



Energy Innovation Systems and their dynamics – Denmark in global competition

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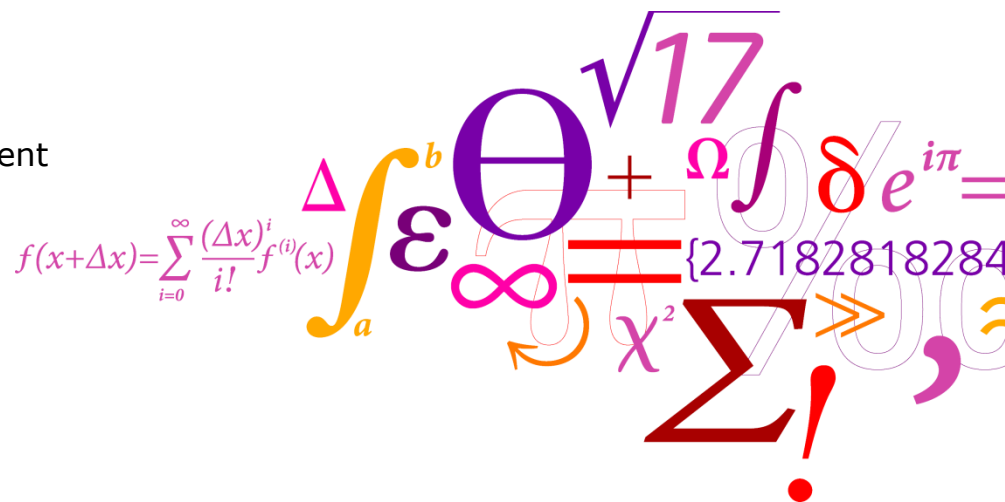
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Energy Innovation Systems and their dynamics – Denmark in global competition

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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 ooo

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

CHALMERS



DTU Management Engineering
Department of Management Engineering

NIFU

Nordisk institutt for studier av
innovasjon, forskning og utdanning

Nordic Institute for Studies in
Innovation, Research and Education



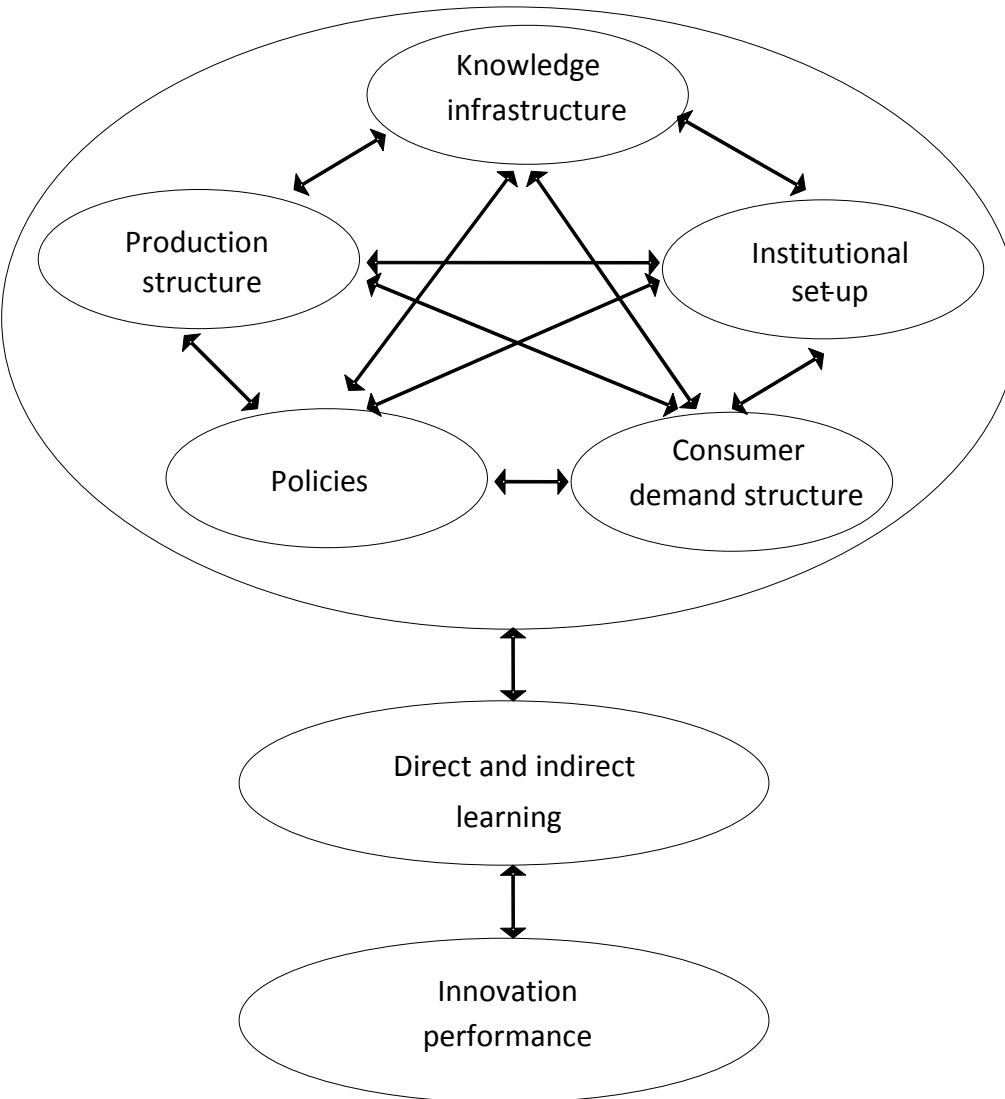
EIS – Research and networking activities



