plants (% Increase)
2002	30	80
2007	20	45
2012	10	20
2015	<10	10
2018*	0	0

*Cost/Energy offset from sequestering CO2 with criteria pollutants NOX, SOx, H2S (gasification)

Why the 10% Increase in COE Goal?

Relate to Compliance Costs Absorbed for Mandated Pollutants

Coal Plants Absorbed ~ 10% Cost Increase in COE & Capital for each Mandated Pollutant

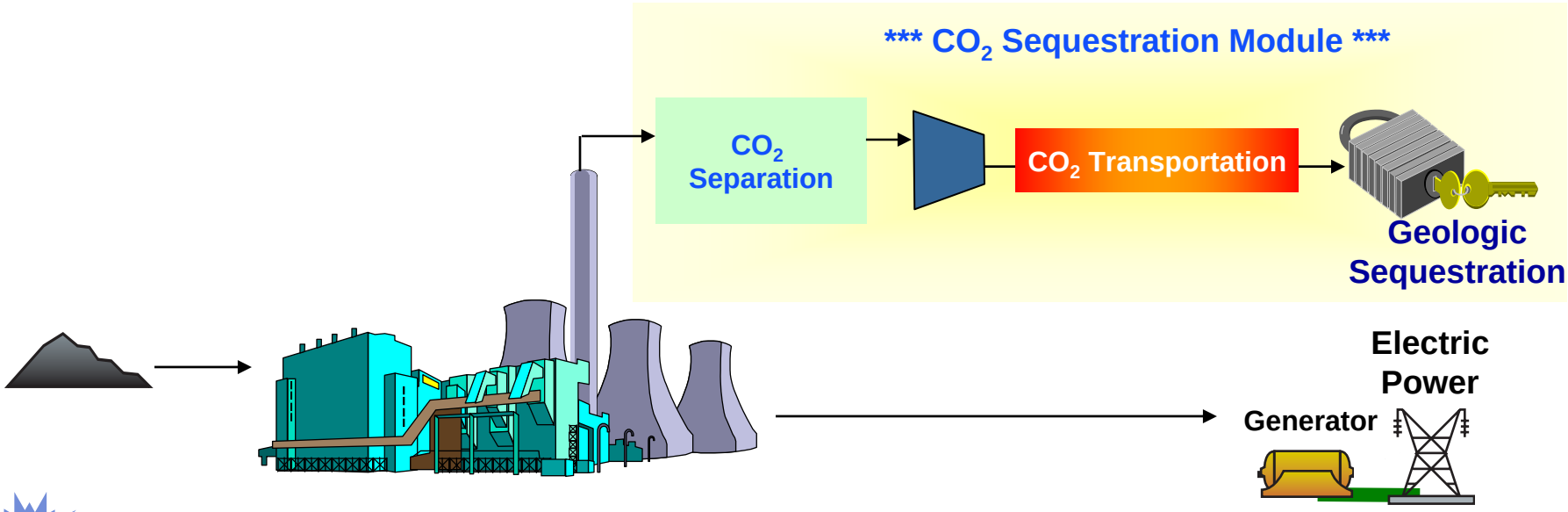


Sources: IECM Calculations

Objectives

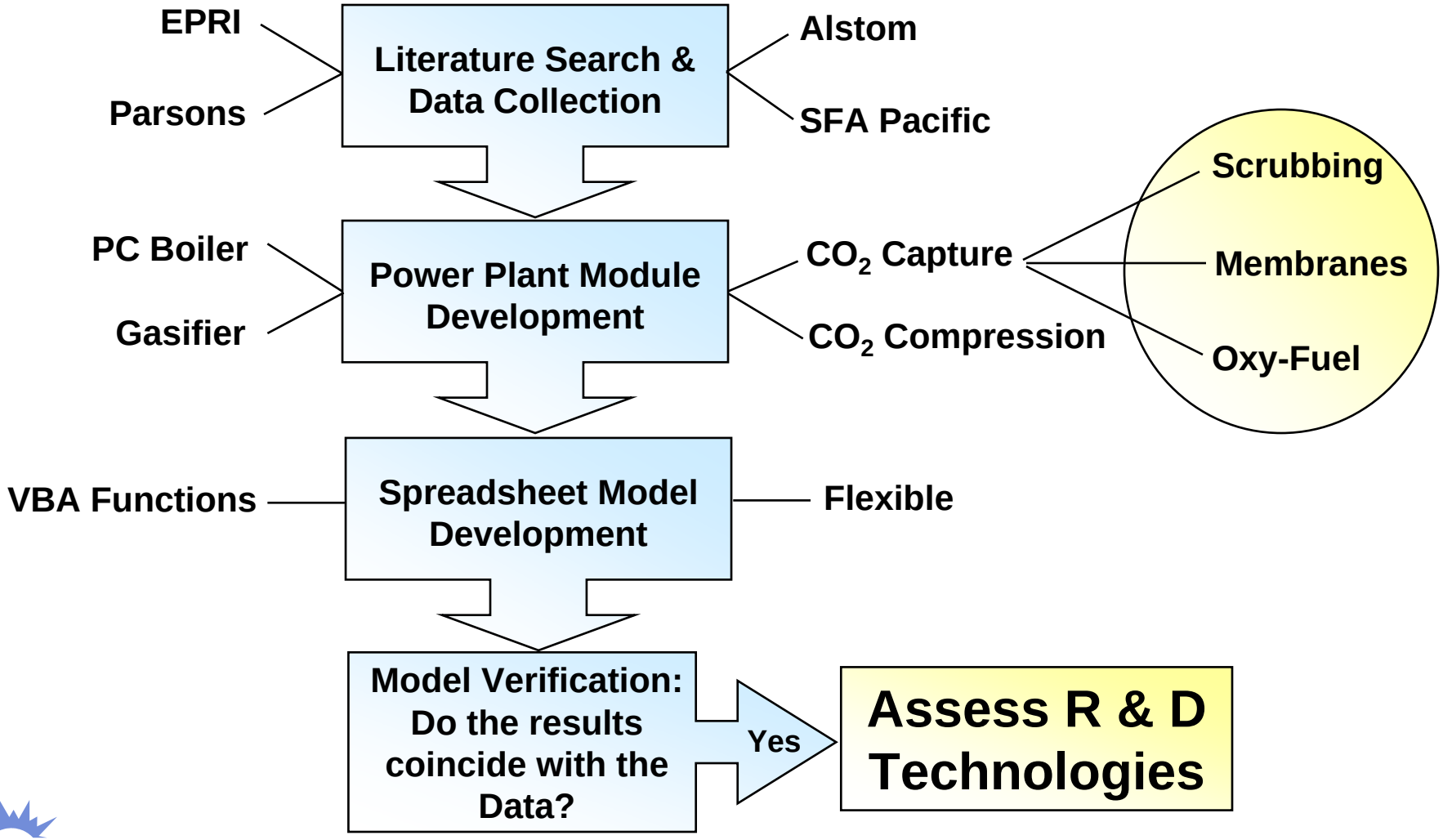
Analyze Detailed Component Costs for Capture & Storage to:

- **Determine where the R&D should be focused**
- **Determine "best case" potential for R&D portfolio**



Methodology

Don't Reinvent the Wheel for Current Technologies



Scenarios

Many Advanced Integrated Schemes Emerging

Coal Gasification

- ✓ CO_2 Hydrates
- ✓ Membranes
- ✓ Advanced Scrubbers
- ✓ Inexpensive Oxygen
- Chemical Looping

Pulverized Coal

- ✓ Oxygen Combustion
- ✓ Membranes
- ✓ Advanced Scrubbers
- ✓ New Sorbents
- Mineral Carbonation
- Chemical Looping

Pathways to Zero Emissions

Producing a concentrated stream of CO_2 at high pressure:

- **Improves sequestration economics**
- **Reduces energy penalty**

✓ Technology Currently Being Evaluated

Key Assumptions

Economic Parameters

Capital Charge Factor (%)	14.5
Dollars (Constant)	2001
Plant Life (Years)	20
Coal ($/ton)	28

