

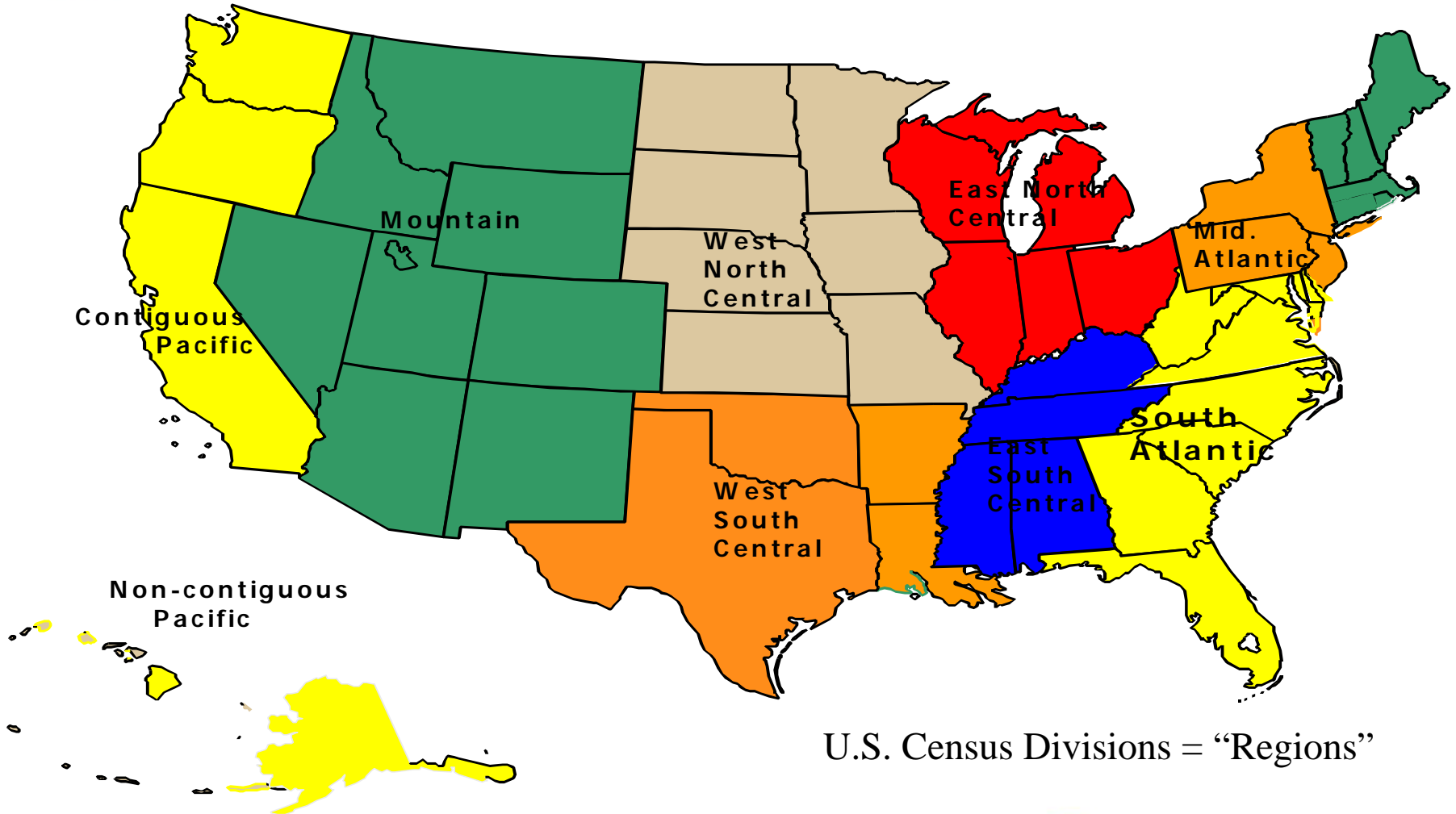


Regional Hydrogen Demand, Production and Cost Estimates

Margaret Singh, Argonne National Laboratory
Jim Moore, TA Engineering, Inc.
Bill Shadis, TA Engineering, Inc.

2005 EIA Midterm Energy Outlook and Modeling Conference
April 12, 2005
Sponsor: Phil Patterson, U.S. DOE

What We Mean by “Region”



U.S. Census Divisions = “Regions”



Why Conduct Regional H2 Analysis?

- Extensive efforts are underway to estimate future H2 costs
- But, no comprehensive assessment yet of regional variation in these costs
- In fact, H2 costs may vary substantially by region:
 - Costs to produce H2 vary by feedstock
 - Regional variation exists in feedstocks available for H2 production
 - For same H2 feedstock, regional variation exists in capital and energy costs
 - Some regions are proportionally more rural than urban
 - H2 delivery costs likely to be higher in rural areas



Why Conduct Regional H2 Analysis (continued)?

- So, this preliminary analysis of regional H2 demand, production and costs was intended to help identify key regional issues that need to be considered in estimating H2 costs
- Further, EIA indicated that if regional H2 price estimates could be developed, it would use them in NEMS
 - In the past, used a single H2 price for all regions
 - In AEO 2005, used our regional H2 cost estimates

