How Fit are Feed-in Tariff Policies?

Fan Zhang
Energy Economist, World Bank
September 2012
Outline

- Production-based renewable incentives
- Design of feed-in tariffs (FiT)
- How to set the right level of FiT support?
- Policy implications
- Q&A
Production-based Renewable Incentive Policies

- **Price-based**
  - Feed-in tariffs (FiT)
    - Guaranteed price premium above the electricity market price
    - Guaranteed purchase by utilities

- **Quantity-based**
  - Renewable portfolio standards (RPS)
  - Competitive bidding
FiT is the most popular RE incentive policy

- 46 European countries from 1991-2010
Design of Feed-in Tariffs (I)

- **Price differentiation**
  - **Installation type**
    - Residential vs. utility
    - PV - rooftop vs. ground-mounted
    - Biomass - type of feedstock
  - **Location**
    - Greece offers separate rates for mainland vs. island
  - **Size**
    - Restrict FiTs to installations below a certain size (e.g. <20MW)
    - Size-specific rates

<table>
<thead>
<tr>
<th>Generator Size</th>
<th>FiT (€/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 150 kW</td>
<td>0.117</td>
</tr>
<tr>
<td>&gt; 150 kW, &lt; 500 kW</td>
<td>0.092</td>
</tr>
<tr>
<td>&gt; 500 kW, &lt; 5 MW</td>
<td>0.083</td>
</tr>
<tr>
<td>&gt; 5 MW, &lt; 20 MW</td>
<td>0.078</td>
</tr>
</tbody>
</table>

- **Resource intensity**
  - German and French FiTs are differentiated by resource intensity
Design of Feed-in Tariffs (II)

- **Time trends and cost containment**
  - **Digression rates**
    - German wind FiT rates decrease by 2% annually
    - Germany PV FiT digression rates are determined by the amount of new installation
  - **Indexing to inflation**
    - Many FiT policies are not indexed to inflation
    - French FiTs raise rates annually by 60% of inflation on new contracts and 70% on existing contracts
  - **Capacity/generation caps or triggers**
    - Italy’s solar program limits the total capacity at 1,200 MW.

<table>
<thead>
<tr>
<th>Croatian FiTs for Hydro &gt; 1 MW, ≤ 10 MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant’s Cum. Annual Gen.</td>
</tr>
<tr>
<td>≤ 5 GWh</td>
</tr>
<tr>
<td>&gt; 5 GWh, ≤ 15 GWh</td>
</tr>
<tr>
<td>&gt; 15 GWh</td>
</tr>
</tbody>
</table>

- **Funding triggers**
  - Swiss FiTs have a budget constraint
Types of Feed-in Tariffs

- **Standard FiT**
  - FiT rates are fixed over the contract

- **Variable FiT**
  - FiT rates vary annually according to electricity market changes
  - Example: Germany’s pre-2000 FiT

- **Premium FiT**
  - A fixed premium on top of a variable electricity price
How to set the “right” level of FiT

The Policy Questions

- How responsive is investment to the level of FiT?

Europe’s Largest Solar Power Plant in Ukraine
Higher wind installation under FiT
### A glance at the data (I)

<table>
<thead>
<tr>
<th>Variable</th>
<th>FiT</th>
<th>TGC</th>
<th>No Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual wind installation (MW)</td>
<td>301</td>
<td>298</td>
<td>3.33</td>
</tr>
<tr>
<td>Annual wind generation (TWh)</td>
<td>2.73</td>
<td>1.93</td>
<td>0.024</td>
</tr>
<tr>
<td>FiT rate / TGC price (euro cents/kWh)</td>
<td>6.67</td>
<td>6.03</td>
<td>-</td>
</tr>
<tr>
<td>Avg. end-use electricity price (euro cents/kWh)</td>
<td>7.88</td>
<td>9.04</td>
<td>5.74</td>
</tr>
<tr>
<td>Avg. industrial natural gas price (euro/GJ)</td>
<td>5.32</td>
<td>5.74</td>
<td>4.5</td>
</tr>
<tr>
<td>Total electricity output (TWh)</td>
<td>119.65</td>
<td>217.15</td>
<td>48.9</td>
</tr>
<tr>
<td>Wind power potential (TWh)</td>
<td>1433</td>
<td>3021</td>
<td>1156.4</td>
</tr>
<tr>
<td>Competitive wholesale market (0/1)</td>
<td>0.51</td>
<td>0.73</td>
<td>0.06</td>
</tr>
<tr>
<td>Obs.</td>
<td>301</td>
<td>41</td>
<td>545</td>
</tr>
</tbody>
</table>