System parameters

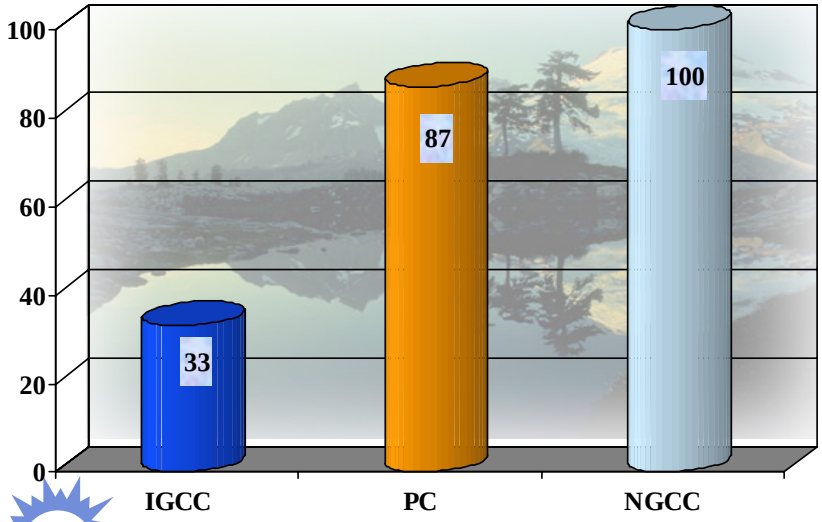
Capacity Factor (%)	65
% CO2 Capture*	90
Pipeline Distance (miles)	50
Saline Injection Pressure (psia)	1,500

*Most Cases

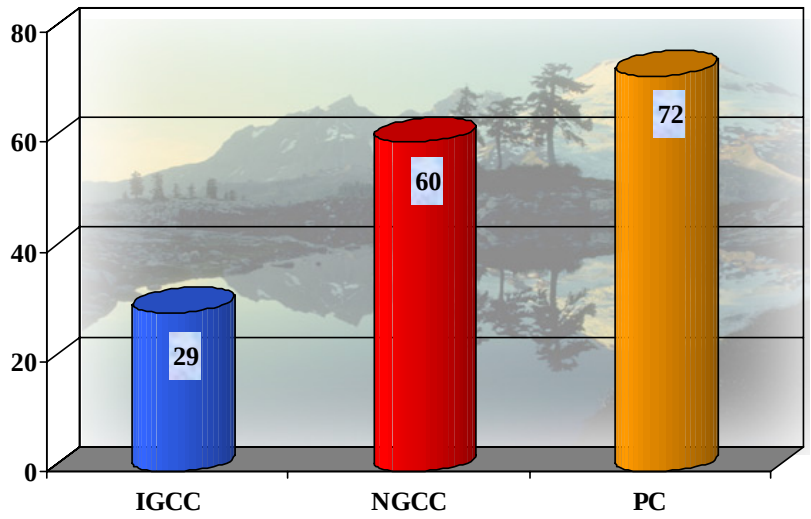
Status of Current "Best Case" Technologies
Using State-of-the-Art Scrubbing Technologies

- 5 to 30% Parasitic energy loss
- 30 to 100% Increase in capital cost
- 25 to 100% Increase in cost of electricity

Effect of CO_2 Capture on Capital Cost
(% Increase Resulting From CO_2 Capture)