Methodology

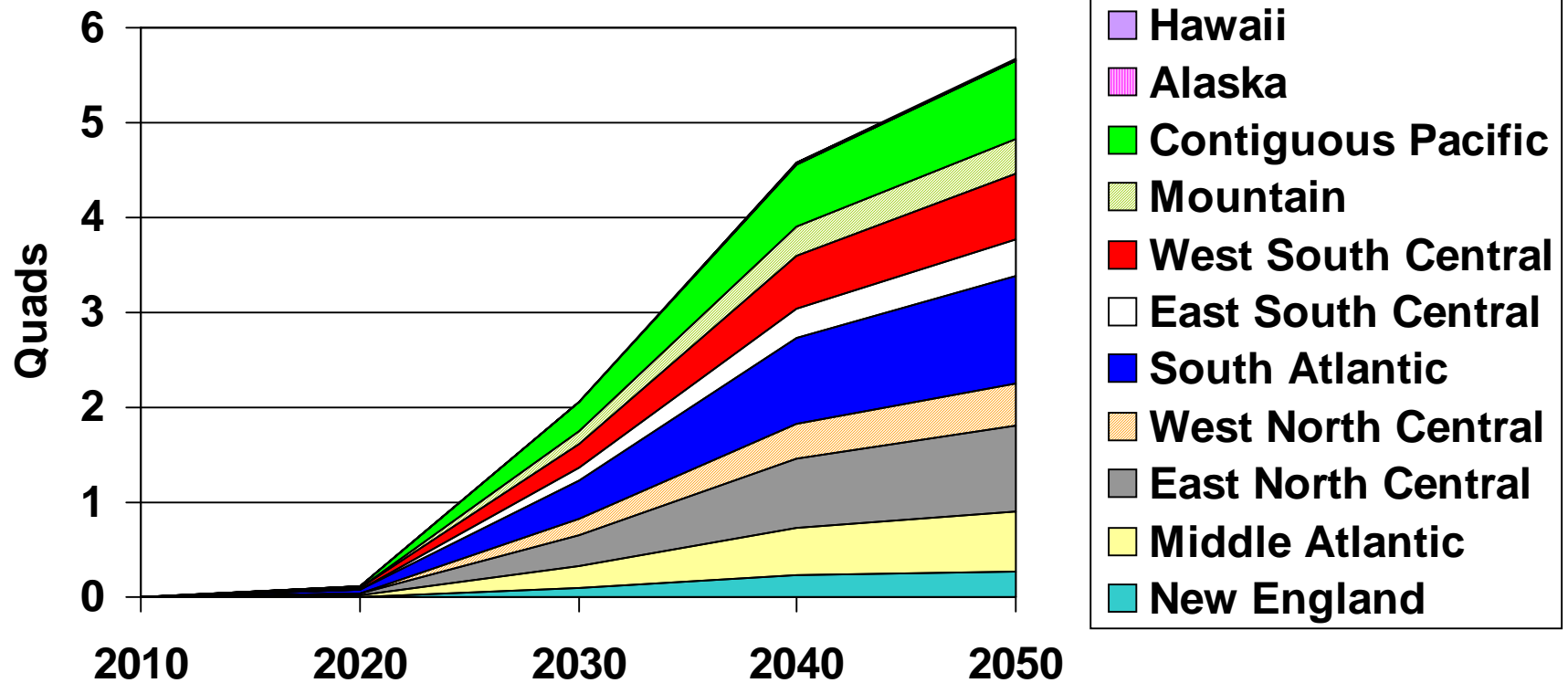
- Develop a scenario of significant H2 demand by FCVs by region to 2050
 - Time period consistent with other analyses which extend to 2050
 - Disaggregate the Pacific region (Alaska and Hawaii are separate)
- Estimate H2 production by region, feedstock, production method, and delivery method over time
 - Amount produced from different feedstocks is assumed to be dependent on feedstock availability, not costs
 - Comprehensive set of regional supply curves were not available
- Estimate H2 cost for each production/delivery method by region