Individual sub-projects and Platform



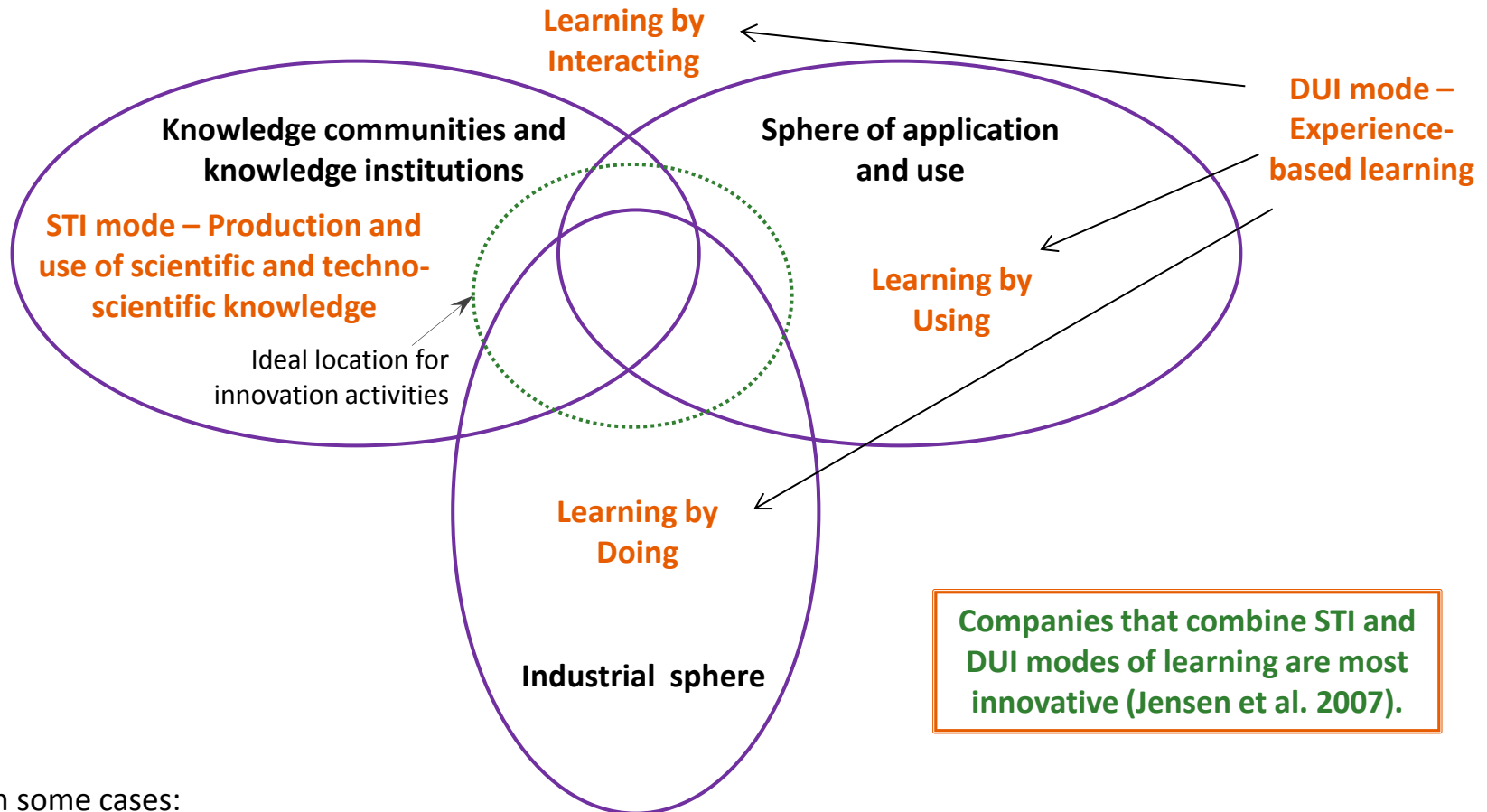
Innovation systems and their innovation performance