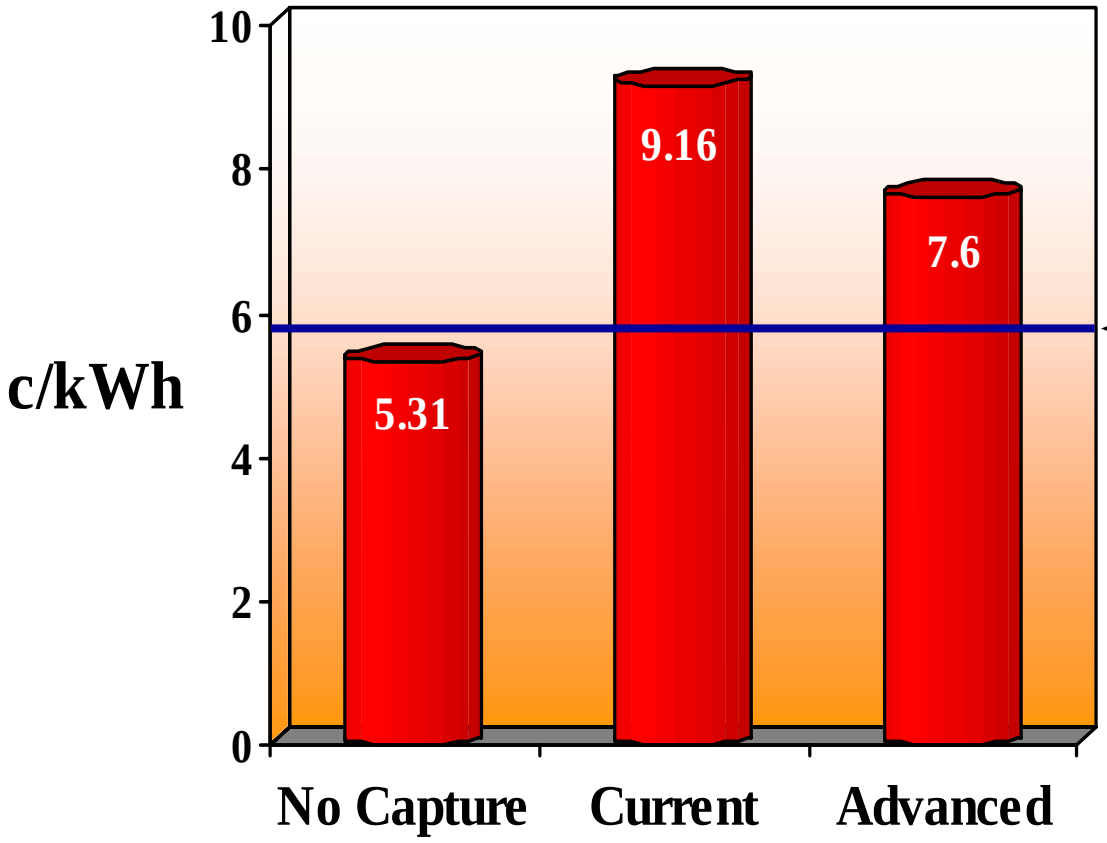


Effect of CO_2 Capture on Cost of Electricity
(% Increase Resulting From CO_2 Capture)



Analyses Allows Us To Dissect Economics

Where Should R&D Best Focus?



