Policy Options for Renewable Energy Incentives: the View from Europe

or

What’s with Feed-in Tariffs?

Massachusetts Wind Working Group

November 9, 2006

J. F. Manwell
Overview

• Renewable energy in Europe today
• Historical wind energy growth
• Need for incentives
• Renewable energy policy incentives in US
• The situation in Europe
• Implications for Massachusetts?
Context for European Interest in Renewable Energy

• Meltdown at Chernobyl nuclear plant, 1986
• Awareness of “social costs” of energy production
  – Olav Hohmeyer (Germany, 1990’s) initiated the discussion
• Climate change/ attempt to meet Kyoto protocol requirements
• Relatively limited conventional fuels in Europe
• Renewable energy products/economic growth
Renewable Energy Vision in Europe

• A very high rate of deployment of renewable energy projects is needed
• Some form of financial support is required
  – Cannot rely on market alone
• Regulatory encouragement
  e.g. building codes
• Support of research and development
  Comprehensive approach
• Support for education at all levels
  e.g. European Masters in Renewable Energy

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A Significant Role for Renewable Energy is Envisioned

- Possible transformation of world’s energy supply:

Source: German Advisory Council on Global Change, 2003

Figure 1
Transforming the global energy mix: The exemplary path until 2050/2100.
Source: WBGU
The Debate in Europe

• There is a general consensus that incentives are needed for renewable energy systems
• There has been considerable debate over which incentive should be used: RPS vs. Feed-in Tariffs
• Arguments particularly between Germany and the UK
• Have resulted in rifts within the European renewable energy community
  – World Wind Energy Assoc. ("German")
  – Global Wind Energy Council ("UK")
• Consensus in favor of feed-in may be emerging

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The Debate Has Sometimes Been Difficult!

Source: Rickerson and Zytaruk, AWEA, 2006

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The Central Difference

• RPS (Renewable Portfolio Standard)
  – Fixed quota for RE projects/unspecified price for electricity sold (set by bidding)

• Feed-in Tariffs
  – Fixed price for electricity sold/unspecified quantity of RE capacity (deployment rate is function of price)
Wind Energy Historical Background (1)

• Widely used throughout world (for mechanical power) until industrial revolution; decline through 19th century

• Little development anywhere in last 200 yrs until approx. 1975
  – Except wind water pumpers in U.S. west in 1800’s and small wind electric systems in U.S. in 1930’s
  – Some R&D projects and proposals
Wind Energy Historical Background (2)

• Occasional efforts to revive wind energy (for electricity) throughout 20th century
• Oil crises of 1970’s lead to federal R&D and policy changes in US, especially due to Pres. Carter and Gov. Brown (California)
• US was early leader in 1970’s (95% of wind energy capacity before 1980)
  – Beginning of the “wind farm” era
• World leaders are now Germany and Spain
Some pre-Wind Farm Era Wind Turbines

- **Smith-Putnam, VT, 1930’s-40’s**
- **Gedser, Denmark, 1950’s**
- **Hütter, Germany, 1950’-60’s**
- **WF-1, UMass, 1970’s**
1970’s Policy Incentives in US

• Investment tax credits in US and California
  – Tax incentives based on cost of wind turbines

• Public Utility Regulatory Policy Act of 1978 (PURPA)
  – Guaranteed access to grid
  – Required utilities to buy electricity at “avoided cost”
  – Utilities offered attractive “standard offers” for sales in California

• These lead to the growth of California wind farms (among other projects)
Wind Farm Era Turbines
1970’s-80’s

Enertech (from VT), in California

US Windpower (from Massachusetts), in California

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More Recent Wind Turbines

Vestas (from Denmark), in Hull, MA, 2001

REpower (Germany) 2006

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Sample Wind Energy Installation Rates

Thousands MW Installed Per Year

Source: Gipe, OSEA

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Current Incentives in the US

• Tax credits
• RPS (in some states)
• Systems benefit charges (SBC)
  – Such as Renewable Energy Trust Fund
• Net metering
• Green power

