Deployment of Renewables

Optimal subsidy levels

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For references, sources etc. see CMI EP 59.
Outline

- Potential of Renewables
- Learning externalities
- Market place barriers
- Non market place barriers
Resource base is available

Losses

4
6
8
10 Billion Tonnes of Oil Equivalent per year

Resource base is available

Bonn TBP (2004)
Shell (1996)
WBGU (2004)
WEC (1994)

WEA (2000)
Greenpeace (1993)
Fischer & Schrattenholzer (2001)
IPCC (1996)
RIGES (1993)
Grubb & Meyer (1993)
IEA (2002)
Hall & Rosilio-Calle (1998)

Based on MIT, 1.5TW for 100 years – 30mt Uranium (WEA 20mio to reserve)
But costs for most technologies still higher

Public R&D differs between technologies (OECD)

Source: IEA
Expectation – learning will reduce costs

- Learning costs
- Investment cost new technology
- Investment cost old technology
- Future benefits
- Capacity new technology
- Capacity old technology

Price / unit capacity vs. Installed capacity
Use global welfare function to calculate marginal benefits

\[ U(X, L) \] utility with consumption \( X \), labour \( L \)
\[ P(K, L) \] production with capital \( K \), labour \( L \)
\[ C(E) \] Cost of new capacity with experience \( E \)
\[ \beta \] discount factor

Global welfare function:

\[ W = \sum_{t \geq 1} \beta^t U(P(K_t, L_t) - C(E_t)I_t, L_t) \]

Constraints on capacity and experience

\[ K_t = (1 - \delta)^t K_0 + \sum_{l=1\ldots t-1} (1 - \delta)^{t-l} I_l \quad \forall t \]
\[ E_t = E_0 + \sum_{l=1\ldots t-1} I_l \quad \forall t. \]
Marginal impact of changing investment at \( I \)

\[
\frac{dW}{dI_t} = -\beta^l \frac{\partial U_t}{\partial X} C(E_t) \\
+ \sum_{t' > t} \beta^{t'} \left( \frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1 - \delta)^{t - t'} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right) \\
+ \sum_{t' > t} \frac{\partial W}{\partial I_t} \frac{\partial I_{t'}}{\partial I_t}
\]
Marginal impact of changing investment at $I$

$$\frac{dW}{dI_l} = -\beta^l \frac{\partial U_l}{\partial X} C(E_l)$$

$$+ \sum_{t \neq l} \beta^t \left( \frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1 - \delta)^{t-l} \right)$$

$$+ \sum_{t > l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}$$

Lost utility if consumption changes to investment

Benefit from Extra future production

Cost saving from future cost reductions

Future output should be optimal – 0?
Marginal Learning Externalities

Additional investment brings additional experience
-> this reduces future investment costs
-> but not sufficient to justify technology in early years
did we consider all the aspects?

\[
\frac{dW}{dI_l} = -\beta^l \frac{\partial U_l}{\partial X} C(E_l) \\
+ \sum_{t > l} \beta^l \left( \frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1 - \delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right) \\
+ \sum_{t > l} \frac{\partial W}{\partial I_t} \frac{\partial I_t}{\partial I_l}
\]
did we consider all the aspects?

\[
\frac{dW}{dl_t} = -\beta^t \frac{\partial U_t}{\partial X} C(E_t) \\
+ \sum_{t>l} \beta^t \left( \frac{\partial U_t}{\partial X} \frac{\partial P_t}{\partial K} (1 - \delta)^{t-l} - \frac{\partial U_t}{\partial X} \frac{\partial C_t}{\partial E_t} I_t \right) \\
+ \sum_{t>l} \frac{\partial W}{\partial I_t} \left( \frac{\partial I_t}{\partial I_t} \right)
\]

Not necessarily zero

Assume growth constraints: \( I_{t+1} \leq (1 + g)I_t \)

\[
\frac{dW}{dl_t} = \frac{\partial W}{\partial I_t} + \sum_{t>l}(1 + g)^{t-l} \frac{\partial W}{\partial I_t}
\]
… adding the benefit from accelerated future deployment adds value to early deployment

... but only if the total strategy profitable.
Why does market not invest?

• Non homogeneous product -> IT has diff. pricing
• Learning spill over -> can’t appropriate benefit
  – Patenting works ‘only’ in Pharmaceuticals
  – Long timeframes -> large spill-over, high risk

• Example Oil: Government offered tax rebates to incentivise deep water drilling
What drives deployment benefit?

- Higher $g$, lower $r$ -> more weight on future benefit.
- Multiple local equilibria possible.
Strategic deployment of Photo Voltaics

Learning investment required (5% discount, 2005-2040)

<table>
<thead>
<tr>
<th>Billion Euro</th>
<th>€40/MWh</th>
<th>€50/MWh</th>
<th>€60/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>17%</td>
<td>110</td>
<td>55</td>
<td>29</td>
</tr>
<tr>
<td>20%</td>
<td>38</td>
<td>20</td>
<td>12</td>
</tr>
<tr>
<td>23%</td>
<td>17</td>
<td>10</td>
<td>6</td>
</tr>
</tbody>
</table>

Benefit cost ratio (5% discount, 2005-2040)

<table>
<thead>
<tr>
<th>NPV /Learning</th>
<th>€40/MWh</th>
<th>€50/MWh</th>
<th>€60/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>17%</td>
<td>0</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>20%</td>
<td>4</td>
<td>15</td>
<td>38</td>
</tr>
<tr>
<td>23%</td>
<td>17</td>
<td>44</td>
<td>92</td>
</tr>
</tbody>
</table>
Support profile:
- Increases with market size
- Decreases with tech costs
- Funding mechanism shifts costs

Off grid niche markets:
- Contribute but don’t suffice
- Distributed high value
  - Crucial
What happens if we only use CO2 policy?
Strategic deployment cuts discounted cost by factor three
Uneven playing field

- OECD direct subsidies US$20-30 billion in 2002
- 0.8 of $17 billion export credit guarantees for renewables
- Government carries main risk for nuclear & CCS
- Environment Externality of coal €8.7 to €25/MWh
- Additional €10-€23/MWh for estimated CO\textsubscript{2} damage
- Regulation or free allocation does allocate damage costs
- Security of supply risk, geo-political costs
Market place barriers

- Network tariffs do not reward distributed generation if e.g. peak correlated
- Trade, dispatch, T-allocation historically day ahead, but wind needs hours to have accurate prediction
- With large intermittent generation – large spot market volume – large market power - discriminates against renewable generation
- Vertically integrated firms benefit from balancing costs which they can pass on to consumers
- Without LT contracting high investment/regulatory risk -> especially strong for 0 MC technology
Non market place barriers

- Administrative frameworks tailored for existing tech
- Administrative frameworks for large projects -> small projects face relative higher transaction costs
- Public acceptance requires time & commitment
Conclusion

- Potential of Renewables is sufficient
- Strategic deployment to address learning and growth externalities
- Market place barriers … surprisingly many
- Non market place barriers … administrative frameworks and public acceptance crucial