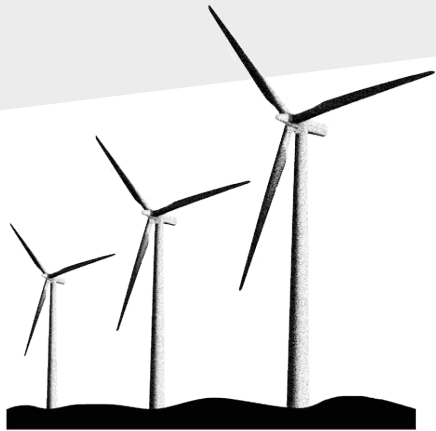


Analysis of Wind Industry Success: Denmark and United States



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Hypothesis

We plan to identify and analyze the driving factors that have contributed to Denmark's success in the wind energy industry in comparison to the United States. We will measure the success by comparing the GWh of electricity produced by wind per capita and per square kilometer in these countries and analyzing the trends of increased wind power production with evolving energy policies.

Outline

Denmark

- Technology History
- Policy History
- Active MW Added Wind Capacity

United States

- History
- State Case Studies
 - California, Texas, Iowa

Calculations

- Measures of Success
- Comparisons via Graphs

Conclusions

Denmark

Denmark: Technological History

- “Bottom-up” strategy for development
- Manufacturing



Policy History

1970s

- Dependent on imported oil
- Oil crisis → Switch sources → Proactive Energy Policy
- Energy tax on electricity prices → R&D for renewables
 - Nuclear? Parliament excluded it in 1985, 1 year before Chernobyl
 - Wind? Yes.
- Goal: reduce dependence on oil and focus on energy savings
- Converted power plants oil → coal

Policy History

1980s

- Danish families offered tax incentives for generating power
 - → Local wind cooperatives formed
- Taxes on coal and oil + subsidy on construction and operation of wind turbines and biomass plants
 - Increased competitiveness of renewables
- Government set ambitious targets to install wind power

Source: International Renewable Energy Agency

Policy History

1990s

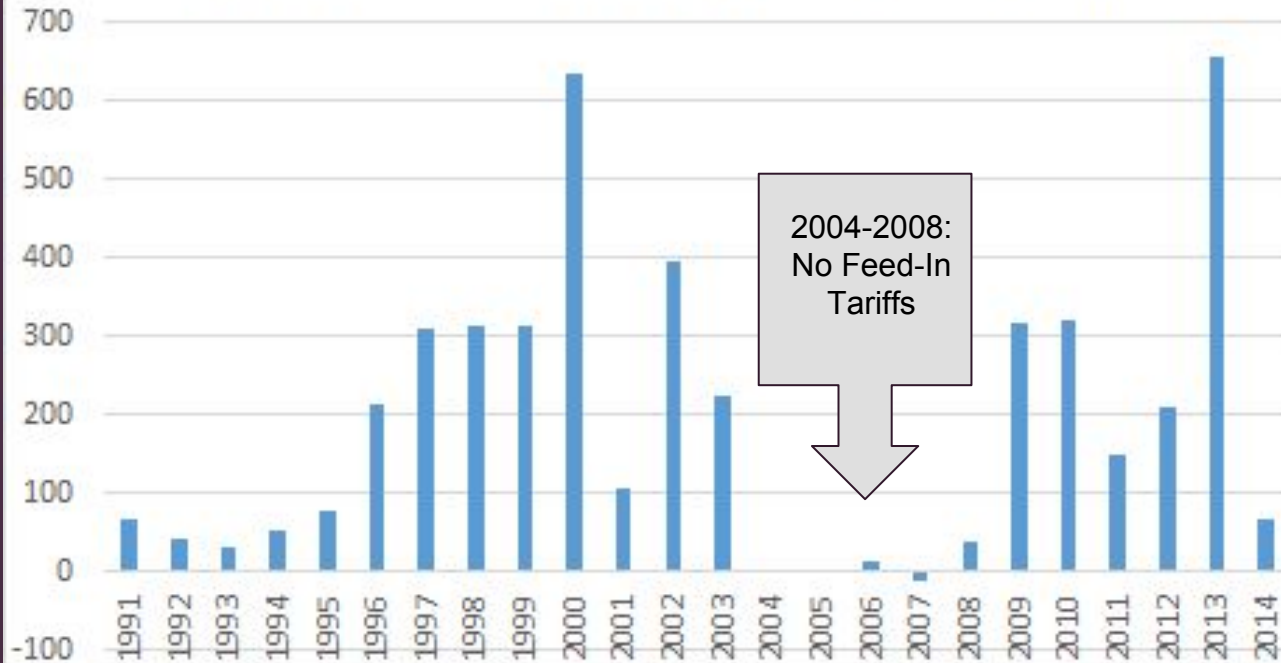
- 1990: “Energi 2000”
 - One of the first energy plans in the world without nuclear
- High public involvement
- 1993: Feed-in Tariff (FIT) implemented
- Offshore wind grew
- Danish Energy Agency created
- Legislation to liberalize Denmark’s electricity market

