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Energy Innovation Systems and their dynamics – Denmark in global competition

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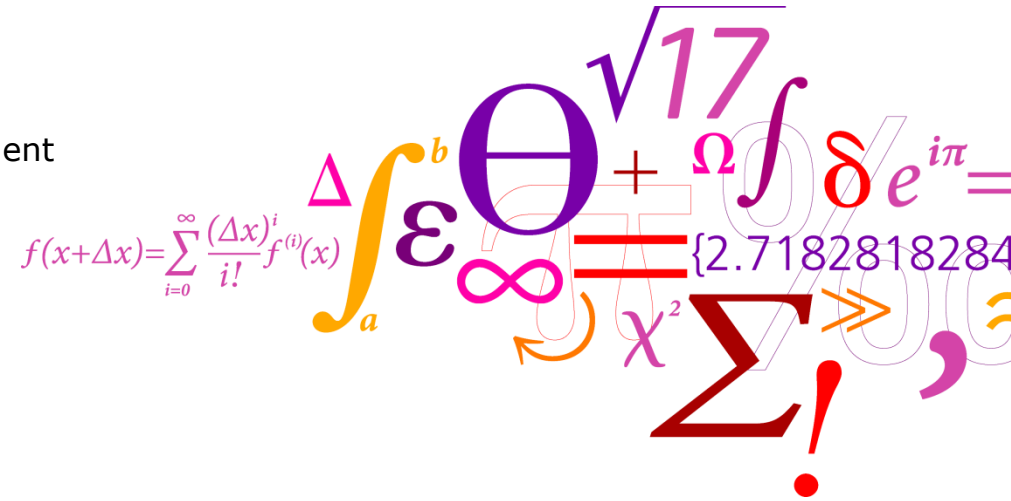

DTU Management Engineering
Department of Management Engineering

Why studies of energy innovation systems and their dynamics?

- Because innovation and technological change are important for creating a move towards sustainable energy systems.

- Because the characteristics of the innovation systems with respect to new and renewable energy technologies are central for how well societies perform and are able to contribute to the needed changes in a strong international competition.

- Knowledge and insight in this is needed.

- Because efforts for solving the climate challenges can go hand in hand with socio-economical development and progress – mutually support each other
  - at least to some degree
  - should do, as far as possible
- Because energy technology business is a major industrial and economic field.
- And because sustainability and climate challenges increasingly often appear as driving force for innovation.

EIS – a research alliance

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH
Centre for European Economic Research

Universiteit Utrecht

Copenhagen Business School
HANDELSHØJSKOLEN

AALBORG UNIVERSITET

eawag
aquatic research

NIFU
Nordisk institutt for studier av innovasjon, forskning og utdanning
Nordic Institute for Studies in Innovation, Research and Education

CHALMERS

DTU
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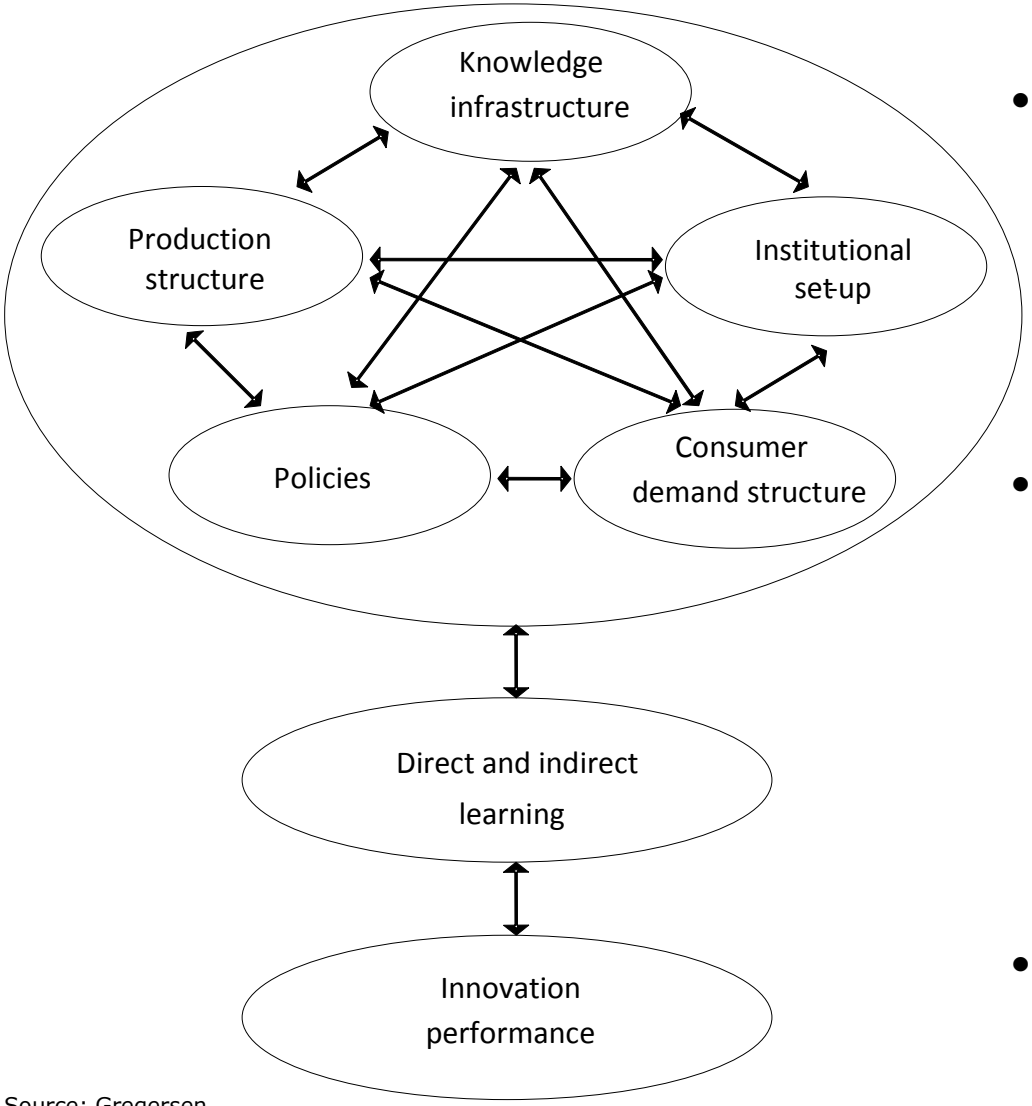
Plus a number of stakeholders; interest organisations, authorities and institutions.