- Capital Cost Decrease
- Steam Stripping Efficiency

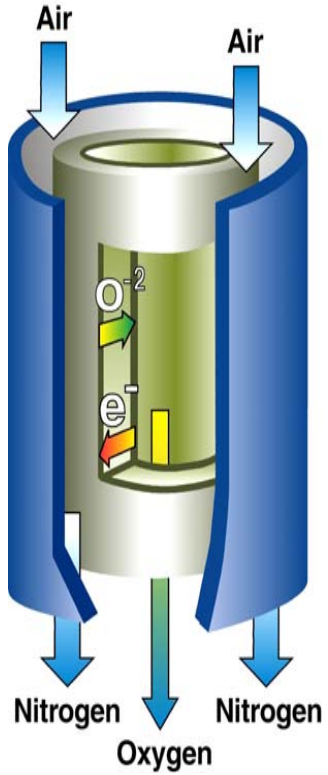
GOAL→ 20% Increase in COE

- Loading/Unloading Efficiency
- Improved Capacity

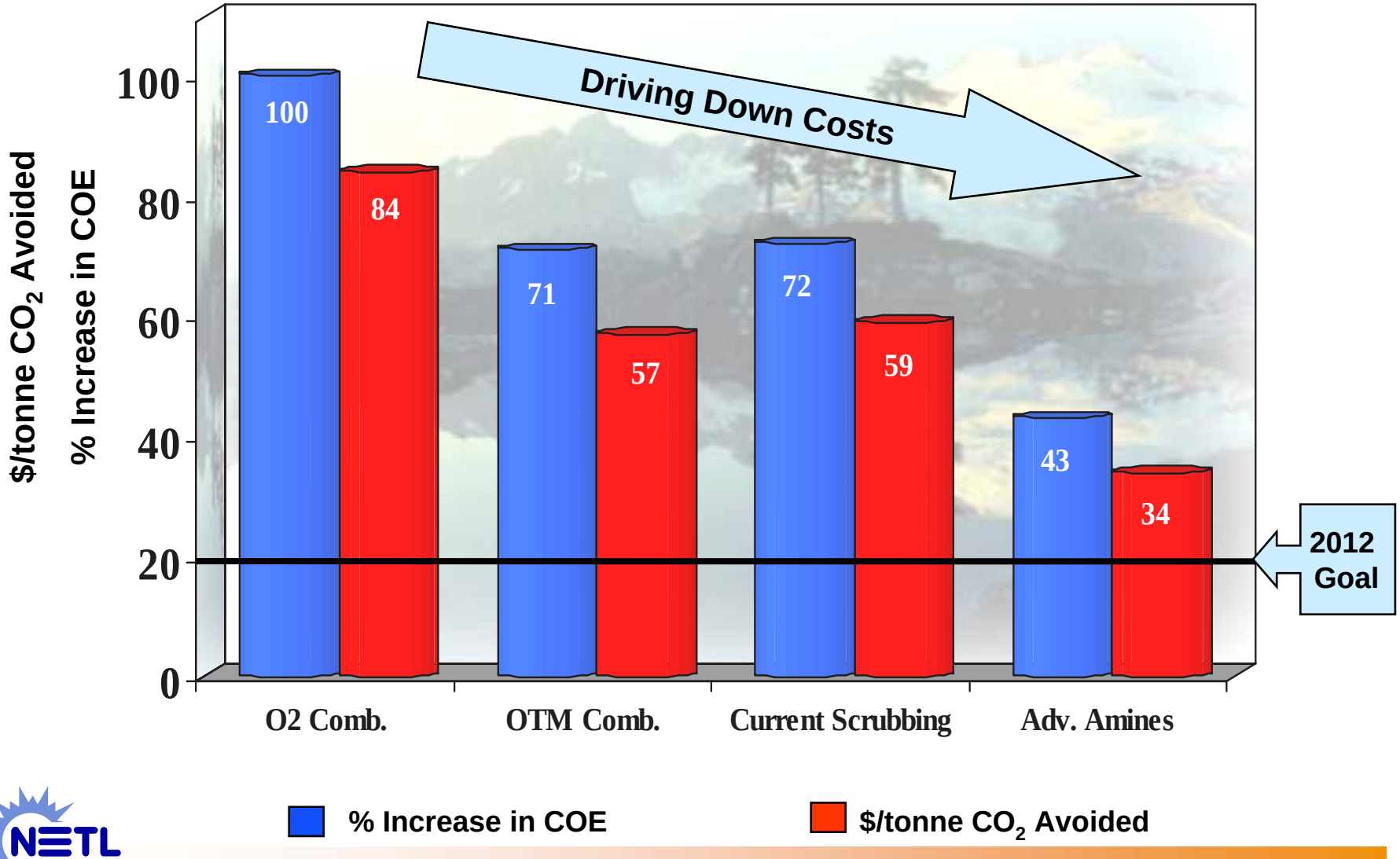