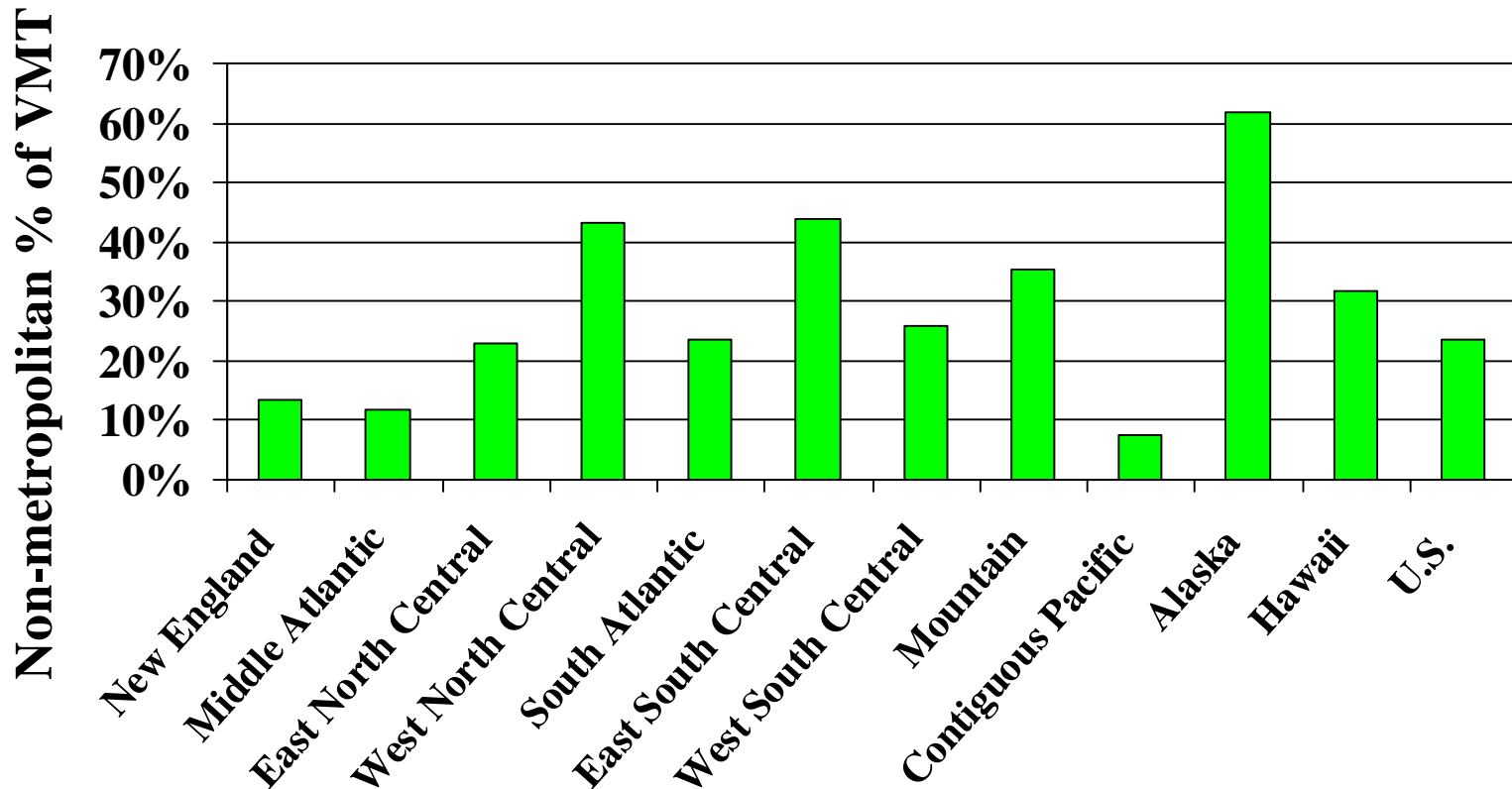
Regional H2 Demand Estimates

- Assumed H2 penetration of GYOW scenario from the joint DOE/NRCan 2050 study (2003)
 - FCVs 2015 commercialization (demos earlier)
 - FCVs 50% of LV sales by 2035 and stabilize at 50%
 - See http://www.eere.energy.gov/office_eere/ba/future.html
- By 2050, FCVs are 50% of stock and use ~6 quads (~45 billion gallons (GGE)) annually
- Allocated to regions according to current gasoline demand
- Allocated within regions according to metro/non-metro area travel
 - Used U.S. EPA county VMT estimates
- Assumed FCVs travel initially only in and between metro areas, but eventually would expand throughout the U.S. like today's vehicles

Regional H2 Demand in GYOW



Non-metropolitan H2 Demand Varies Among Regions in GYOW



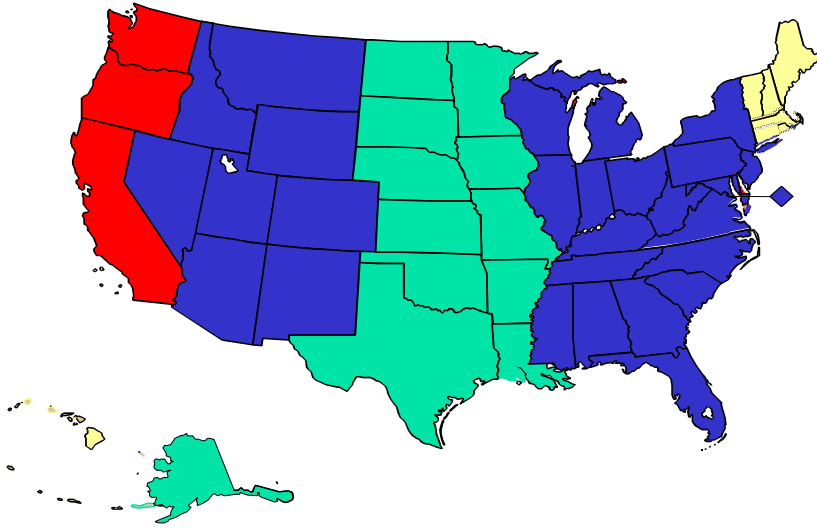


Regional H2 Production Estimates: Key Assumptions

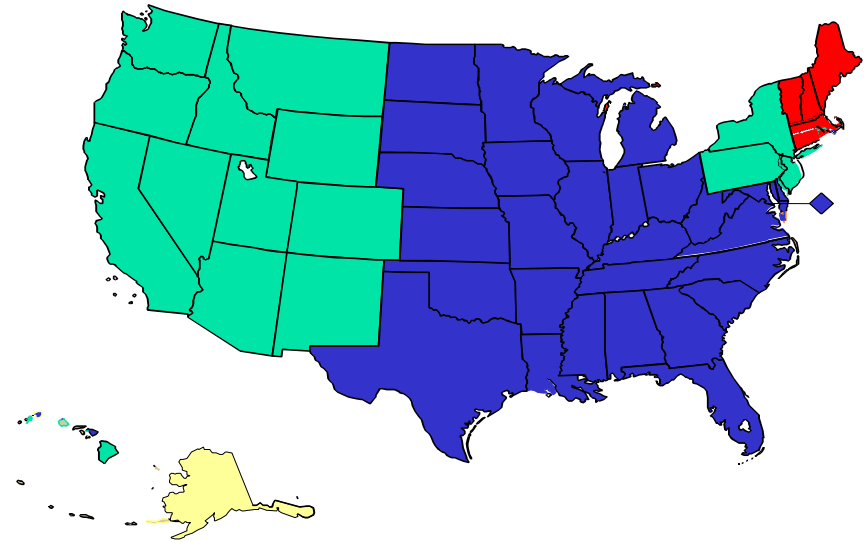
- Each region produces sufficient H2 to meet its demand
- H2 in metro areas: centralized production from diverse sources
- H2 in non-metro areas: predominantly produced at fueling stations (distributed production) from natural gas and/or electrolysis
- Feedstocks used to produce H2 depend solely on region-specific resource availability
 - Resource characterization derived from EIA, NREL, ORNL
 - In general, the greater the resource in a region, the more likely it will be used
- Natural gas as a feedstock phased out by 2050
 - DOE program “wish”