EIS – Research and networking activities

Individual sub-projects and Platform

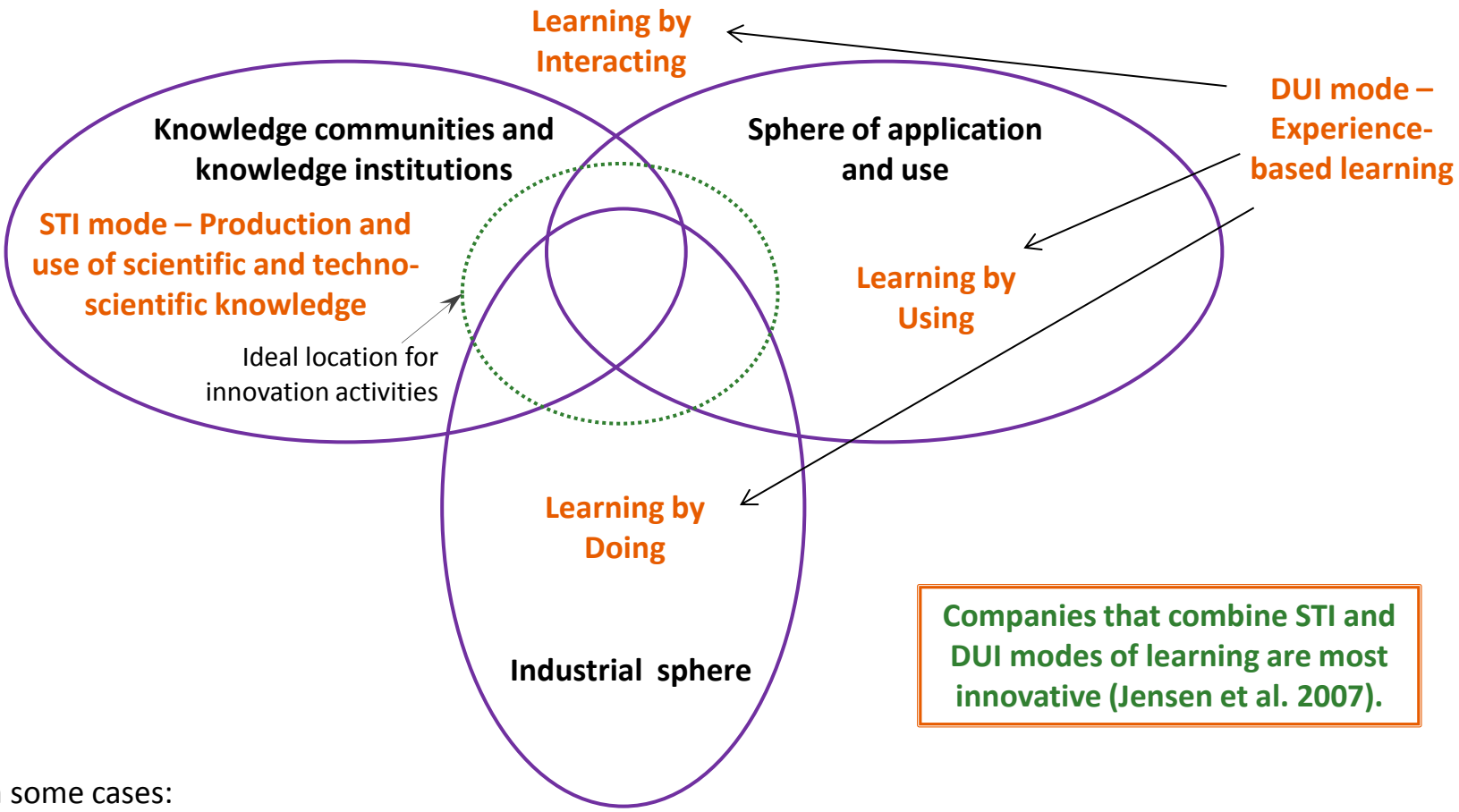
Innovation systems and their innovation performance



Source: Gregersen and Johnson (1997)

- Learning and knowledge development in a broad sense:
  - learning by using
  - learning by doing
  - analytical, formalised knowledge production
- Learning in interaction
  - learning across organisational borders
    - demand and need-driven innovation
    - integration between market mediated and non-market mediated activities
- Systemic interplay! – synergies?

Knowledge and learning in innovation – 3 main spheres



Companies that combine STI and DUI modes of learning are most innovative (Jensen et al. 2007).