PC with Amine Scrubbing

Pulverized Coal Scenarios

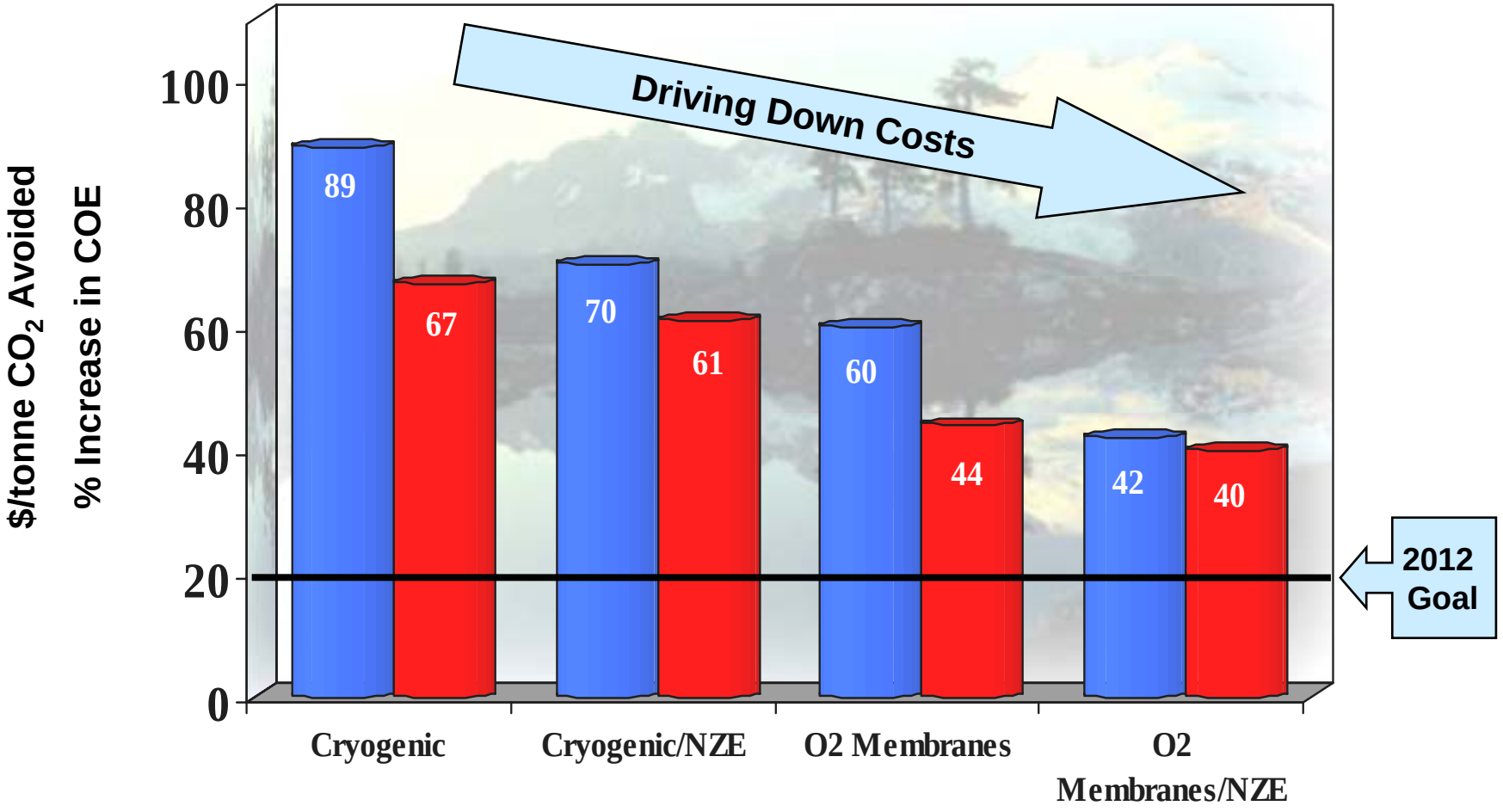
- Current Scrubbing - Chemical Absorbents (MEA)
- Advanced Scrubbing
- Oxy-Fuel Combustion
- Oxygen Transport Membrane