* Differences between "No Policy" and "FiT" and "TGC" in all variables are statistically significant at 1%

1. Renewable policies are effective in stimulating clean energy deployment.

2. Many factors affect the political appeal of a renewable policy: renewable endowment, electricity demand and prices.
3. Policy certainty is an important determinant of renewable development

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard FiT</th>
<th>Variable FiT</th>
<th>Premium FiT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual wind installation (MW)</td>
<td>325</td>
<td>102.60</td>
<td>85.86</td>
</tr>
<tr>
<td>Annual wind generation (TWh)</td>
<td>4.16</td>
<td>0.71</td>
<td>1.89</td>
</tr>
<tr>
<td>FiT rate / TGC price (euro cents/kWh)</td>
<td>6.69</td>
<td>6.62</td>
<td>4.22</td>
</tr>
<tr>
<td>FiT contract length (years)</td>
<td>14.01</td>
<td>9.07</td>
<td>6.88</td>
</tr>
<tr>
<td>Grid access</td>
<td>0.99</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>Avg. end-use electricity price (euro cents/kWh)</td>
<td>7.79</td>
<td>7.86</td>
<td>8.23</td>
</tr>
<tr>
<td>Avg. industrial natural gas price (euro/GJ)</td>
<td>5.61</td>
<td>4.97</td>
<td>4.9</td>
</tr>
<tr>
<td>Total electricity output (TWh)</td>
<td>152</td>
<td>88.04</td>
<td>70.46</td>
</tr>
<tr>
<td>Wind power potential (TWh)</td>
<td>1522</td>
<td>1042</td>
<td>1836</td>
</tr>
<tr>
<td>Competitive wholesale market (0/1)</td>
<td>0.58</td>
<td>0.24</td>
<td>0.77</td>
</tr>
<tr>
<td>Obs.</td>
<td>165</td>
<td>88</td>
<td>48</td>
</tr>
</tbody>
</table>
The level of feed-in tariffs is a poor predictor of deployment
Econometric Analysis

- **Estimation Model**

\[ W_{it} = \beta_0 + \beta_1 F_i T_{it} + \beta_2 E_{it} + X_{it}' \gamma + c_i + v_t + u_{it} \]

- **Methodology**
  - Dynamic panel data model
  - System Generalized Methods of Moments
  - Instrumental variables: lagged variables and natural gas prices
Results

- Higher FiT rates do not necessarily lead to higher levels of wind installation.
  - Non-economic barriers
  - Overly generous subsidies may have driven up investment costs by allowing inefficient investment in low wind-speed sites or rent-seeking

- The contract length and guaranteed grid access have a positive and statistically significant effect on wind capacity growth.
  - A 1% increase in contract length increases annual wind installation by 0.3%
  - Providing grid access almost doubles wind installation

- The higher the electricity prices the lower the wind installation; but with a competitive wholesale market, the higher the electricity prices, the higher the wind installation

- The higher the variable FiT rates, the lower the wind generation after controlling for wind capacity
  - High FiT rates allowed inefficient investment in low-wind-speed sites.
Policy Implications

- FiT policies are effective in promoting RE but may not be cost-effective.
- Market structure and the length of the FiT are equally important in determining policy effectiveness.
- To maintain a predictable and stable policy environment can enhance policy effectiveness at lower costs.
References