4th sphere in some cases:
Policy and regulation – 'policy learning'

Sources: Borup and Andersen 2010 and Jensen et al. 2007

Different approaches – Two main perspectives

Perspective	Characteristics
1. Firm focused Firm innovations Firm cooperation, value chains, information sources Framework conditions – general national innovation systems	Individual firms' innovations; eventually their context and their interaction, e.g. with universities and other R&D partners. Economic.
2. Change focused Functions of innovation systems Connections and interplay between activities/actors Sustainable innovation and greening of economy	Innovation as an issue of change on sector level or societal level; establishment of new technologies; Sustainability transition

In general:

Actors, activities, networks and institutions

Maturity - size

Smaller niches or mainstream/regimes

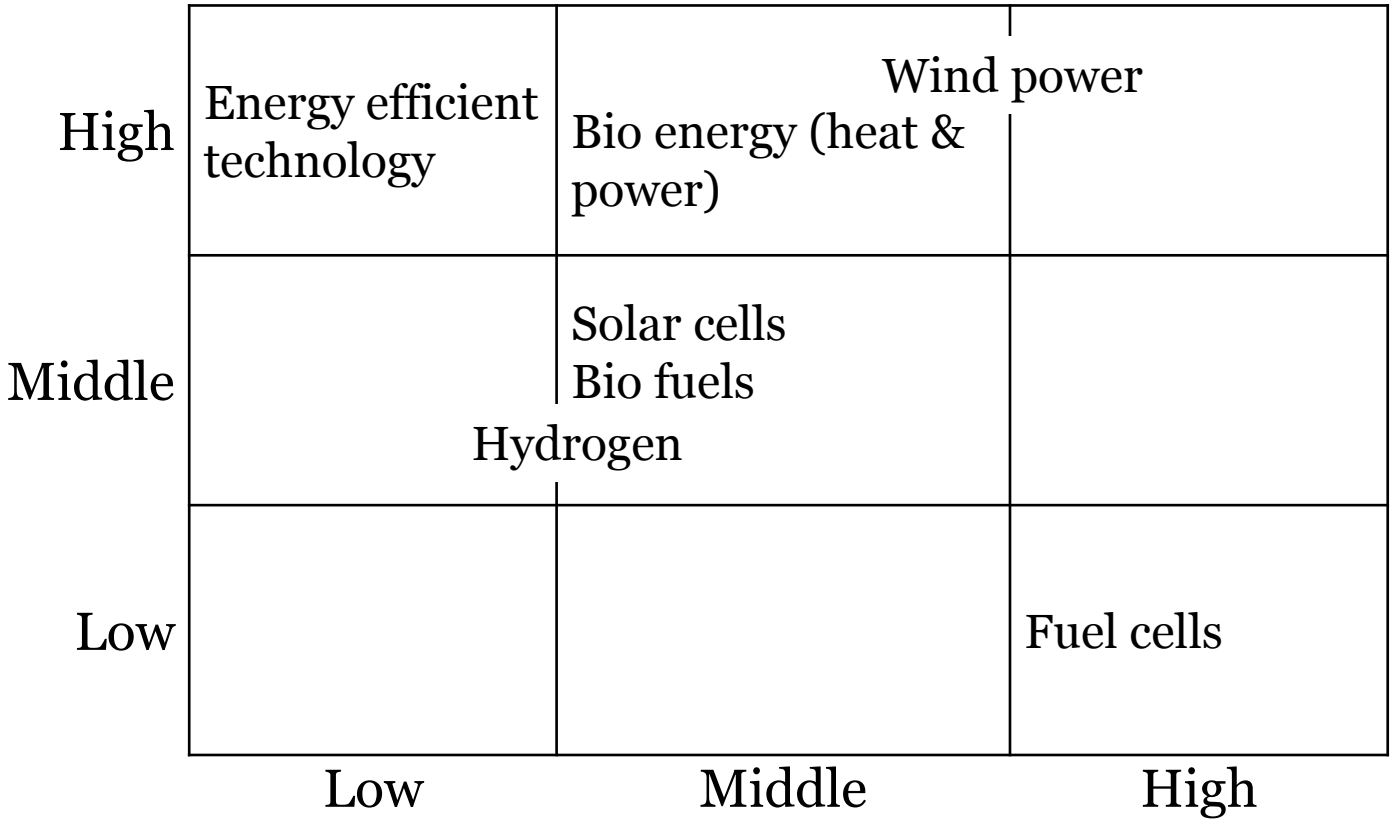
Technological innovation system

7 functions = central processes:

1. **Entrepreneurial activities**
2. **Knowledge development / learning**
3. **Knowledge diffusion in networks**
4. **Guidance of search**
5. **Market formation**
6. **Mobilization of resources**
7. **Legitimacy creation**

Types of knowledge – general picture, selected technologies

Application-based knowledge



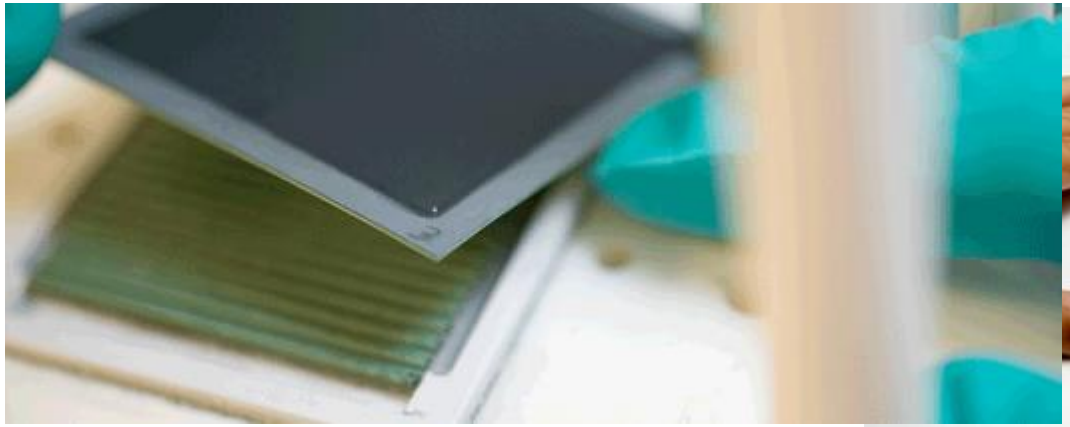
Research-based knowledge

Examples of results on overall level – DK

Solar cells innovation system: small, scattered, import primarily, component exports to foreign markets (e.g. Germany), not deeply embedded in existing energy sector, some research, stop-go policy support, significant increase in use in recent years (application-based learning), but with little strategic edge and little technological and industrial competence build-up