Policy History

2000s

- 2001: New governing party came to power
 - Favored low taxes and less government interference
- 2001-2004: Phased out FIT
- 2004-2008: Stagnation in wind market
 - Only 25 MW added
- 2009: New Prime Minister + Promotion of Renewable Energy Act
- 2011: Energy Strategy of 2050
 - 100% independence from fossil fuels in national energy mix
- 2012: Danish Energy Agreement
 - Framework up to 2020 + direction through 2050

Active MW of capacity added per year



Source: Danish Energy Agency

United States

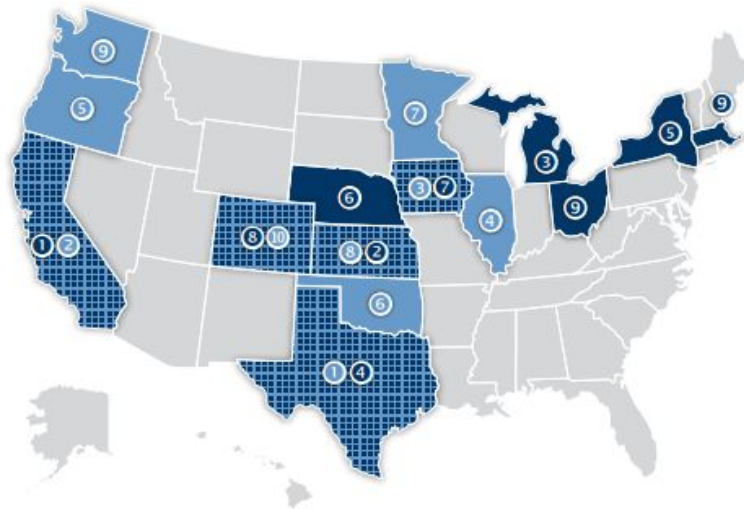
United States Policy History

- 1970's oil crisis lead to Carter signing the 1978 National Energy Act and 1980 Energy Security Act
- 1992 Production Tax credit enacted providing a 1.5 cent/kWh subsidy for wind power generation
- 1999 Wind Powering America Initiative announced
 - Goal: increase wind power over the next 10 years
- 2000's State level Renewable Portfolio Standards adopted in several states
- 2008: Obama administration releases "20% wind by 2030"
- 2015 Wind Vision update to 2008 wind plan, including more offshore

State Case Studies

- California
- Texas
- Iowa

States Leading Wind Power Development (2013)



Cumulative Capacity (MW)	
1 Texas	12,354
2 California	5,829
3 Iowa	5,177
4 Illinois	3,568
5 Oregon	3,153
6 Oklahoma	3,134
7 Minnesota	2,987
8 Kansas	2,967
9 Washington	2,808
10 Colorado	2,332

Annual Capacity (MW)	
1 California	269
2 Kansas	254
3 Michigan	175
4 Texas	141
5 New York	84
6 Nebraska	75
7 Iowa	45
8 Colorado	32
9 Ohio	3
10 Massachusetts	3

