Incentive policies for small PV in France

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April 2016
Motivation

- Technology with a fast market increase
- Policy debate on the various incentive measures (feed-in, R&D subsidies, tradable green certificates, renewable portfolio standard, net metering) coupled with the European 2020 target and in our case study, with the 2030 objectives of the French “Transition Energetique”.

Projections in France
Evolution des tarifs d'achat d'électricité solaire photovoltaïque en France

Evolution trimestrielle des tarifs d'achat – France continentale

Tarif dit T1

Résidentiel
Questions and modelling strategy

Do we really need Feed In Tariffs (FIT) for French residential consumers?
- Which is the level of learning achieved in the small PV market?
- Which is the optimal path of the capacity to be installed to reach a predetermined target (32%) for 2030?

What we do:

1. We link profitability of Photovoltaic (PV) investment & annual installed capacity (in this context we estimate learning).
2. We simulate the optimal path on a panel of small PV installations across France and find the FIT that induces such path.
A brief summary of the related literature (I)

- Learning curve: PV prices decrease as the amount of technology deployed increases (seminal works: Shaeffer et al. 2004, Nemet, 2006; Pillai 2015, Rubin 2015)
  - Limits: sensitivity to data, complexity of the technology and factors of cost reduction other than learning.

- Deployment: diffusion of innovation are often described by logistic functions or "S-curves" (the Bass model-Gerowskki, 2000, Guidolin and Mortarino, 2010)
  - Limits: these models do not take into account the incentive policies such as subsidies and feed-in tariffs.

- Profitability of PV investment: values of investments in different countries in Europe, Japan, Germany in presence of incentive schemes (Dusonchet and Telaretti, 2010, Zhang and Hamori, 2011, etc...).
  - Limits: no link with long term targets on terms of installed capacity.
Drivers vs. barriers in small PV adoption

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>- Costs too much to buy/install</td>
</tr>
<tr>
<td></td>
<td>- Cannot earn enough/save enough money</td>
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<tr>
<td></td>
<td>- Lose money if I move home</td>
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<tr>
<td></td>
<td>- High maintenance costs</td>
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<tr>
<td></td>
<td>- Environmental benefits too small</td>
</tr>
<tr>
<td></td>
<td>- Would make more self-sufficient/independent</td>
</tr>
<tr>
<td>Environmental</td>
<td>- Home/location not suitable</td>
</tr>
<tr>
<td>Security of supply</td>
<td>- System performance or reliability not good enough</td>
</tr>
<tr>
<td></td>
<td>- Energy not available when I need it</td>
</tr>
<tr>
<td>Uncertainty and trust</td>
<td>- Hard to find trustworthy information or advice</td>
</tr>
<tr>
<td></td>
<td>- Hard to find trustworthy builders to install</td>
</tr>
<tr>
<td>Inconvenience</td>
<td>- Hassle of installation</td>
</tr>
<tr>
<td>Impact on residence</td>
<td>- Disruption or hassle of operation</td>
</tr>
<tr>
<td></td>
<td>- Potential requirement for planning permission</td>
</tr>
<tr>
<td></td>
<td>- Reserving space on rooftops</td>
</tr>
<tr>
<td></td>
<td>- Take up too much space</td>
</tr>
<tr>
<td></td>
<td>- The installation might damage my home</td>
</tr>
<tr>
<td></td>
<td>- Would not look good</td>
</tr>
</tbody>
</table>


- We account for financial motives
An overview of the Database (I)

- **180 observations** spread over 22 French regions: yearly observations on residential PV installations - quantity and price both of materials and installation- generating less than 3 kWp.
- France has **added 13.08 MWp** of solar capacity from residential sector during 2007-2013.
- **Yearly growth rate** has decreased from 94.3% in 2008 to 5.93% in 2013.
An overview of the Database (II)
Material price accounts in mean for 80% of adoption costs despite regional differences.

Material price decreases (in mean from 6.64 in 2007 to 3.13 in 2013) while installation price is stable (highest for L-R).
Comparing the FiT with PV costs

- **FiT** (granted 20 years) for PV integrated to buildings started in 2006, in 2009 reached 60.17 euros and then unevenly decreased (starting in 2011 suspended for bigger PV installations).
- **Limited profitability** overall (Fit and Price very close).
- **Grid parity** is **not** achieved since Price is much higher than the electricity price throughout the period.
Comparing the FiT with PV costs (II)
Regional differences

IDF

Rhone-Alpes

Year

FIT
System price
Electricity price (tarif'bleu base)
We define the demand $q_t$ as the probability of adoption $P_t$ times the potential market sizes $M_{it}$ in each region (now NE, SE, NW, SW, Bretagne) at each point in time:

$$q_t = M_{it} \cdot P_t$$

where

$$P_t = \frac{\exp(V_{it})}{1 + \exp(V_{it})}$$

$$V_{it} = NPV_{Ut} = FIT_t \cdot E \cdot \sum_{k=1}^{N} \frac{1}{(1+\delta)^k} - \frac{p_t}{E}$$

$$p_t = p_0 \cdot \left(\frac{x_t}{x_0}\right)^b$$

where $b$ is an elasticity coefficient, $\eta$ is the learning rate.