Fuel cells innovation system: small, research and science based companies, not deeply embedded in existing energy sector, considerable public R&D support, emphasis on research knowledge, little application and use-based learning

Biomass energy innovation system: larger, considerable application-based learning and R&D, integrated in existing energy sector, connected with machine industry (CHP), agriculture and biotech sectors



Generalized conclusions - I

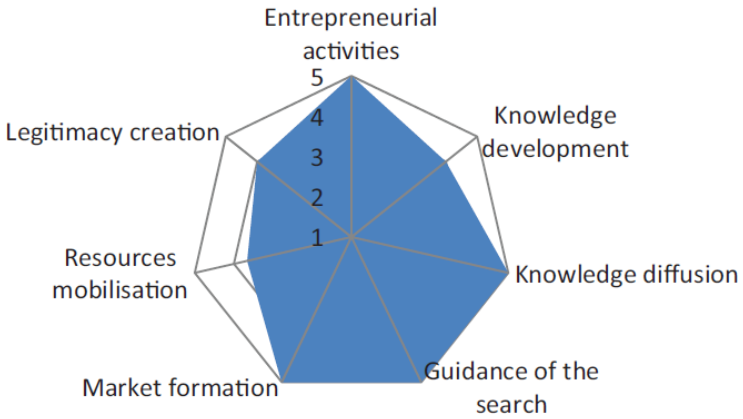
- Innovation systems with respect to individual energy technologies differ considerably. Insufficient to analyse the general energy innovation system. Differs e.g. concerning:
  - Types of actors
  - Types of knowledge/learning
  - Maturity – technology use, market application, industrial networks
  - Degree and character of embedment the existing energy sector
  - Connections to other industrial sectors and areas - new technologies do not start from scratch but somehow grow out from existing areas
  - Markets, policies and market formations

- DK EIS often have a significant emphasis on application based learning and learning by doing (lack in some areas)
  - This is a strength – but dependent on how specifically it takes place

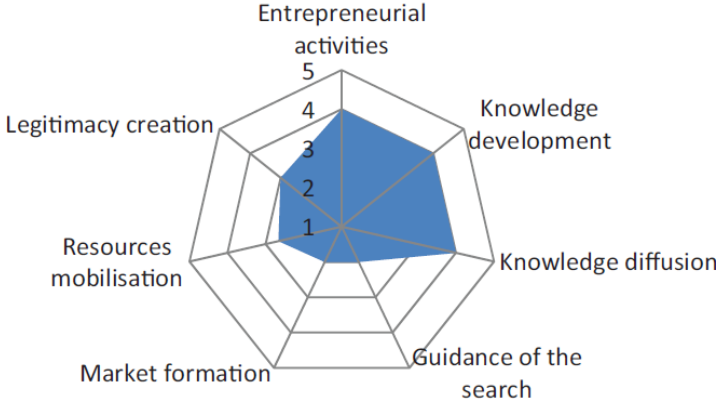
Generalized conclusions - II

- Energy innovation systems differ significantly between countries
  - E.g. between countries as similar and close as the Nordic countries –
    - different energy systems, different competences, different industrial developments, etc.
- Example offshore wind around the North Sea:

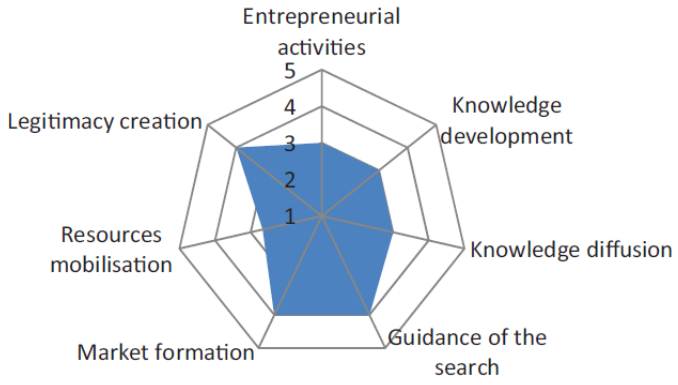
Offshore Wind TIS Germany



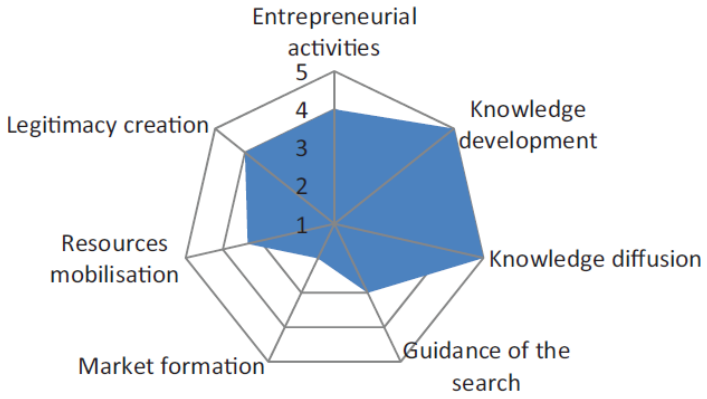
Offshore wind TIS Netherlands



Offshore Wind TIS UK

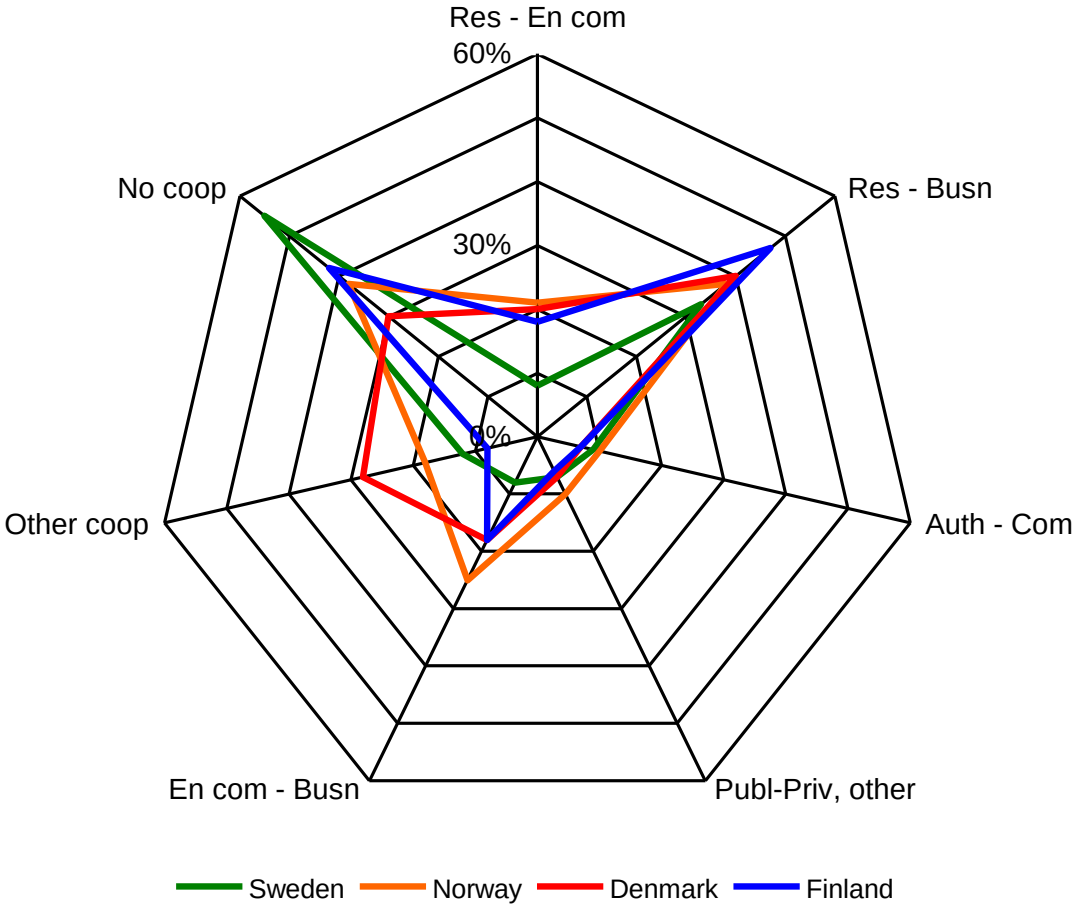


Offshore Wind TIS Denmark



Source: Wieczorek et al. 2013 (analysis 2009-2011)