See www.dsireusa.org for information by state

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Tax Credits

• Investment tax credits
  – No guarantee that generator actually works
  – No longer commonly used for wind energy

• Production tax credits (PTC)
  – Often required to make projects economic
  – Boom/bust cycles
  – Need tax liability
  – Not applicable to public entities

• Renewable Energy Production Incentive (REPI)
  – Somewhat analogous to PTC, but for public entities
  – Appropriation of funds needed annually
Renewable Portfolio Standards (RPS)

- RPS in place in some US states (e.g. Texas, Mass.) and some European countries (e.g. UK)
- Based on quota
- Retail suppliers required to supply certain fraction of electricity from renewable sources
- Requirement translates to a value for each kWh
  - Upper limit set by penalty for non-compliance
RPS (2)

• Typically, renewable aspect of electricity is “unbundled” from the electrons
• Renewable aspect is represented by renewable energy credits (REC’s)
• REC’s can be bought and sold
• Obligation is met by acquiring sufficient REC’s
• Price set by bidding; supply and demand
RPS (3)

• Value of REC’s difficult to quantify \textit{a priori}
• Power purchase agreement (PPA) for REC’s needed for project financing
  – PPA for energy sale needed as well
• Value of REC’s could change with time, making a PPA difficult to obtain
• Supply/demand effect on REC’s value creates difficulties when changing eligibility
  – E.g. hydro or biomass in Mass.
RPS in Texas

- RPS has had some success in Texas:

![Wind Capacity Growth In Texas](image)

Source: Gipe, OSEA
RPS in Texas (2)

- PTC has been needed as well:

Source: Gipe, OSEA

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Wind Energy Growth in Europe

- Growth in Germany, Spain started when renewable tariffs implemented
- Growth in Denmark declined when renewable tariffs stopped

Source: Gipe, OSEA
The European Feed-in/RPS Breakdown

- Note: Denmark switched from feed-in after change of government
- Conservatives in UK are now recommending feed-in tariffs

<table>
<thead>
<tr>
<th>Feed-in</th>
<th>RPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Belgium</td>
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<tr>
<td>Denmark</td>
<td>Italy</td>
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<tr>
<td>France</td>
<td>Sweden</td>
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<td>Germany</td>
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<td>Greece</td>
<td>Poland</td>
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<td>Ireland</td>
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<td>Luxembourg</td>
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<td>Netherlands</td>
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<td>Portugal</td>
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<tr>
<td>Spain</td>
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<td>Czech Republic</td>
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<td>Estonia</td>
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<td>Hungary</td>
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<td>Latvia</td>
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<td>Lithuania</td>
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<td>Slovak Republic</td>
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<td>Slovenia</td>
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</tbody>
</table>

Source: Rickerson and Zytaruk, AWEA, 2006
Feed-in Tariff

• Also known as “EEG tariff” or “Advanced Renewable Energy Tariff”
• Used in most European countries (e.g. Germany, Spain)
• Based on mandated *price* of electricity sold into the electric grid from RE source
• Different prices for different *sources*
• Different prices for different *wind regimes*
Origin of Feed-in Tariffs

• Denmark had something like the feed-in tariff for wind in the 1980’s
• Germany introduced method in 1991
  – Stromeinspeisungsgesetz für Erneuerbare Energien (Act on Feeding in to the Grid Electricity Generated from Renewable Energy Sources)
• Has been updated (2000)
  – Erneuerbare Energie Gesetz (EEG, Renewable Energy Sources Act)
EEG: Obligation to Purchase Renewable Energy and Pay for it

- Utility is obliged to connect RE power plants to their grid at connection point that is technically and economically suitable
- Suitability includes reasonable upgrade if required
- Utility must purchase electricity at fixed rates of EEG
EEG: Grid Connection Costs

• Costs to connect to the grid must be paid by project operator
• Costs to upgrade grid paid for by grid operator
EEG: Payment

- Local utility pays project operator for electricity at required rates
- Excess costs are distributed throughout German electricity networks
### Overview of German EEG Tariffs