Examples of Regional Resource Characterization

Coal



Biomass



Resource availability relative to other regions

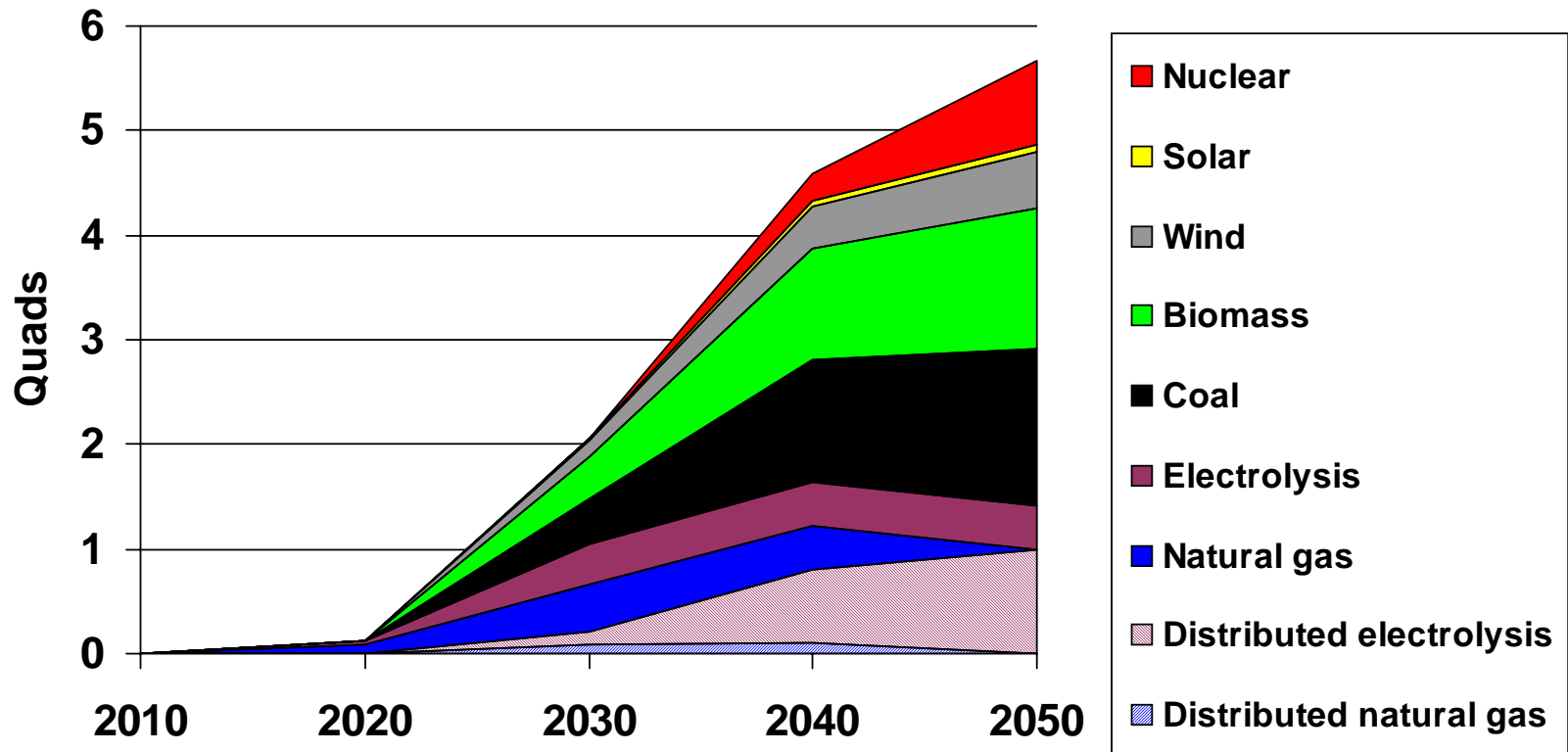
Blue: High

Green: Good

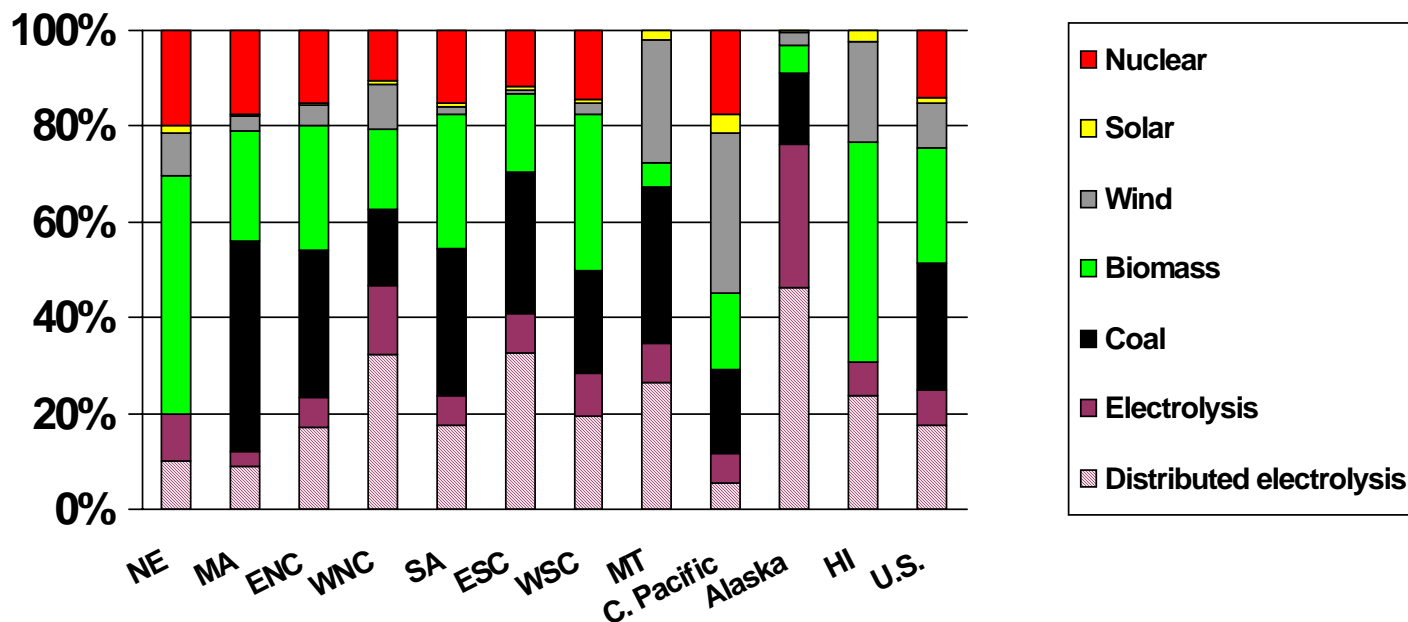
Red: OK

Yellow : Low

