An Innovation Perspective On Green Transition

Presentation at The Salzburg Energy Seminar & Reform Group Meeting, 26-30 August 2013

Professor Atle Midttun
GREEN TRANSITION: ARE WE MAKING IT?
GHG emissions by regions: 1970-2005

Source: OECD

IEA Scenarios

Ecomodernity, a new Kondratiev Cycle?
What distinguishes a TR from a random collection of technology systems and justifies conceptualizing it as a revolution are two basic features.

1. The strong interconnectedness and interdependence of the participating systems in their technologies and markets.

2. The capacity to transform profoundly the rest of the economy (and eventually society).
Green Transition From an Innovation Perspective
Technology Push

From Rothwell 1994

• Big Science to drive Green transition:
  – Nuclear
  – NASA Solar
  – CCS ?
  – Geoscience

• Problems
  – Over-confidence in science to deliver
  – Underestimation of commercial realities
  – Underestimation of consumer and societal preferences
Demand Pull

- Markets to drive Green transition:
  - Green consumers
  - Niche markets
  - CO$_2$ markets

- Problems
  - Over-confidence in consumer engagement
  - Underestimation of need for iterative dynamics

From Rothwell 1994
The Coupling Model

Complex Industrial transformation processes

From Rothwell 1994
Organising Innovation: Multiplier effects of industrial systems

Midttun & Ørjasæter, 2012
Bridging Radical and Incremental Innovation

Fig. 3. Degrees of social shaping during transitions and stable periods (Tushman and Rosenkopf, 1992: 339).
Green Cars

Visibility in societal and policy debates

Battery-electric

Fuel cell

Hybrid-electric

Biofuel

Battery-electric


Fig. 3. Hype-disappointment cycles for green car propulsion technologies.
Electric Care Radical or Incremental Innovation?
The Battle of Modernities

Fig. 3. Carbon modernity: generation by source 1973–2010. Source: IEA (2011a).


Fig. 6. EU power capacity mix in 2000 and 2011. Source: IEA (2011a).
Takeoff for Green Energy

A Result of Policy and Technology Migration

From Kåberger 2012
Green Fracking?

Green fracking in the US?

Source: U.S. Energy Information Administration, Annual Energy Outlook 2013 Early Release
Smart Grids, crossover between el and IT
The system of Innovation model
Bringing in Public Policy

- Institutions of Policy Formulation
- Institutions of Public & Private Research
- Institutions of Policy Formulation
- Institutions of Public & Private Research
- Institutions of Technology Bridging
- Institutions of Industrial R&D
- Institutions of Promotion of Entrepreneurship

Interactions:
- ER&D collaboration
- Formal interaction
- Technology diffusion
- Personnel mobility
Green Transition and the Kantian Rule

Act only according to that maxim whereby you can, at the same time, will that it should become a universal law

(Foundations of the Metaphysics of Morals 1785)

Acutely important in the age of the Anthroposcene
The Greens in the EU parliament

Source: Wikipedia & Europeangreens.eu
Greening Policies

Road Map 2050

• By 2050: cut emissions to 80% below 1990 levels

Road Map 2050

• achieve a reduction of GHG emissions by 80%.

Remix – 100% renewable electricity is achievable by 2050

Energiewende...

CO2 emission per unit of GDP will be 40-45 percent lower in 2020 than in 2005.

Increase the share of renewable energy in its energy mix to 15 percent by 2020.

Experiments with circular economies
• Germany, Japan and China are trying out Circular economies
The Dynamics of Experience/Technology Learning
### The learning effect

<table>
<thead>
<tr>
<th>Value</th>
<th>Series2</th>
<th>Series3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td>0.500095</td>
<td>0.01</td>
</tr>
<tr>
<td>0.002</td>
<td>0.500155</td>
<td>0.0175</td>
</tr>
<tr>
<td>0.004</td>
<td>0.500252</td>
<td>6.80625</td>
</tr>
<tr>
<td>0.008</td>
<td>0.500409</td>
<td>5.615156</td>
</tr>
<tr>
<td>0.016</td>
<td>0.500661</td>
<td>4.632504</td>
</tr>
<tr>
<td>0.032</td>
<td>0.501063</td>
<td>3.821816</td>
</tr>
<tr>
<td>0.064</td>
<td>0.501698</td>
<td>3.152998</td>
</tr>
<tr>
<td>0.128</td>
<td>0.502695</td>
<td>2.601223</td>
</tr>
<tr>
<td>0.256</td>
<td>0.504214</td>
<td>2.146009</td>
</tr>
<tr>
<td>0.512</td>
<td>0.506505</td>
<td>1.770458</td>
</tr>
<tr>
<td>1.024</td>
<td>0.509837</td>
<td>1.460628</td>
</tr>
<tr>
<td>2.048</td>
<td>0.514439</td>
<td>1.205018</td>
</tr>
<tr>
<td>4.096</td>
<td>0.52024</td>
<td>0.99414</td>
</tr>
<tr>
<td>8.192</td>
<td>0.526228</td>
<td>0.820165</td>
</tr>
<tr>
<td>16.384</td>
<td>0.52894</td>
<td>0.676636</td>
</tr>
<tr>
<td>32.768</td>
<td>0.519079</td>
<td>0.558225</td>
</tr>
<tr>
<td>65.536</td>
<td>0.474137</td>
<td>0.460536</td>
</tr>
</tbody>
</table>