<table>
<thead>
<tr>
<th>Source</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<th>2010</th>
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<tr>
<td>Solar power</td>
<td>48,1</td>
<td>45,7</td>
<td>43,4</td>
<td>41,2</td>
<td>39,1</td>
<td>37,1</td>
<td>35,2</td>
<td>33,4</td>
<td>31,7</td>
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<td>Wind power initial tariffs/ prolongation*</td>
<td>9</td>
<td>8,9</td>
<td>8,8</td>
<td>8,7</td>
<td>8,6</td>
<td>8,5</td>
<td>8,4</td>
<td>8,3</td>
<td>8,2</td>
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<tr>
<td>Wind power final tariffs</td>
<td>6,1</td>
<td>6</td>
<td>5,9</td>
<td>5,8</td>
<td>5,7</td>
<td>5,6</td>
<td>5,5</td>
<td>5,4</td>
<td>5,3</td>
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<tr>
<td>Biomass &lt; 500 kW</td>
<td>10,1</td>
<td>10</td>
<td>9,9</td>
<td>9,8</td>
<td>9,7</td>
<td>9,6</td>
<td>9,5</td>
<td>9,4</td>
<td>9,3</td>
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<tr>
<td>Biomass 500 kW - 5 MW</td>
<td>9,1</td>
<td>9</td>
<td>8,9</td>
<td>8,8</td>
<td>8,7</td>
<td>8,6</td>
<td>8,5</td>
<td>8,4</td>
<td>8,3</td>
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<tr>
<td>Biomass 5 MW - 20 MW</td>
<td>8,6</td>
<td>8,5</td>
<td>8,4</td>
<td>8,3</td>
<td>8,2</td>
<td>8,1</td>
<td>8</td>
<td>7,9</td>
<td>7,8</td>
</tr>
<tr>
<td>Hydropower and Gas (from landfills, mines, sewage plants) &lt; 500 kW</td>
<td>7,65</td>
<td>7,65</td>
<td>7,65</td>
<td>7,65</td>
<td>7,65</td>
<td>7,65</td>
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<td>Hydropower and Gas &lt; 5 MW</td>
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<tr>
<td>Geothermal power &lt; 20 MW</td>
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<td>8,93</td>
<td>8,93</td>
<td>8,93</td>
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<tr>
<td>Geothermal power more than 20 MW</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
<td>7,14</td>
</tr>
</tbody>
</table>

*Windpower: initial tariffs: first 5 years (onshore), first 9 years (offshore, if installed till 2006), Prolongation 0-15 years depending on site quality, Feed-In tariff duration 20 years

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**J. Lackman, Bundesverband Erneuerbare Energie e.V., 2002**

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Close-Up of Some German EEG Rates

- Rates for wind depend on onshore or offshore
  - Early years have higher rates
  - Length of time depends on percentage of reference yield
- Rates for PV depend on size and type of application

<table>
<thead>
<tr>
<th>Years</th>
<th>Rate (USD)</th>
<th>*</th>
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</thead>
<tbody>
<tr>
<td>On Land Wind</td>
<td></td>
<td></td>
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<tr>
<td>60% Reference Yield</td>
<td>11.5</td>
<td>0.109</td>
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<tr>
<td>100% Reference Yield</td>
<td>9.2</td>
<td>0.109</td>
</tr>
<tr>
<td>150% Reference Yield</td>
<td>5</td>
<td>0.109</td>
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<tr>
<td>All</td>
<td>To year 20</td>
<td>0.069</td>
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<tr>
<td>Offshore</td>
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<tr>
<td>60% Reference Yield</td>
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<td>0.114</td>
</tr>
<tr>
<td>100% Reference Yield</td>
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<td>0.114</td>
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<tr>
<td>150% Reference Yield</td>
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<td>0.114</td>
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<tr>
<td>All</td>
<td>To year 20</td>
<td>0.069</td>
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<tr>
<td>Solar PV</td>
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<tr>
<td>&lt; 100 kW rooftop</td>
<td>20</td>
<td>0.681</td>
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<tr>
<td>&gt; 100 kW rooftop</td>
<td>20</td>
<td>0.674</td>
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<tr>
<td>Freestanding</td>
<td>20</td>
<td>0.570</td>
</tr>
</tbody>
</table>