Marching Toward The Goals - PC Power Plant



Marching Toward The Goals - PC Power Plant O2 Combustion



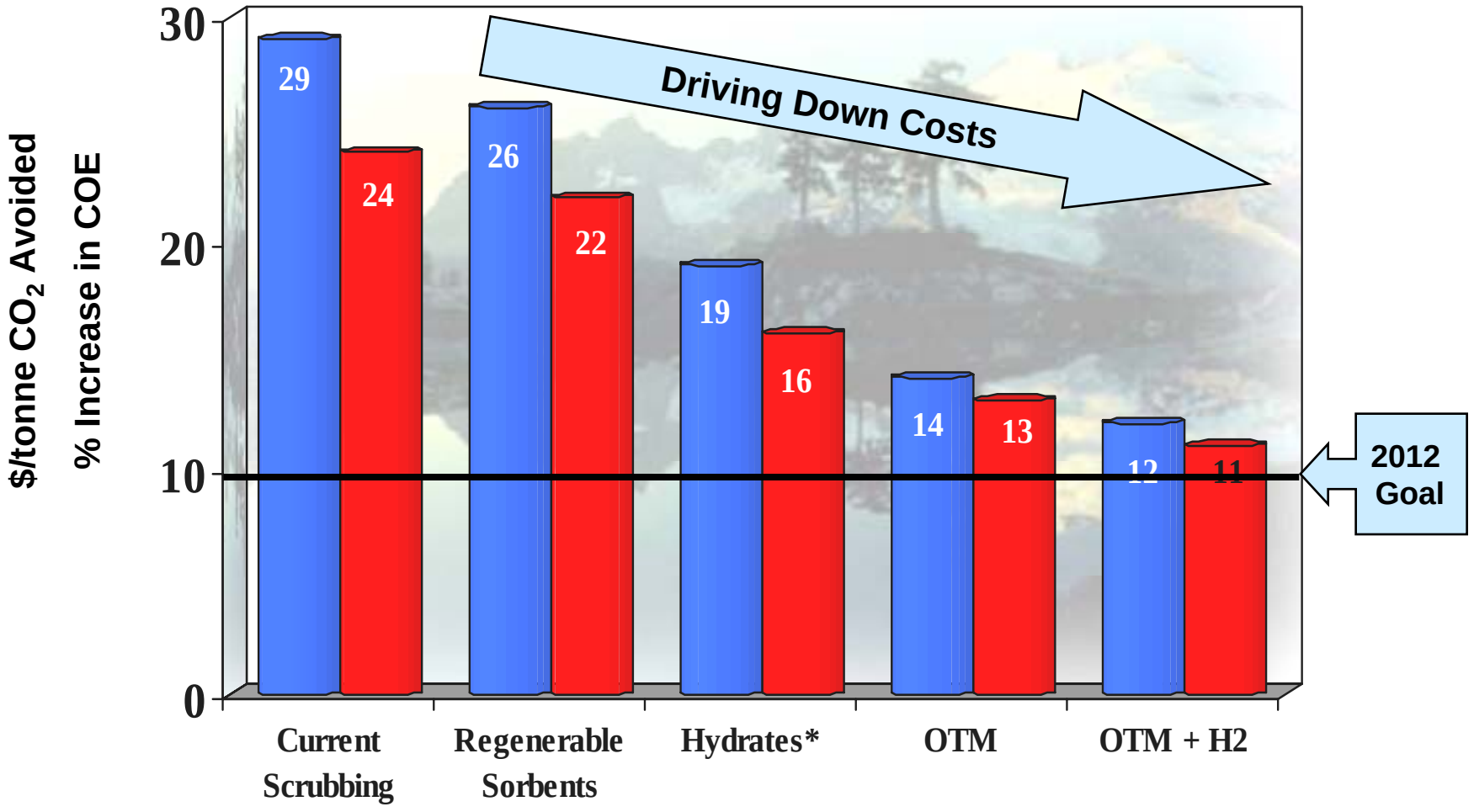
NZE: Near Zero Emissions (i.e. Sequestration of > 90% of Flue Gas Stream)

IGCC Scenarios

- Current Scrubbing - Physical Absorbents (Selexol)
- Oxygen Transport Membranes
- CO_2 Hydrates
- Dry Regenerable Sorbents

Tampa Electric Co.
IGCC Polk Power Station

Marching Toward The Goals - IGCC Power Plant



Future Work

- Continuous feedback loop with emerging R&D
- Add new technologies as appropriate (e.g. chemical looping, mineralization)
- Mesh R&D technology pathways directly to program goals
- Develop “dynamic” documentation on results and methodology