U.S. H₂ Production by Feedstock Varies Over Time



H2 Production by Feedstock Varies Significantly by Region



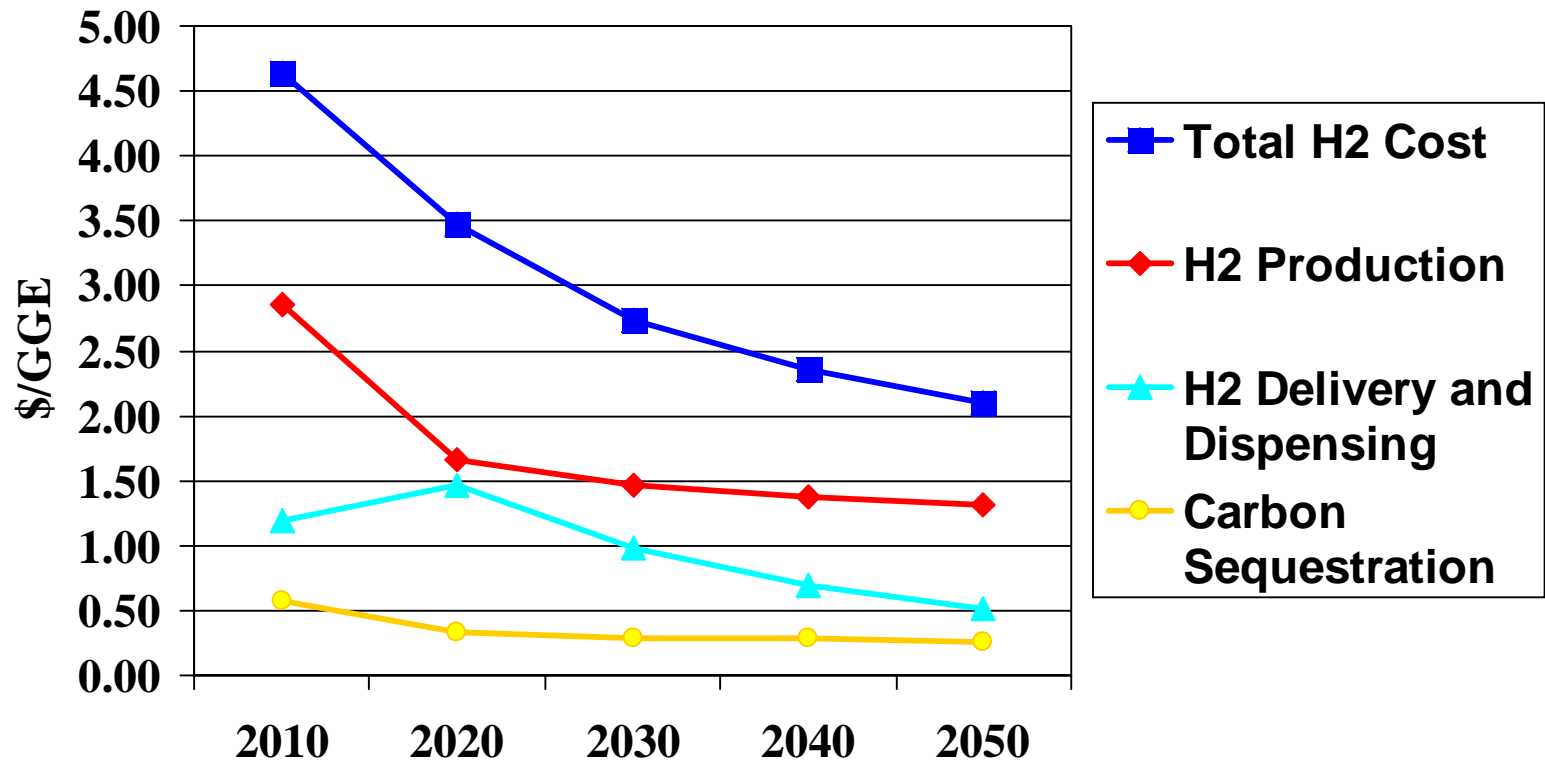
2050



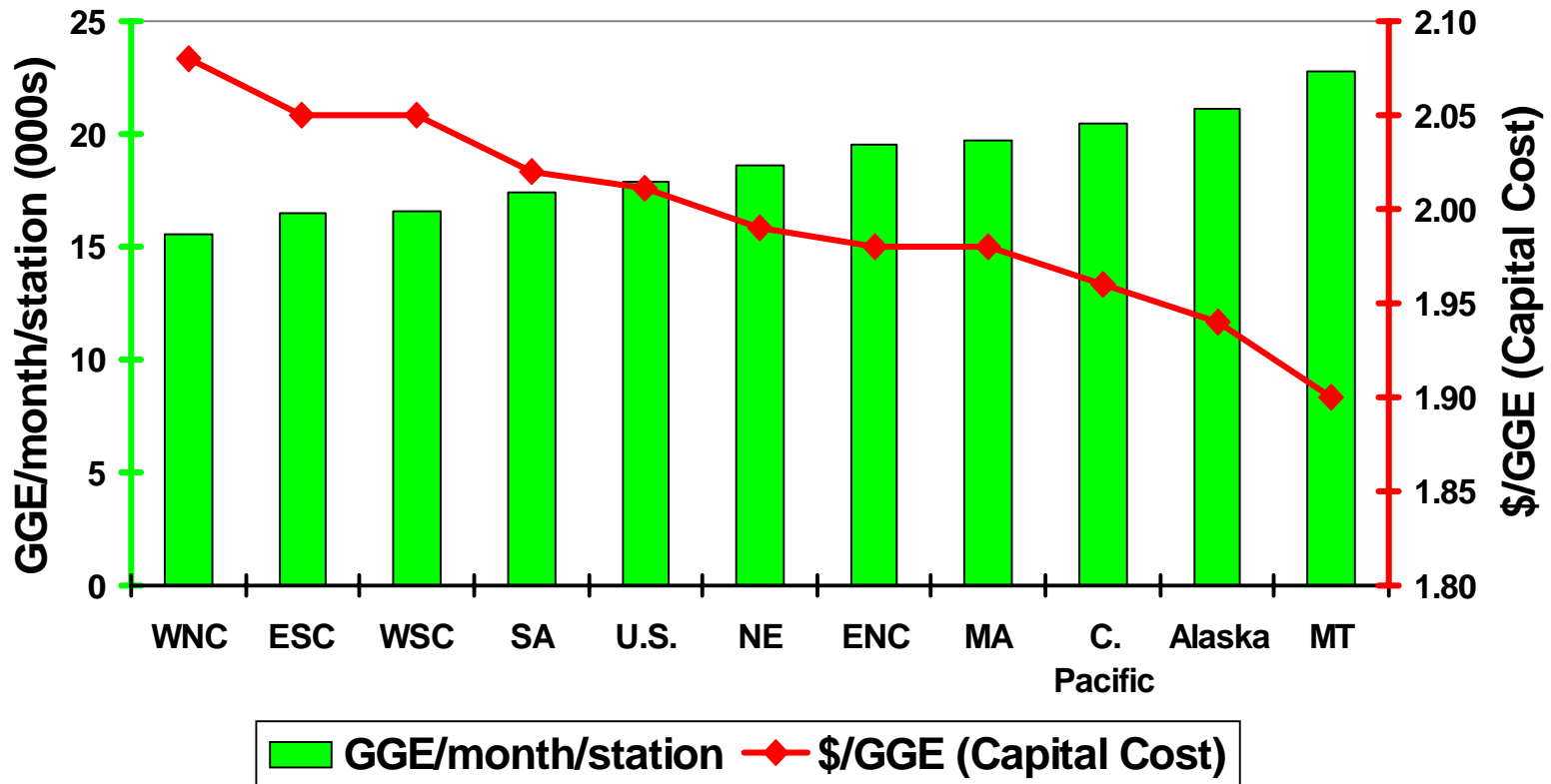
Regional Cost Estimates: Key Assumptions