Source: LBNL via NREL

California

1978

- State and Federal tax incentives
- PURPA

1980

- Unsuccessful turbines
- “Top- down” strategy

Mid 1980s

- 79% wind power supplied worldwide

1986

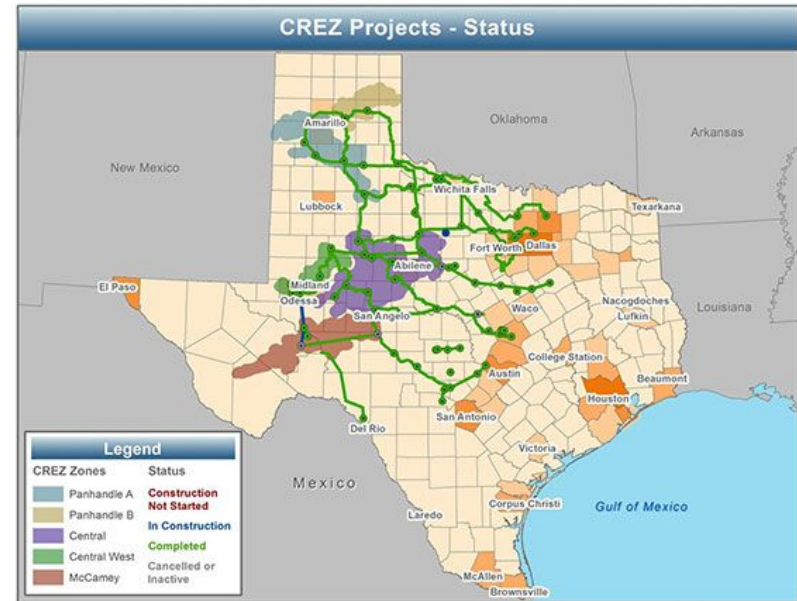
- Reduction in government subsidies



Sources: NREL, Matthias Heymann
Image: The Telegraph

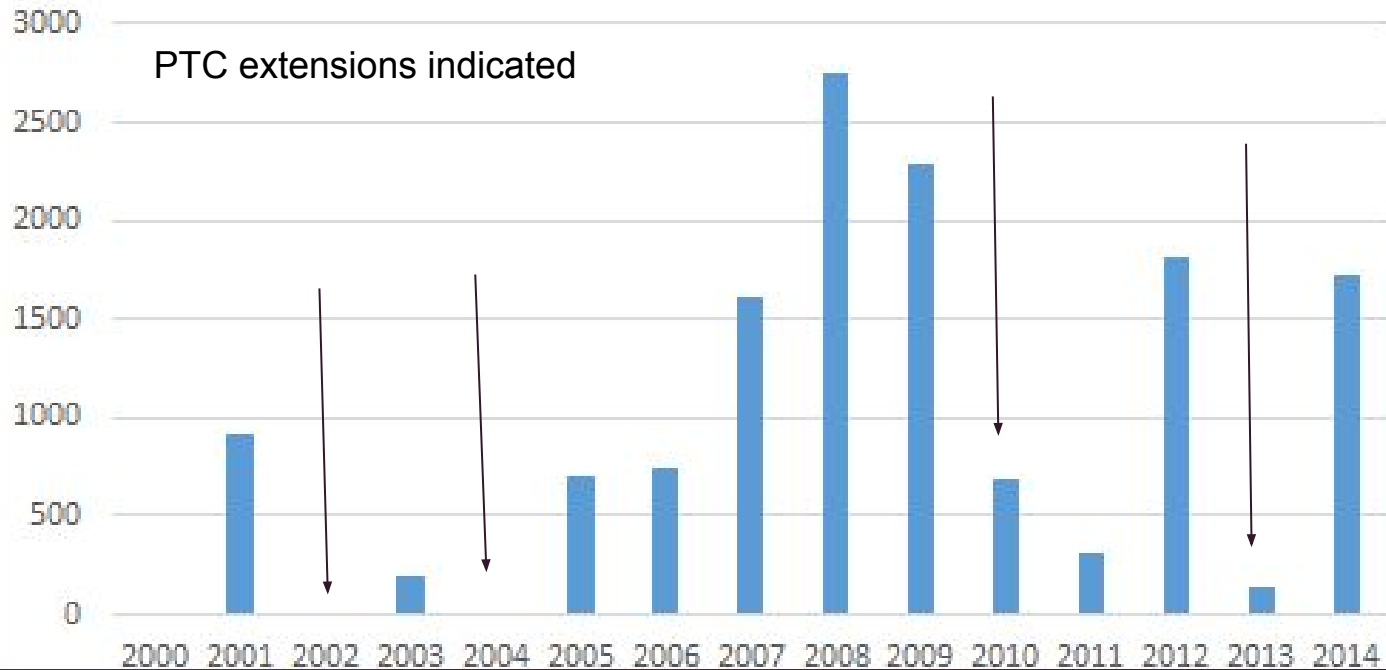
Texas

- Most installed wind capacity of any state
 - 9% of electricity for state
- Renewable Portfolio Standard (RPS)
 - 1999, 2005
 - Competitive Renewable Energy Zones (CREZ)
- REC trading program