In average, coefficient $b = -0.3387$ and $\eta = 0.209$: the average system price is reduced by 21% each time that installed capacity doubles.

Combined with the logit equation, after assuming that $q_t / M_{it} < 1$ and $M_{it} = M_i$, and applying a log transformation gives $\log(q_t) = NPV_{Ut}$, that is

$$\log(q_t) = a_1 \cdot \log(NPV_{it}) + a_2 \log(x_{it}) + a_3 t + \epsilon_t,$$

where $x_{it}$ accounts for the diffusion.
Our Regionalization

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### Estimation Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ln(N PV)</td>
<td>2.54***</td>
<td>0.50***</td>
<td>0.84</td>
<td>0.45**</td>
</tr>
<tr>
<td>Diffusion</td>
<td>0.56***</td>
<td>0.57***</td>
<td>0.66***</td>
<td>0.59***</td>
</tr>
<tr>
<td>After 2011</td>
<td>-1.23***</td>
<td>-1.25***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bretagne</td>
<td>-1.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW</td>
<td>-0.97</td>
<td></td>
<td></td>
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<tr>
<td>NE</td>
<td>-0.6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SW</td>
<td>-0.75</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SE</td>
<td>-1.05</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bretagne</td>
<td>1.70*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NW x after 2011</td>
<td>-1.54***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE x after 2011</td>
<td>-1.02***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SW x after 2011</td>
<td>-1.13***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE x after 2011</td>
<td>-1.55***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cons.</td>
<td>-3.66***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>R2</td>
<td>0.53</td>
<td>0.92</td>
<td>0.92</td>
<td>0.91</td>
</tr>
</tbody>
</table>

*legend: * p<.1; ** p<.05; *** p<.01*
- Model (1) both the NPV and diffusion effect are significant.
- Model (2) both the FiT and the diffusion effect remain significant but the coefficient values attached to these variable change dramatically due to decrease in demand after 2011.
- Model (3) results are mainly driven by the 2011 dummy.
- Model (4) shows that indeed the decrease in the development of the PV market is different among regions: Bretagne is particularly affected, followed by NW and SW.
Assume 3 alternative expansion objectives:

1. **Current growth rate until 2030**: we continue the trend after 2011. (at national level adds 203 units per year, 7810 in total).
2. **Doubling capacity in 2030** as compared to 2013 (256 per year nationally)
3. **Sustained growth rate until 2030**: 5% per year (exponential expansion path with 9991 installations in total by 2030).

   Both in national and regional cases.

For each scenario we determine a path for the level of adoption at each period until 2030. Using the adoption level determined by each scenario, we calculate the corresponding net present value per period. Then, considering learning coefficient estimated, we are able to calculate the (decreasing) price of panels and consequently the optimal FiT needed to reach the net present value calculated.
Current growth scenario by region

Trajectories
Current growth scenario by region

FiT
For **SW** to follow this path, a very high FiT of nearly 1 €/kWh is required in the short run quickly decreasing to 25 c€/kWh in 2030.

**NE** requires a FiT of 57 c€/kWh first, gradually reducing to 20 c€/kWh in 2030.

In contrast, **NW** and **SE** regions where solar panels are the least and the most developed, respectively, this scenario allows the government to gradually lower the FiT rates from about 25 c€/kWh to about 12 c€/kWh.

**Bretagne** shows slow growth rate in recent years so continuing in this trend only requires a low FiT of 5-6 c€/kWh.
Notorious slow down in the adoption of small PV.
Waves of adoption that alternate in different regions.
Thin profitability and no grid parity: verified by the estimation results where the episode in 2011 has a significant impact: highly dependant on incentive policies.
Strong learning in small PV (21% decrease in price when capacity doubles) due to decrease in material prices.
Very ambitious PV development objectives may need an increase in FiT but most realistic scenarios show that, thanks to learning effects, optimal FiTs are generally decreasing.
Regional differences should be considered to fix optimal FiTs.
The End

THANK YOU
Total consumption decreases in 18% and buildings are the main contributors with 54% (first two).
Exploring the relationship P and Q

![Graph showing the relationship between total system price and cumulative number of installations.](image-url)
PV market in Europe

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