NEW PATH CREATION: AN EVOLUTIONARY PERSPECTIVE ON THE EMERGENCE OF THE WIND POWER INDUSTRY

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Path Dependence and the Life-cycle of the Development of a New Techno-industrial Pathway

- **Pre-formation phase**
  - Pre-existing structure and paths of technologies, industries and institutions determine variety of local opportunities and scope for novelty and experimentation

- **Path creation phase**
  - Selection of path from alternatives via contingent circumstances or direct purposive action; development of momentum and critical mass

- **Path dependence phase**
  - Development, ‘positive lock-in’ to, and evolution of selected technological, industrial, or institutional path by local cumulative and self-reinforcing (autocatalytic) processes

- **Path decay phase**
  - Loss of momentum and development resulting from rise of external competition; decline of dynamism due to internal ‘rigidification’ (‘negative lock-in’), or purposive abandonment of path

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Emergence of path  | Path development  | Onset of path-breaking  | Path dissolution
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Time
New path creation

• Important for path dependence theory to have some explanation of why and how new pathways are created in the first instance in order to lead into explanations of how their subsequent growth and development becomes path dependent.

• “To be truly evolutionary, path dependent systems also need mechanisms that generate novelty and hence new pathways of development” (Martin and Sunley 2006, p.407).
Innovation

“The implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations” (OECD 2005, p. 46).
Technological paradigms

- Dosi (1982), building on the Kuhnian concept of scientific paradigms (Kuhn 1962), argued that technologies develop and diffuse along trajectories that are path dependent because of the influence of the technological paradigms within which they are developed.
- Such paradigms are the prevailing models for the solution of techno-economic problems (Markard and Truffer 2006).
Techno-economic paradigm

• “a collectively shared logic at the convergence of technological potential, relative costs, market acceptance and functional coherence” (Perez 2010, p. 186).
First major problem confronting the introduction of a significant innovation is how to overcome the prevailing techno-economic paradigm and its established network externalities, technologies, products and services (Markard and Truffer 2006).

Some scholars of the sociology of technology and evolutionary economics argue that “niches” are required within or outside of existing knowledge structures and networks as the location of radical innovations (Geels 2004).
Definition of niche

• A niche may be defined as an application context in which the new product or technology is temporarily protected from the standards and selection rules of the prevailing paradigm (Kemp et al 1998, Hoogma et al 2002, Markard and Truffer 2006).

• A niche may be:
  • A distinctive set of economic circumstances in which innovations do not have to compete initially on equal terms with the dominant technological paradigm.
  • A production locality where the barriers to innovation are less than elsewhere.
Functions of niches

• Niches provide space for inventions and innovations to incubate without being subjected to prevailing competitive market pressures or the normal selection criteria that accompany the dominant techno-economic paradigm.

• The informal rules of niche environments are less articulated and subject to higher degrees of uncertainty than those of the established paradigms (Geels 2004).
Niche environments provide opportunities for inventions to be commercialised into innovations. They do not themselves create innovations. Those are introduced as a result of interactions between economic actors, policy makers and the users of innovations or their results.

It is therefore necessary to have theory of agency that explains how specific actors create and introduce radical innovations in niche environments.
Human agency in new path creation

• Garud and Karnøe (2001) argue that any theory of new path creation should attach a significant role to the importance of strategic agency and the considered “mindful deviation” of entrepreneurs from established pathways.

• Puffert (2000) goes further in arguing that the very existence of established pathways may make actors more eager and motivated to attempt to make their new technologies and ways of doing things the basis of new pathways.
Human agency and Entrepreneurs

• Entrepreneurs of various kinds create new pathways as they navigate the current flow of events in “real time” and seek to set new processes in motion by “mindful deviation”

• The two ideas “real time influence” and “mindful deviation” distinguish the explanation of new path creation from those of subsequent path dependency (Garud and Karnøe 2001)
Critical mass and diffusion

• One innovation does not make a new economic pathway. Changes occur slowly at first while producers, designers, distributors and consumers engage in feedback and learning processes (Perez 2010). This is usually a cumulative process and critical mass builds up over time as clusters of innovations emerge in new economic sectors.

• This process is preceded by sometimes quite lengthy periods of individual inventions. After the accumulation of relevant inventions entrepreneurs begin to take up these new ideas and commercialise them as innovations.
Definition of critical mass

• Critical mass is a well known phenomenon in non-linear dynamic systems (Lorenz 1993).

• It may be defined as a point of discontinuity that induces a dramatic turnaway from an existing system (Witt 1997).
Significance of critical mass

• Existing techno-economic paradigms and network externalities always favour the existing and widely used product variants. For this reason success in the creation of new economic pathways comes down to the prerequisite to pass a critical mass (Witt 1997).
Hypotheses

1. The creation of a new economic pathway requires an economic niche where the dominant networked techno-economic paradigm of the time is weak or not present.