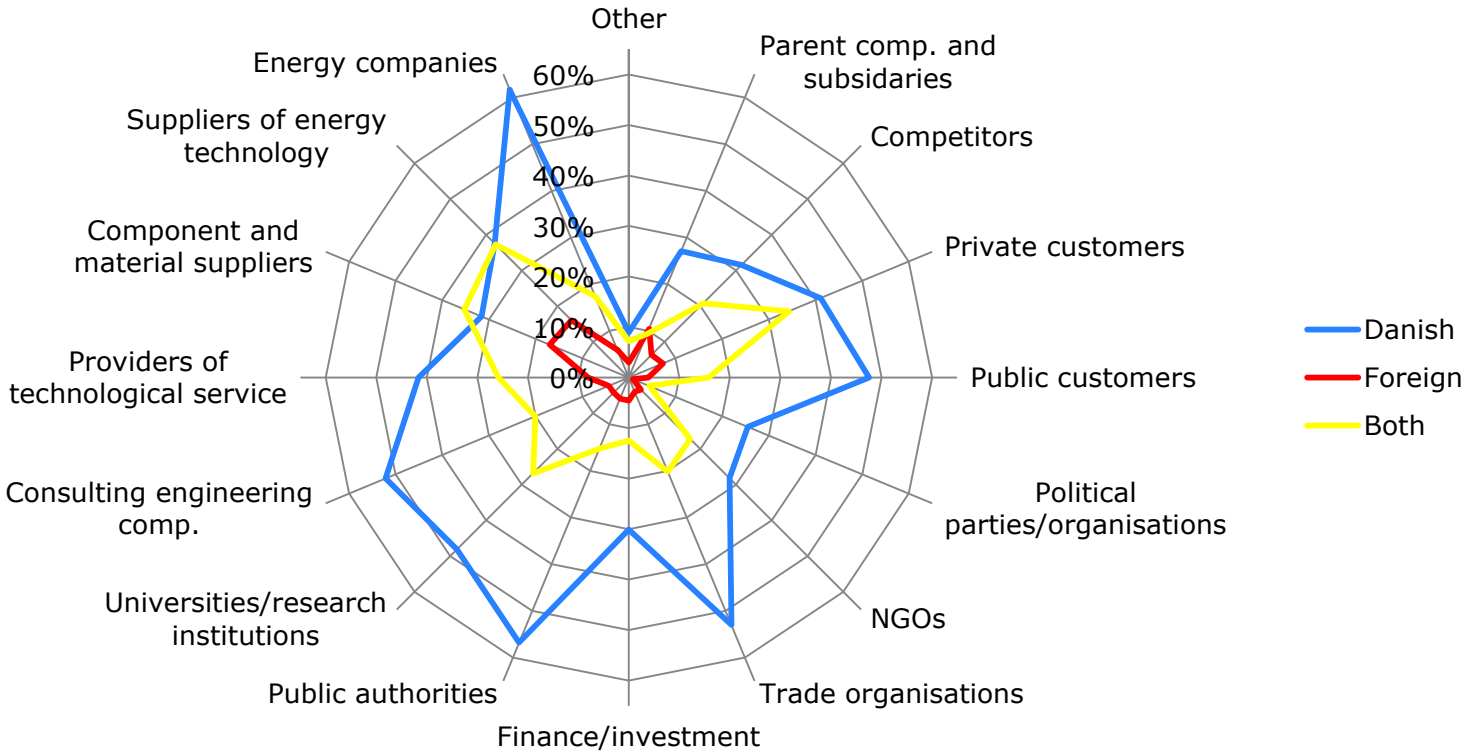
Cooperation patterns in R&D programmes



Generalized conclusions III

- The energy innovation system in Denmark is highly interactive and with much cross-going collaboration and dialogue

Collaboration in energy technology development activities – types of partners



2010-2011, Danish and foreign collaboration partners, all, (share of organisations, N=391) Borup et al. 2012 EIS Survey

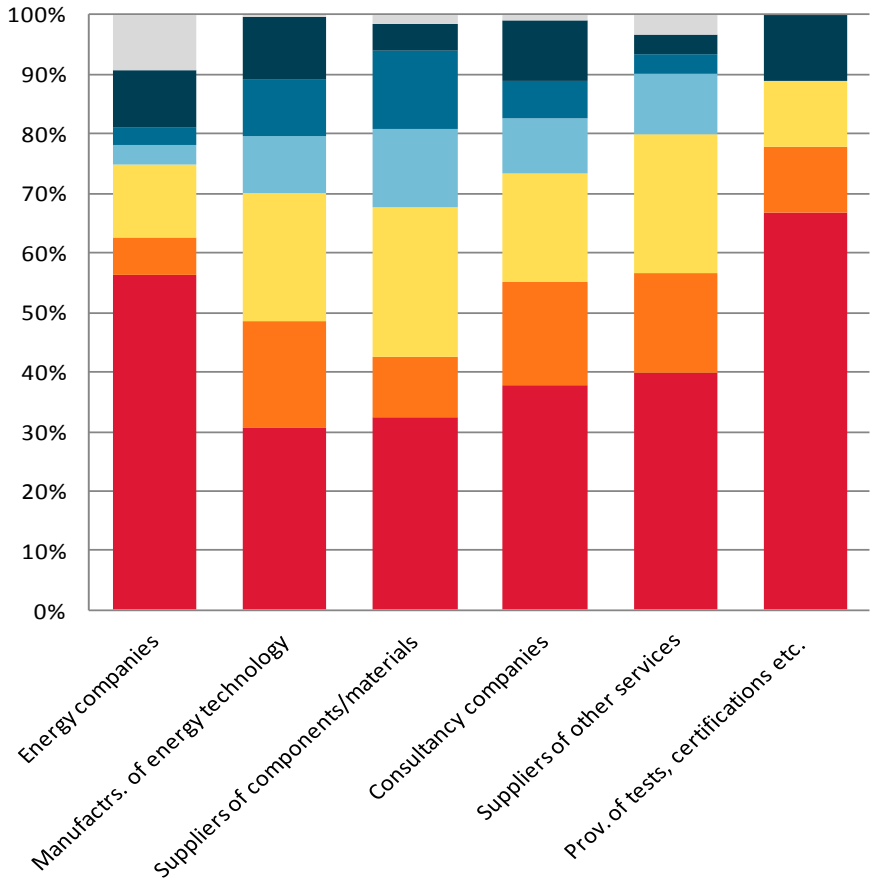
Generalized conclusions IV

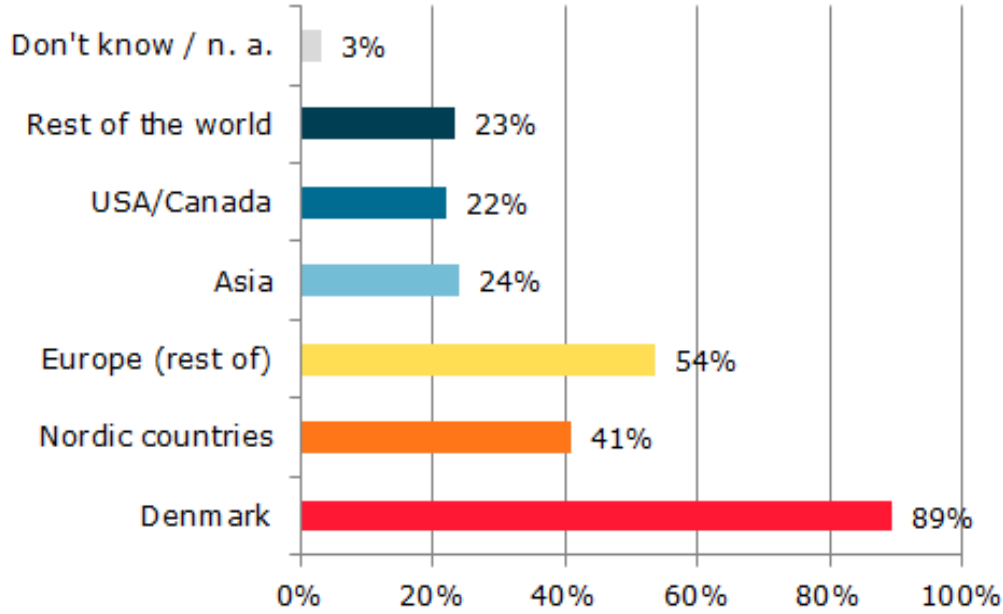
- Though the innovation systems are open systems and with many internationally oriented actors, exports, international connections etc., a considerably share of the interaction takes place within Denmark