 - Established by Public Utility Commission of Texas in 2000
 - ERCOT - Electric Reliability Council of Texas



Source: U.S. Energy Information Agency

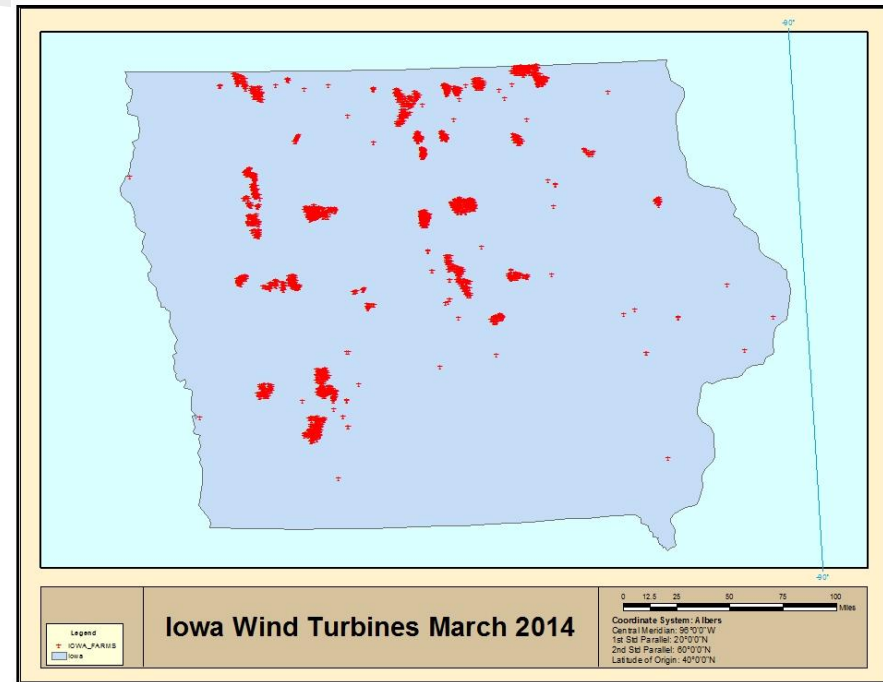
Added MW of Wind Power



Source: US Department of Energy

Iowa

- Coal #1 (~60%) and wind #2 (>25%)
- 1983: law passed requiring major utilities to own or contract a specific amount of renewable energy
- 1992: Federal Renewable Electricity PTC
- 2005: Wind Energy PTC and Renewable Energy Tax Credit
- 2014: >28% electricity generated with wind (first state)