- Starting point: Comprehensive analysis by SFA Pacific, Inc. (prepared for NREL, 2002)
- Replicated and then modified to assume:
 - Technological improvements over time to 2050
 - Energy and capital costs variation by region and/or time
- Centralized production and delivery
 - All plants 150,000 kg/day
 - Initial distribution by truck, then by pipeline
- Distributed production
 - For adequate geographic coverage in non-metro areas, H2 ultimately is available in same number of stations as provide gasoline now (~40,000 per U.S. Economic Census) by region
 - 75% of these stations provide H2 via distributed production
 - In the earlier years, less coverage (just non-metro interstates in 2020)

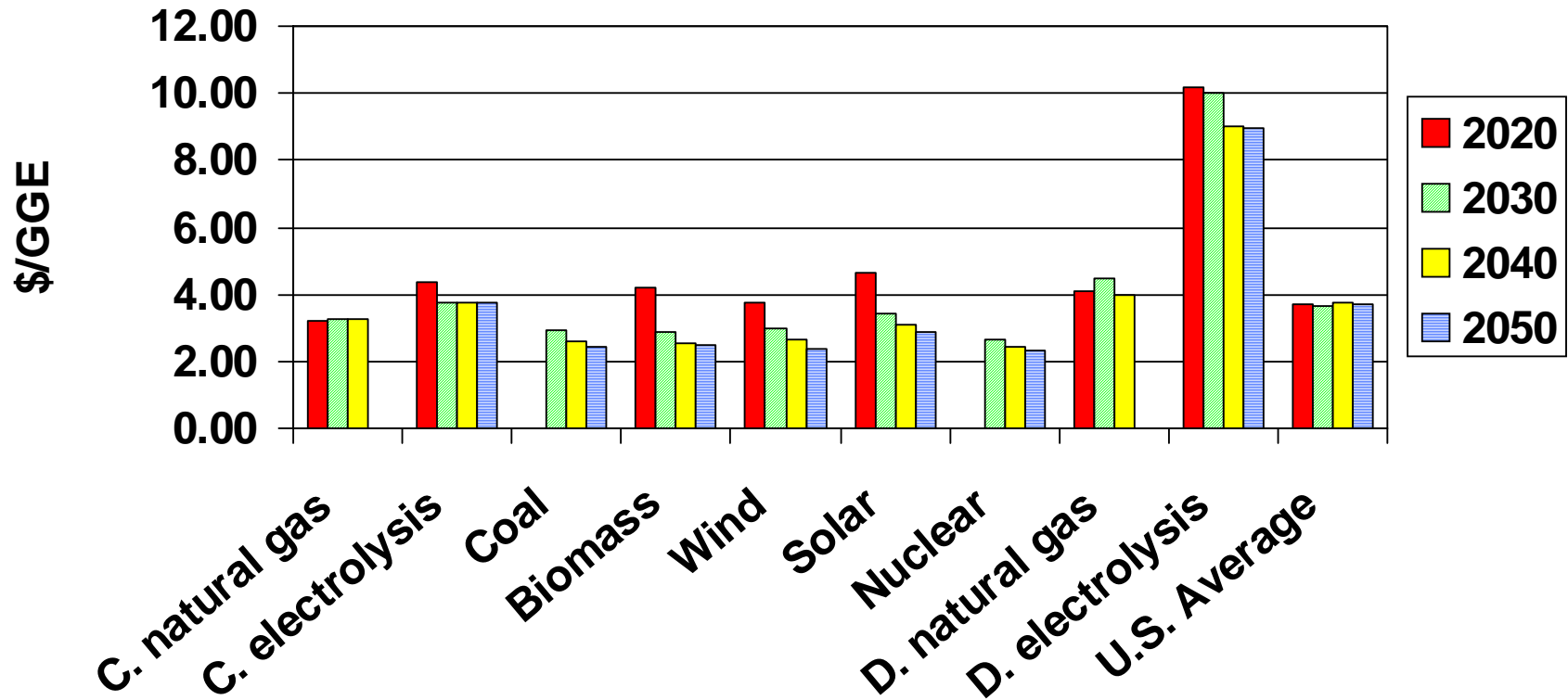
Example: Cost of Centralized Production of H₂ from Coal and Delivery to South Atlantic Region