2. The creation of new economic pathway requires inventions and innovations that involve human agency and decision making.

3. The creation of a new economic pathway requires the diffusion of innovations to the point at which they reach a critical mass and a tipping point is reached between continuation with the existing techno-economic paradigm and the adoption of a new one.
Dominant techno-economic paradigm for the production of electricity

- Oligopolistic production system
- Large capital intensive power stations
- Driven by fossil fuels or nuclear
- Producing AC electricity
- Distributed via national grid network
New path creation: DC windmills - Niches, agency and diffusion

**Niches**
- Rural areas, not connected to AC grid, e.g. Scotland, Denmark, 1820s-1920s
- Demand for radio broadcasts in rural areas, US, 1920s
- Restrictions on diesel fuel imports, Denmark, 1920s-1940s

**Agency**
- James Blythe, Scotland, 1887
- Poul la Cour, Denmark, 1891
- George Darrieus, France, 1903
- Society of Wind Electricians, Denmark, 1925
- Jacobs and Wincharger, 1930
- Lykkegaard windmill company, 1940

**Innovators**
- Marcellus Jacobs
- Lykkegaard windmill company
Economic niches

- Many rural areas not connected to AC grid networks
- Demand for entertainment radio broadcasts in American plains
- Restrictions on diesel fuel imports in Denmark
Invention: Prof James Blythe windmill, 1891, Marykirk, Scotland
Innovation: Poul La Cour 1897 and 1891 windmills, Askov, Denmark
Diffusion: Lykkegaard Co. windmill, 1929, Askov, Denmark
Diffusion: Marcellus Jacobs battery-charging windmill, 1930s, 2.5kW, American Plains.
New path creation: AC wind turbines - Niches, agency and diffusion - Europe

**Niches**

- Inventors
  - 1st AC wind turbine, Balaclava, USSR (Ukraine) - 1931

**Agency**

- Johannes Juul, Denmark - 1950
- Ulrich Hutter, Germany - 1957

**Diffusion**

- Denmark: Unofficial grid connection - 1958
- Denmark 1970s: subsidies and tax breaks; 1979: grid connection made legal - 1960
- Erik Grove-Nielsen, Denmark - 1970
- Amdi Peterson & Tvind teacher group, Denmark - 1978
- Agri-cultural machinery manufacturers e.g. Vestas - 1980
- Local final consumers - 1980
- Exports - 1980
Invention: First AC grid connected wind turbine 1931, 30 m dia., 100kW, Balaclava, Crimea
Innovation: Johannes Juul 1957, 24 m dia., 200 kW, Gedser, Denmark.
Invention: Ulrich Hütter 1958, 34m dia., 100kW, Hütter-Allgaier, Strotton Germany
Shocks to dominant techno-economic paradigm
Innovation: Amdi Peterson, Tvind teacher group, 1978, 54m dia., 1MW, Tvind, Denmark.
Diffusion: HVK/Vestas, 1979, 10m dia., 30kW, Denmark
New path creation: AC wind turbines - Niches, agency and diffusion: North America

Niches

Agency

Diffusion

Inventors

Innovators

US 1970s-1980s: Federal legislation for renewable sources, tax credits; California State set electricity purchasing price, tax credits

Raj Rangi and Pete South, Ottawa

Sandia National Labs, New Mexico

US Windpower, 1980: 1st windfarm (New Hampshire)

Flowind and VAWT Power (Darrieus vert axis turbines)

Zond Systems (imported Danish turbines)

Public policy

1930

1940

1950

1960

1970

1980
Government created economic niches

- The Californian Public Utilities Commission (PUC) high set rate for utilities’ purchase of electricity from renewable energy sources of about 7 cents per kWh.
- The Jerry Brown tax credit of 25% for all solar and wind energy investments made before the end of 1986.
Re-invention: Darrieus wind turbine, late 1970s, 17m dia., Sandia National Laboratories, New Mexico, US.
Diffusion: US Windpower Co, 1980s, 17m dia., 100kW, Altamont Pass, California, US.
Diffusion: Flowind Co, 1980s, 17m dia., 150kW, Altamont Pass, California, US.
Conclusions

• New path creation and the location of new industries is not a random process.
• Depends on the existence or creation of niches where the dominant techno-economic paradigm does not reach or is held at bay by collective action.
• Requires the mindful deviation of innovators from the dominant techno-economic paradigm and the time for incremental innovations to emerge and develop into a new technological trajectory.
• The combined location of niches and innovators determines the geographic distribution of the birth of a new pathway.
• The development of a new pathway also requires agents capable of diffusing innovations to the point at which a critical mass is reached and a new technological pathway is created.
• Innovative firms most often provide this kind of agency. Those that have high levels of knowledge of customer requirements and market demand appear to be the most successful.