Source: Iowa Dept. of Revenue

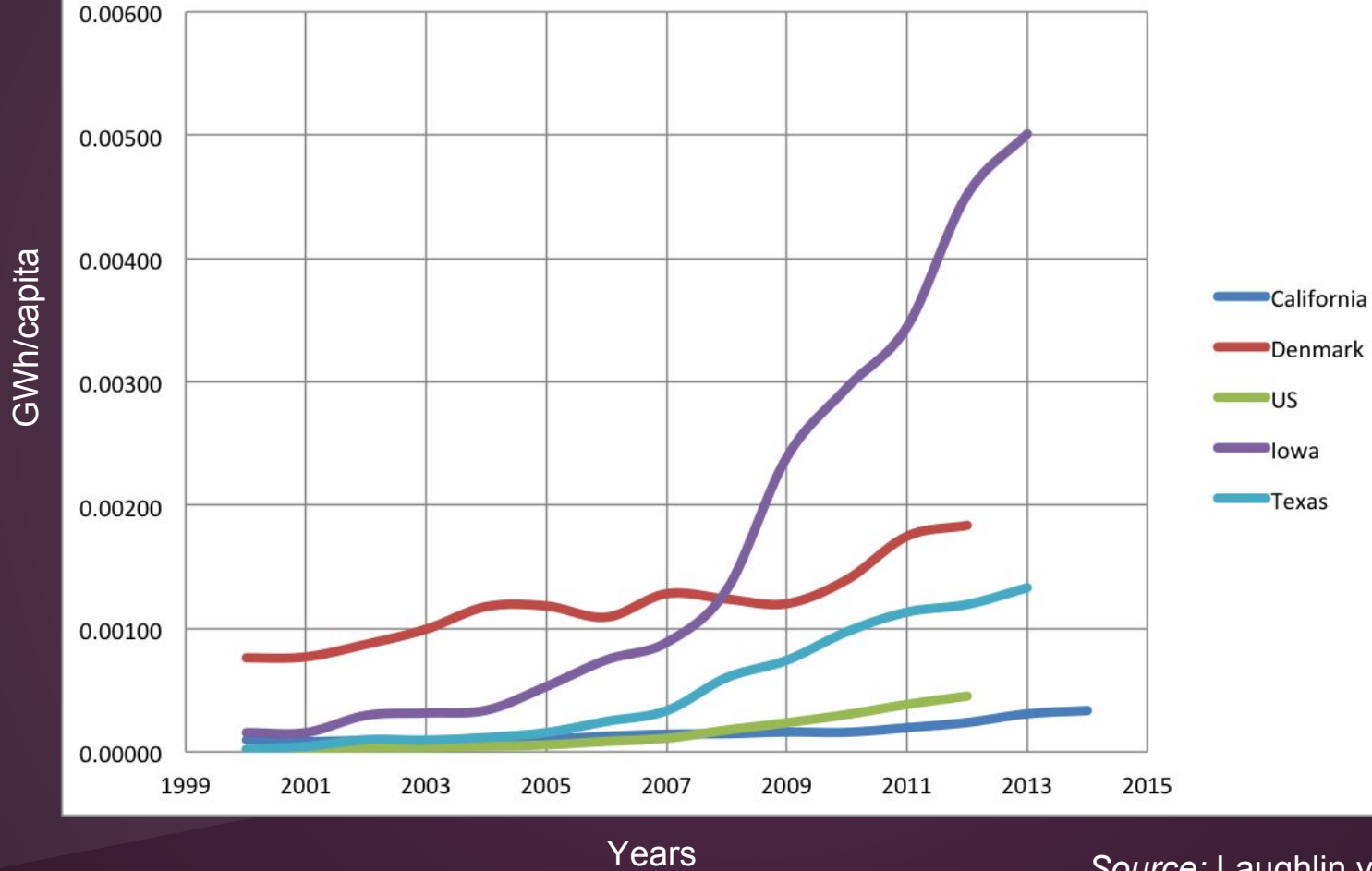
Image: NREL data, Laughlin via ESRI ArcMap