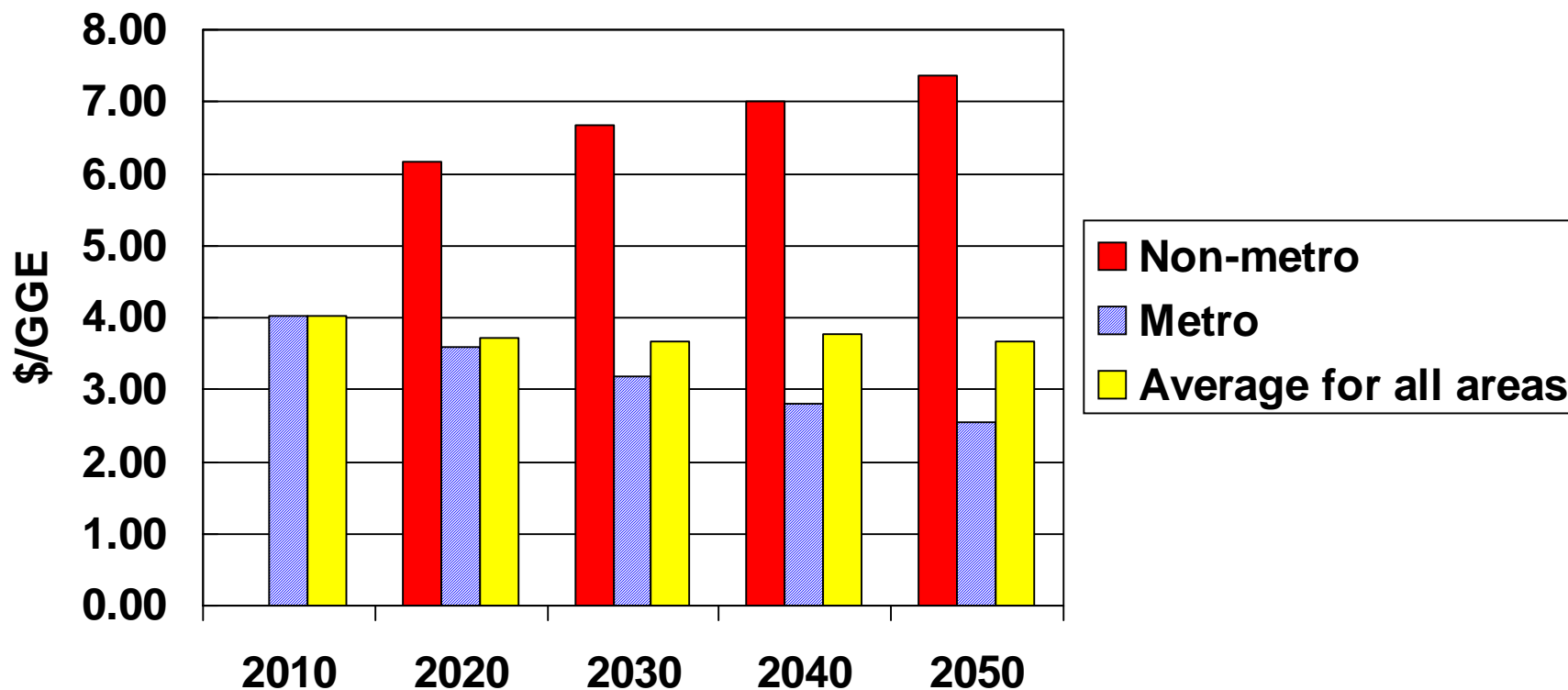
Non-Metro Area Station Totals and H2 Demand Result in Station Size Variation by Region and Per Gallon Capital Cost Variation (2040, Natural Gas)



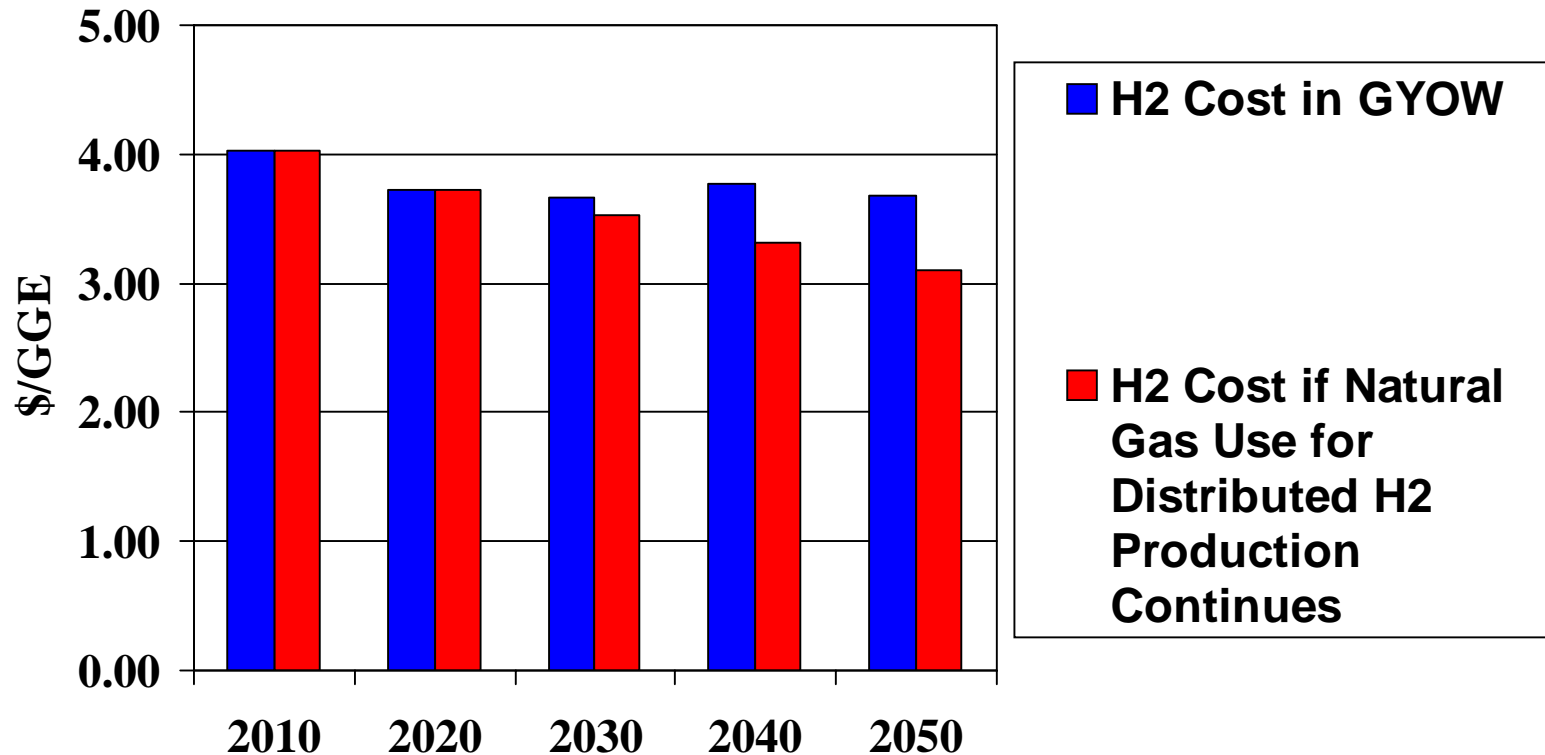
Results: In General, Delivered H2 Costs for All Technologies Decline Over Time, But U.S. Average Does Not