---

NORWEGIAN BUSINESS SCHOOL
Dumping Effects of Renewables

Input renewables
With very low operating costs
GREENING PROCESSES IN A GLOBALISING ECONOMY
Technology Migration Across Lead Markets

Lead markets & policy contexts I, II, III……

Volume

Time

Product cycle
Sequential Lead Markets for PV
The Relay Model

Strategic policy options beyond green niche markets

- **Strong** move towards mainstreaming greening
- **Soft** policy move towards mainstreaming greening

- Blockage
- Industrial engagement
- Further technological learning
- Increased competitiveness
- Lower costs
- Social acceptance
- Strengthening of green industrial interests

- **Stronger** move towards mainstreaming greening
Green Transition on Three Continents

Advanced technological and economic capacities
Greening through replacement
Vested interests and zero sum games
Loose out in volumes to Asia

Rapid growth with eco-efficiency focus
Environmental focus
Massive rollout of new modern capital stock
Taking technological frontier positions in many fields

Unapologetic about growth
Greening must be coupled to development
Options for leapfrogging
But poor infrastructure
THE END
Green Politics EU

Road Map
• By 2050: cut emissions to 80% below 1990 levels through domestic reductions alone.
• Increase the share of energy from renewable sources to 20% (from around 8.5% today) by 2020
• To make the transition towards a low-carbon society EU will invest an additional €270 billion or 1.5% of its GDP annually

Core green policy
• Greenhouse Gas Monitoring and Reporting (2002)
• Effort Sharing Decision (2009)
• Carbon Capture and Storage (2009)
• Transport/Fuels (1998)
• Ozone Layer Protection (2009)
• Fluorinated Gases (2006)

Source: EU
Green Politics Japan

Road Map
• By 2020: achieve a reduction of GHG emissions by 25% below 1990 levels
• By 2050: achieve a reduction of GHG emissions by 80%

Core green policy
• 1990-2003: A number of laws and legal systems were passed in order to establish the ‘Recycling-based Society’

Source: OECD
Green Politics China

Road Map
• By 2020, CO2 emission per unit of GDP will be 40-45 percent lower than in 2005
• Energy consumption per unit of GDP will drop by 16 percent from 2010
• China aims to increase the share of renewable energy in its energy mix to 15 percent by 2020.

Core green policy
• 2005: “the State Council’s Opinions on Speeding up the Development of Circular Economy”
• 2005: “Renewable Energy Law”
• 2007: National Action Plan on Climate Change
• 2008, “Circular Economy Promotion Law”
• 2009; “The revision of the renewable energy law”
• 2011: Action plan to slow down greenhouse gas emissions in light of its national conditions

Source: Charlie McElwee
Circular Economy China

- The world’s third law on circular economy (Germany and Japan)
- 178 pilot units are practicing CE
- In 2010, the output value of resources recycling industry exceeded 1 trillion yuan and the number of employees exceeded 20 million
Green Politics USA

Road maps

• Reduce greenhouse gas emissions to 17 per cent below 2005 levels by 2020.
• To doubling the share of clean energy in the electricity supply mix to 80 per cent by 2035.

Core green policy

• Clean Air Act; 1973
• 2007: The Global Warming Pollution Reduction died in committee
• 2009: The American Clean Energy and Security Act died in the Senate
• 2010: A federal budget to support clean energy development
• 2013: Obama’s Climate Action Plan

Source: EIA & wikipedia
S- curve leaps for disruptive technologies

- Vertical axis DT different attributes of performance than ST
- Disruptive technologies emerge and progress on their own uniquely defined trajectories
- If and when they progress to the point that they can satisfy the level and nature of performance demanded in another value network, the disruptive technology can then invade it