*converted from Euros
Wind Turbine Energy Yields

- Consider reference yield, 60% and 150% of reference
- Example: Vestas V47 on 50 m tower ("Hull I")*

<table>
<thead>
<tr>
<th>Reference Yield</th>
<th>kWh/yr</th>
<th>Mean Wind, m/s</th>
<th>Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>1,331,800</td>
<td>6.0</td>
<td>0.230</td>
</tr>
<tr>
<td>60%</td>
<td>799,080</td>
<td>4.9</td>
<td>0.138</td>
</tr>
<tr>
<td>150%</td>
<td>1,997,700</td>
<td>7.4</td>
<td>0.346</td>
</tr>
</tbody>
</table>

- Implication: Hull I site is better than reference (CF = approx. 0.28)
- Many sites in Massachusetts are better than 60% of reference (see next slide)

*Assumes Rayleigh distribution, 97% availability

Also see http://www.wind-fgw.de/
Measured Wind Data in Massachusetts

Line corresponds to annual wind speed for EEG 60% reference yield
Example: Dortmund

- Inland Germany
- Unremarkable wind: 5.1 m/s
- Municipal electric company
- Enercon 500 kW turbine
- Capacity factor: 0.17
- Cost: Eur 511k (~$639k)
- Financed with bonds

http://www.energie-cites.org/db/dortmund_139_en.pdf
More on the Debate
Feed-in EEG

• Advantages claimed
  – High efficiency
  – Allows price differentiation and reduces costs
  – Planning certainty
  – Low administration expense
  – No effect on government budgets

• Disadvantages noted
  – Lack of a acceptance by some sectors
Arguments for Feed-in

• Rapid deployment of resources
• Rapid development of local manufacturing
• Increases in local acceptance and participation
• Encourages geographic distribution
• Transparent and lower administrative cost
• More jobs, more investment, more competition in manufacturing, equipment suppliers
• Projected costs minimal

Source: Rickerson and Zytaruk, AWEA, 2006
Arguments for RPS

• Predictable market growth
• Minimizes costs to taxpayers and/or rate payers through increased competition among developers
• No picking technological winners
• Market based system of tradable credits
• Projected costs minimal

Source: Rickerson and Zytaruk, AWEA, 2006
Issues with RPS

• Focus on lower price
  – Geographic concentration
  – NIMBY and best sites first
  – High contract failure rates
• Targets near market technologies and leaves technology market to foreign manufactures
• Deployment rates relatively slow
• Single price means “windfall” for best sites
• Favors large developers
• Less portfolio diversity
• Administratively cumbersome and costly

Adapted from: Rickerson and Zytaruk, AWEA, 2006
German Building Code

- For building in rural areas, “Paragraph 35”
- Wind turbines in designated regions are permitted by right
- Evidence now has to be given as to why turbines should not be permitted
  - Rather than the other way around.
  - Streamlined the planning and approval process
- Cities and communities are obliged to identify local wind resource areas.
Feed-in Tariff in North America?

- Already implemented in Canada (Ontario and Prince Edward Island)
- In place to some degree in US in Washington state, Minnesota, Wisconsin (PV and biogas), New Mexico (PV only) and California (PV only)
Recent Experience in Massachusetts

- Wind studies reveal that resource is often as good as much of Germany
  - In spite of that, resource often thought of as too low for development
- Deployment is still slow
- NIMBY is a problem
- Most of the action is in towns with municipal utilities
Lessons from Europe for Massachusetts?

• Massachusetts RPS still relatively young
  – Results not in
  – Should be closely watched

• Could system be developed that includes some of the advantages of RPS and feed-in?
  – Hybrid system with quotas for various sectors (e.g. wind, PV, biomass, hydro); set minimum prices?

• State wide wind zoning law
  – Reduce impact of NIMBY

• Municipal utilities have some intrinsic advantages
  – More encouragement needed?
References

• Much information is available on the Internet
• Links to many documents of relevance:
  http://www.wind-works.org/