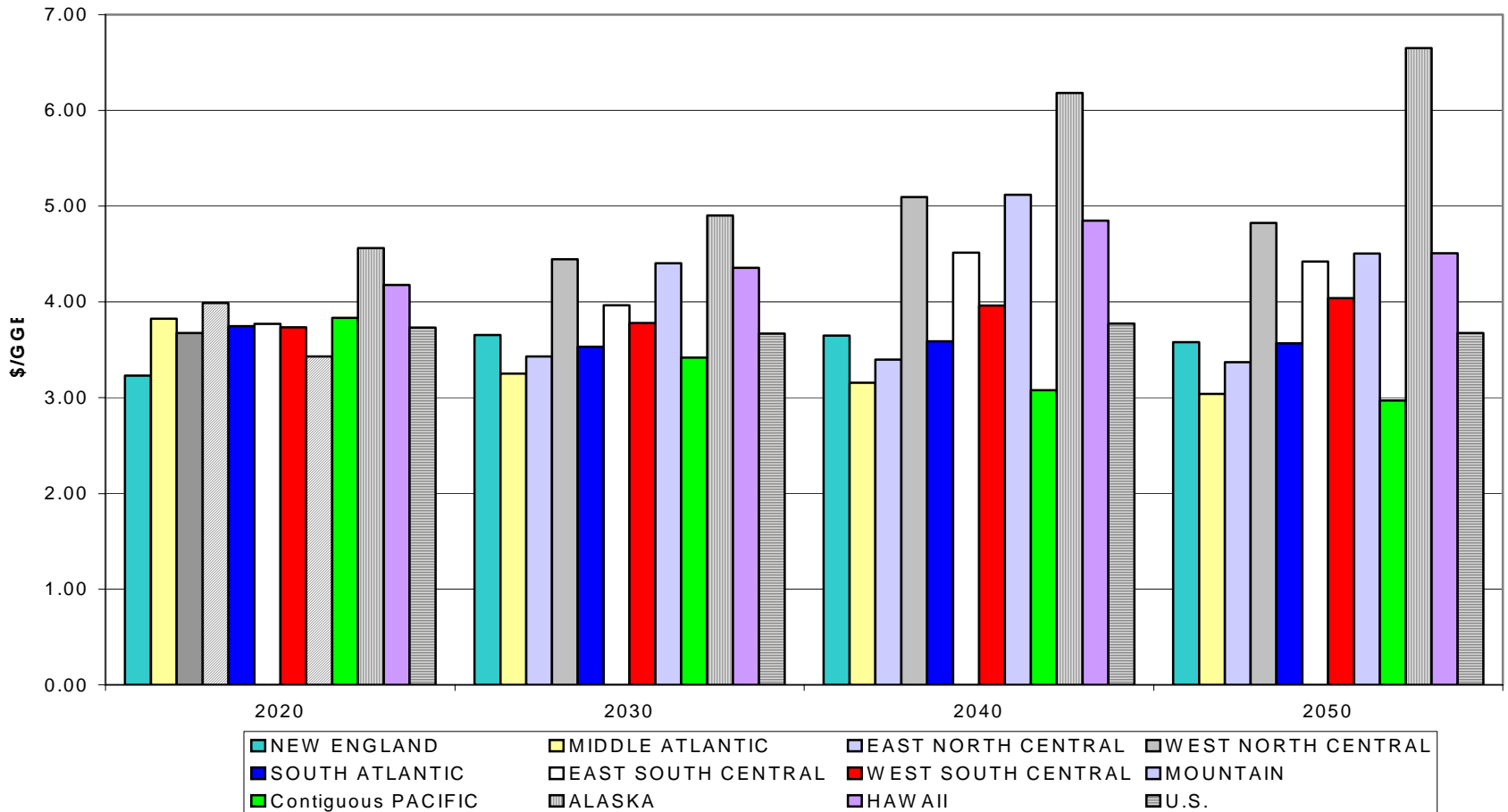
Reason: While Metro Area H₂ Costs Decline Over Time, Costs in Non-metro Areas Rise With Increased Use of Distributed Production, Particularly Electrolysis



Sensitivity Run: U.S. Average H2 Cost Declines Over Time if Distributed Production from Natural Gas is Not Phased-Out



Results: Average H2 Costs Vary Among Regions





Selected Regional Issues Requiring Further Study: Rural FCV Refueling

- Assuming a goal of significant FCV market penetration, should we expect FCVs to fulfill the same rural travel demand as the average vehicle today?
- If so, what might be the predominant method of H2 production and delivery in rural or non-metro areas?
- Does the current gasoline service station infrastructure in these areas have anything to tell us about where H2 stations need to be located?



Selected Regional Issues Requiring Further Study: Regional Differences in the Transition to FCVs

- This analysis assumed no difference among regions in the early years of FCV penetration. Is it more likely that FCVs will penetrate some regions earlier than others? Does that help with refueling infrastructure issues? One option for staged penetration:
 - Contiguous Pacific and Hawaii
 - New England and Middle Atlantic
 - East North Central
 - South Atlantic
 - West South Central
 - East South Central
 - Mountain, West North Central and Alaska



Selected Regional Issues Requiring Further Study: Regional Production

- Can we develop regional supply curves for all the resources that might be used to produce H₂?
- How do we address potential interregional trading of H₂ or H₂ feedstocks?
- Assuming distributed production will be necessary in some areas, should the DOE program “desire” of “no natural gas use” by 2050 be reevaluated?
- What will be the effects of a regionally diverse expansion of extraction and harnessing of natural resources to produce H₂?
 - Air, water, land use



Conclusions

- Regional differences in H2 demand and production will affect H2 costs
- A number of issues related to these regional differences need to be addressed in developing future H2 cost estimates