- Despite globalization and internationalisation: The national level of the energy innovation systems is still significant and important level (for analysis; for navigation; for strategy; for policy)

- The energy area is more innovative than Danish industry in general

Markets for new products and services from Danish companies

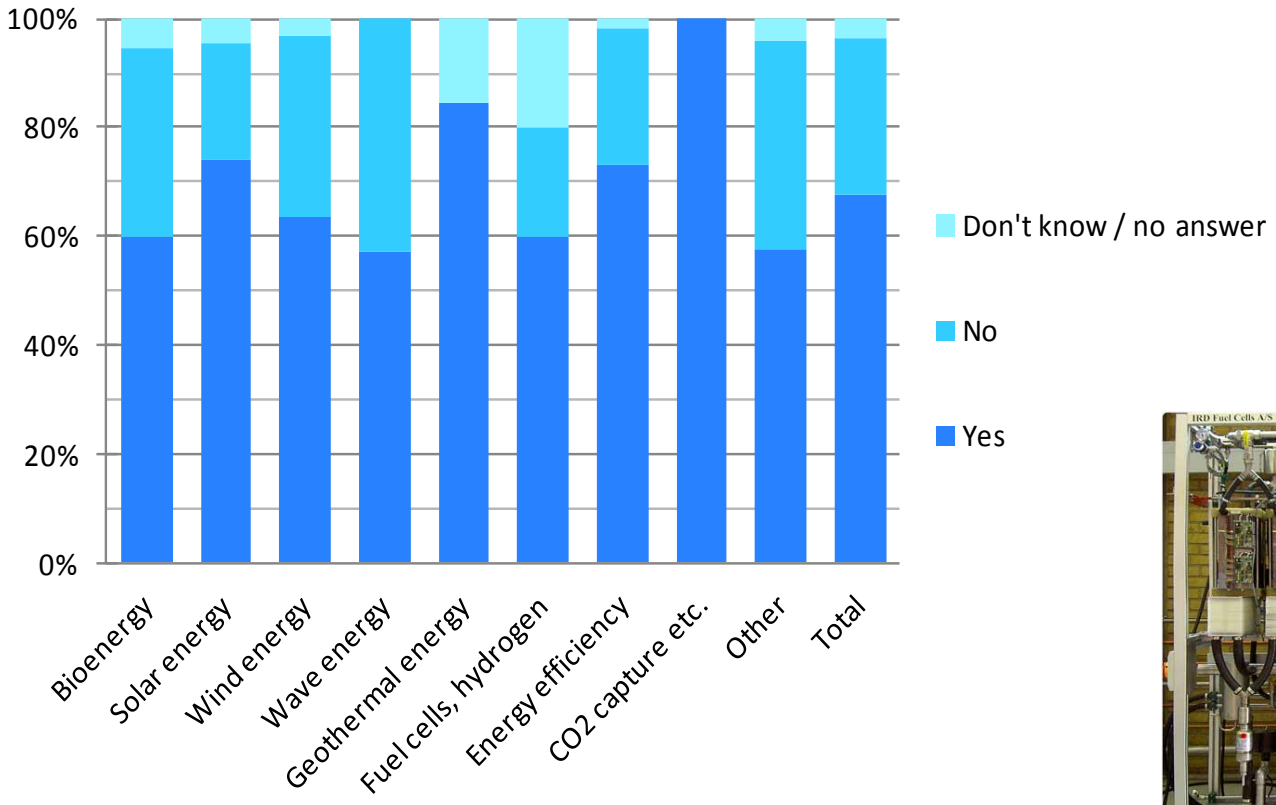


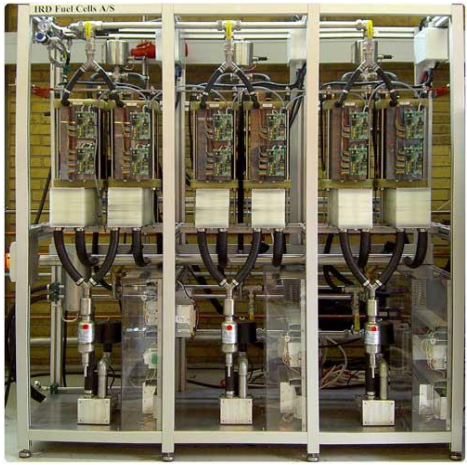


"On which markets are the new products/services sold?", N=213, (Borup et al. 2012 EIS Survey)

Introduction of new energy technology products or services by Danish companies in the energy area

2009-2011, N=314, EIS Survey 2012.