Calculations

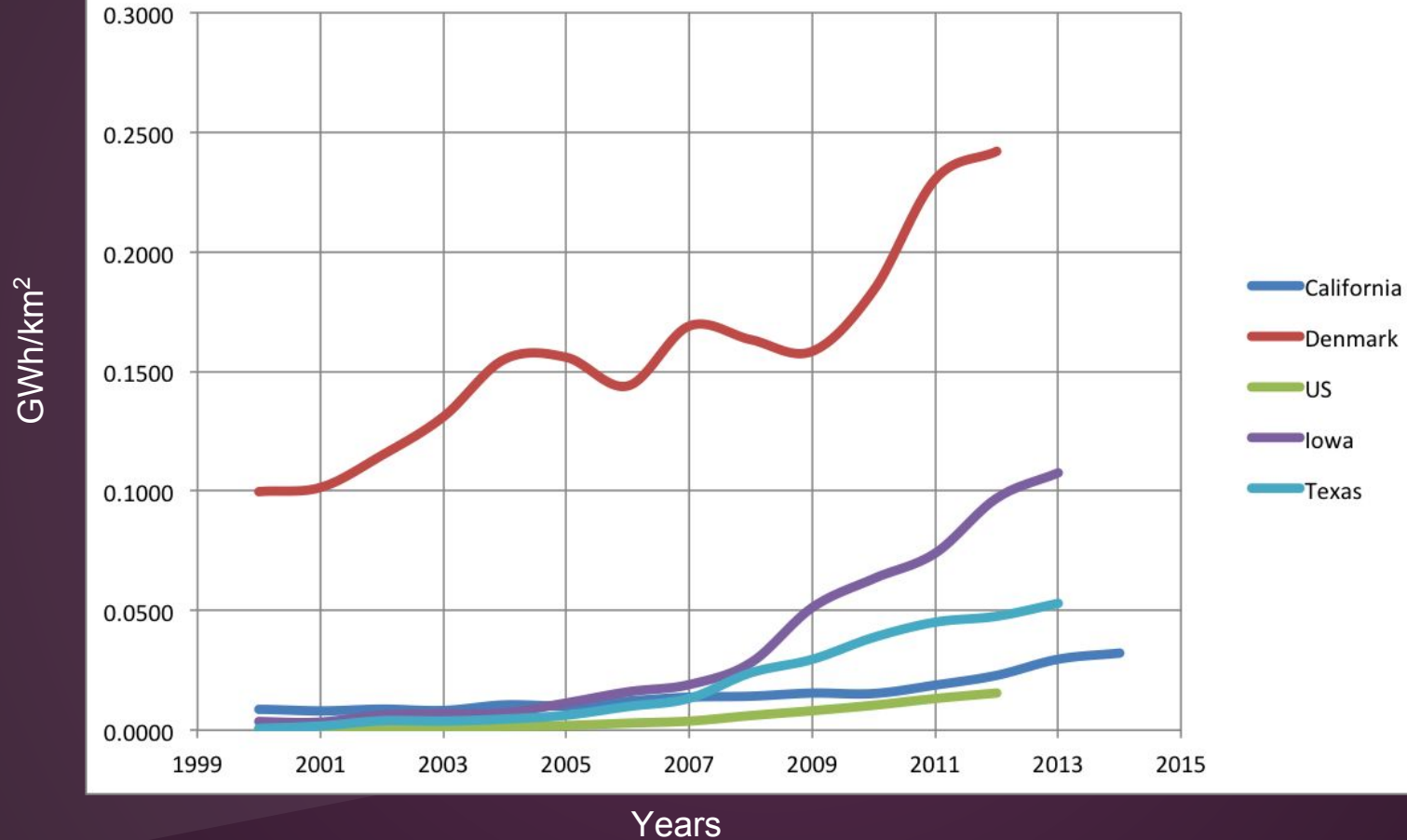
Comparisons for “Success” in Wind Industry

1. GWh of Wind Production per capita
2. GWh of Wind Production per area (km²)

GWh Wind Production/Capita



GWh Wind Production/Area(km²)