Areas addressed in studies of energy innovation systems – so far

- Not least renewable energy and other supply technologies
- Less on system technology, infrastructure and transport
- Little on energy efficiency (end-use technology)

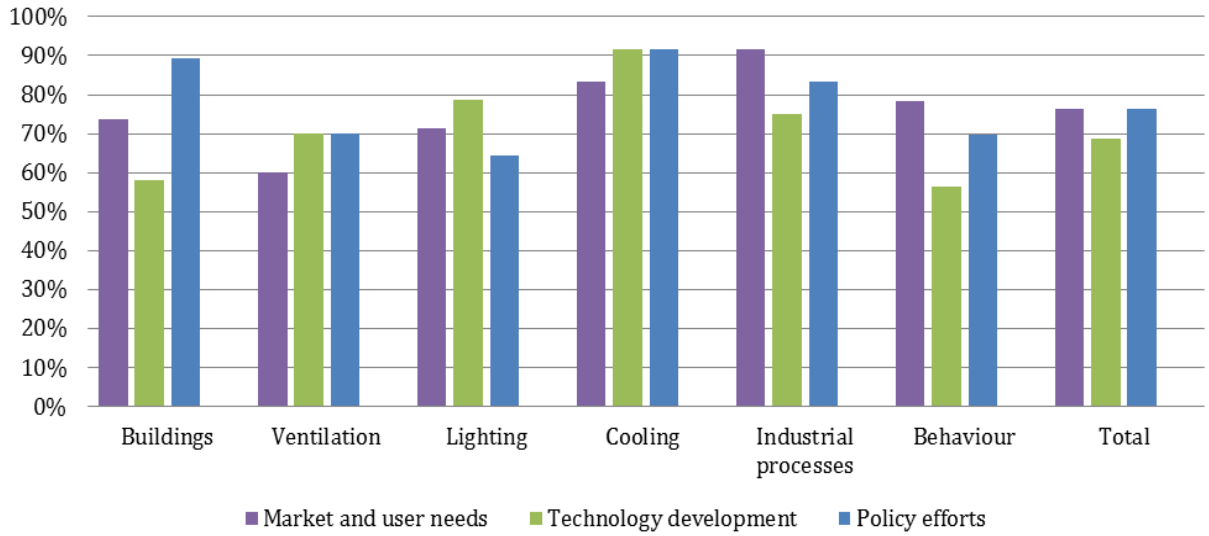
Technology	Keywords	Papers
Photovoltaics	PV, photovoltaic*	15
Wind power	wind, wind power	32
Biofuel	biofuel*, bioethanol	22
Biogas	Biogas	8
Hydrogen, fuel cells	fuel cell, hydrogen	17
CCS	CCS, carbon capture and storage	9
Combined heat and power	micro-CHP, CHP, combined heat and power	7
Electricity system, smart grid	smart grid, electricity system, energy system	25
Renewable energy, sustainable energy	sustainable energy, renewable energy, bioenergy, low carbon	46
Hydropower	hydro, hydro power	3
Nuclear power	Nuclear	8
Coal power	coal, coal power	10
Gas power	Natural gas, gas power	7
Total, duplicates removed		77

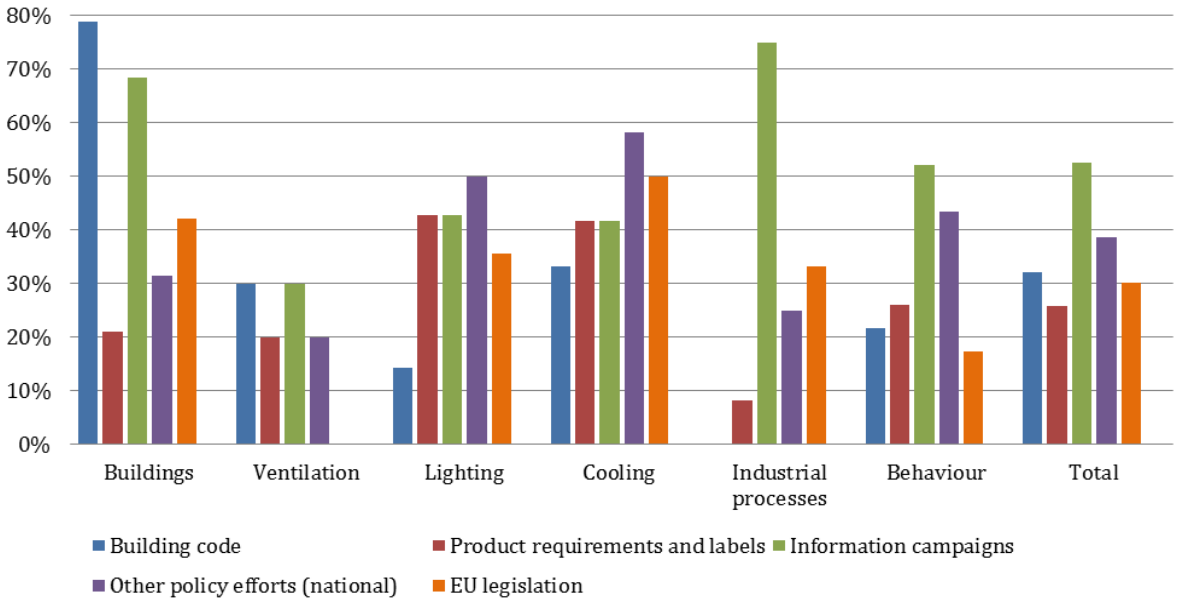
Source: Truffer et al. 2012, Radar paper

Energy efficiency innovation – example

Driving forces of energy efficiency innovation

- Overall level
- Selected policy measures





Share of projects (Elforsk R&D programme, 2002-2011, N=93, Ruby & Borup forthcoming)

Conclusions - further

- Learning from domestic market and niche developments can play an important role
  - Challenged e.g. by less emphasis on common national strategies for individual energy technologies, less strategic edge and low ambitions

- Need of more studies on the role of incumbents in the energy sector and their relations to new actors and niche developments

- Need of more studies on the relation between international level and the country level

- Indicators schemes and statistics on innovation systems and energy systems lack better indicators concerning:
  - Products – categories for 'green' products
  - Market formation, niche developments
  - Policy efforts for market shaping
  - Collaboration and interaction

Thank you.