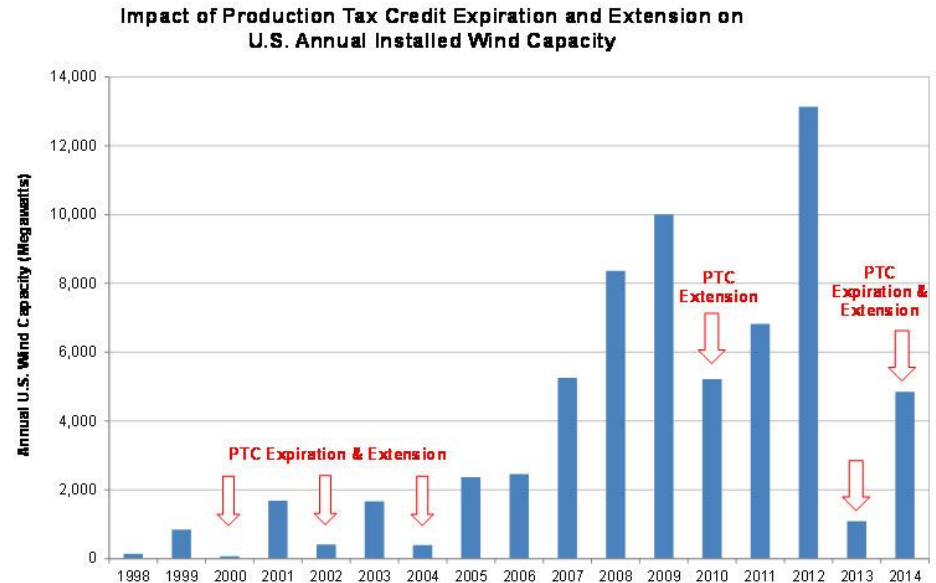


Source: Laughlin via IEA data

Conclusions

The Fall Back of the Production/Investment Tax Credit

- The “on-again, off--again” nature of the incentive makes it very difficult for the industry to get established in the U.S.
- This short-term policy discourages risk-averse investors

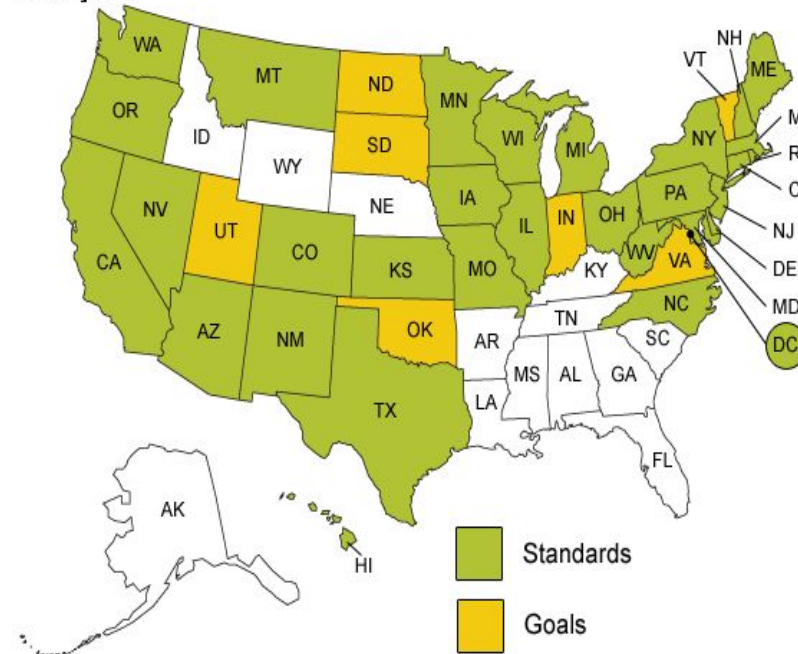


Sources: The White House, U.S. Department of Energy, Fredric C. Menz, Stephan Vanchon

Renewable Portfolio Standards-RPS

- Renewable electricity credit
 - trade system for renewable energy sources
 - one REC for every MWh of electricity placed on the grid from renewable sources
- States with RPS in place have seen an increase in renewable electricity production
- States without RPS have also seen an increase in electricity produced from renewable sources
- No national RPS strategy

States with Renewable Portfolio Standards (mandatory) or Goals (voluntary), January 2012



Source: U.S Energy Information Agency

Benefits of FIT

- What is a feed-in tariff?
 - Long-term agreement aimed to accelerate deployment of renewable energy technology in the electricity sector
- Long-term vision creates stability
- Guaranteed rate per unit of electricity
- Based on production of private companies
- Guarantees priority access to the electrical grid
- Investment security is higher
- Wind-project growth more consistent

Conclusion

Denmark has obtained its status as a leader in wind power production as a result of effective wind technology development and implementation of long-term wind policies through feed-in tariffs.

Though the United States was once a world leader in wind power production, it has since fallen behind Denmark as a result of ineffective technological development and short-term wind policies.