- 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?

Source: Gregersen and Johnson (1997)

Knowledge and learning in innovation – 3 main spheres



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

High	Energy efficient technology	Bio energy (heat & power)	Wind power
Middle		Solar cells Bio fuels Hydrogen	
Low			Fuel cells
	Low	Middle	High

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



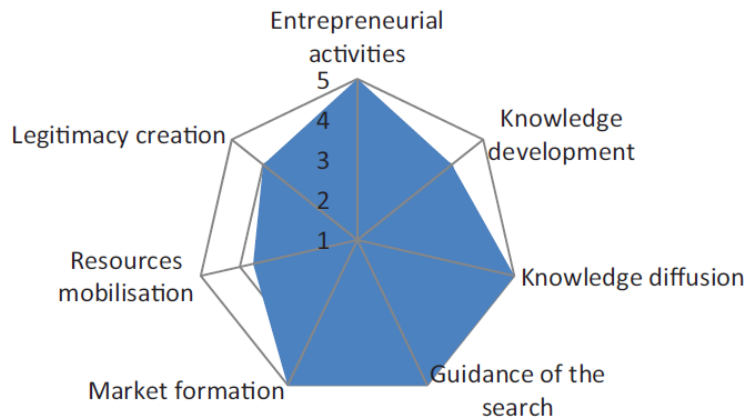
Generalized conclusions - I

- 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

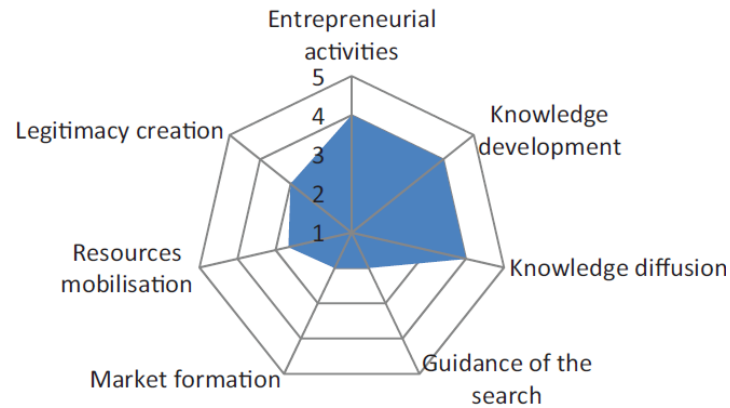
Generalized conclusions - II

- 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:

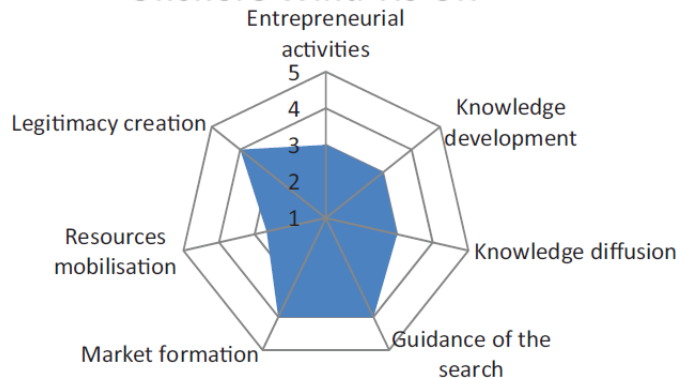
Offshore Wind TIS Germany



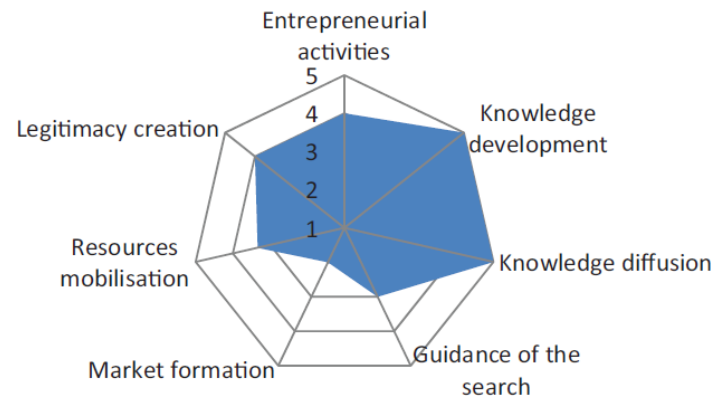
Offshore wind TIS Netherlands



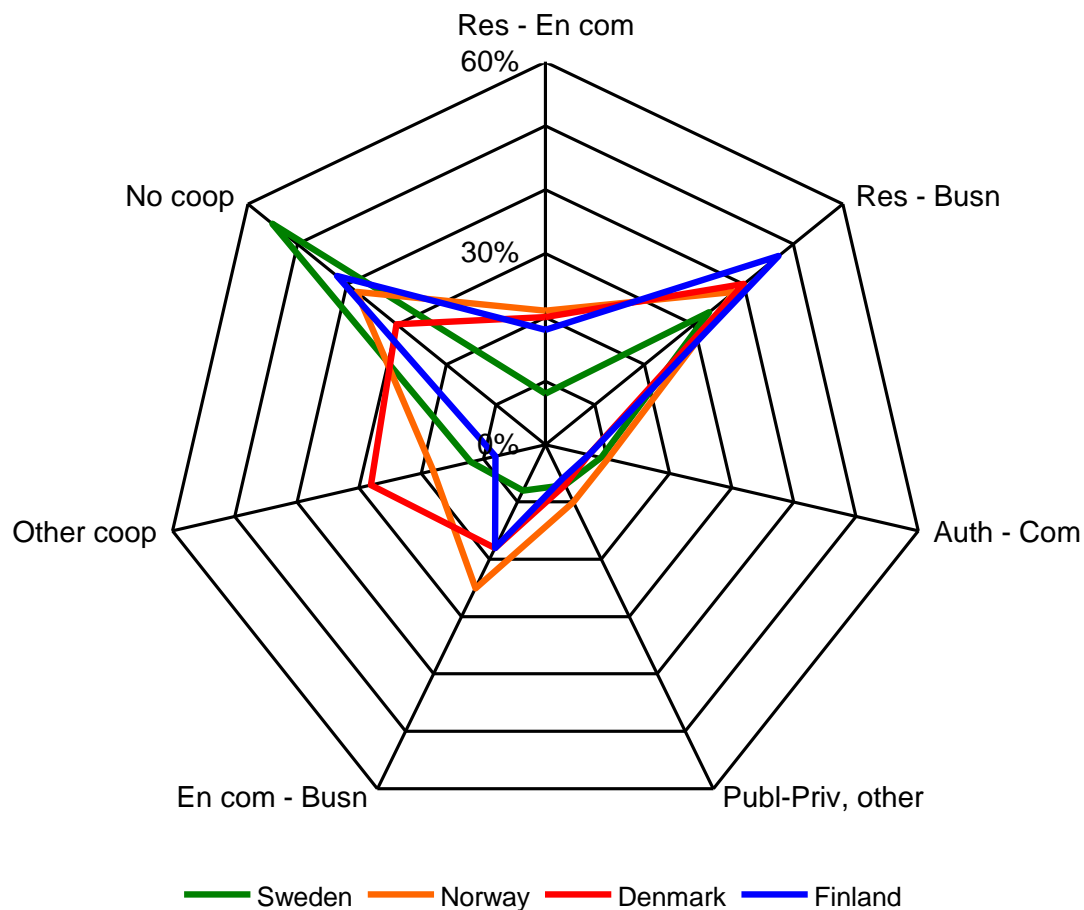
Offshore Wind TIS UK



Offshore Wind TIS Denmark



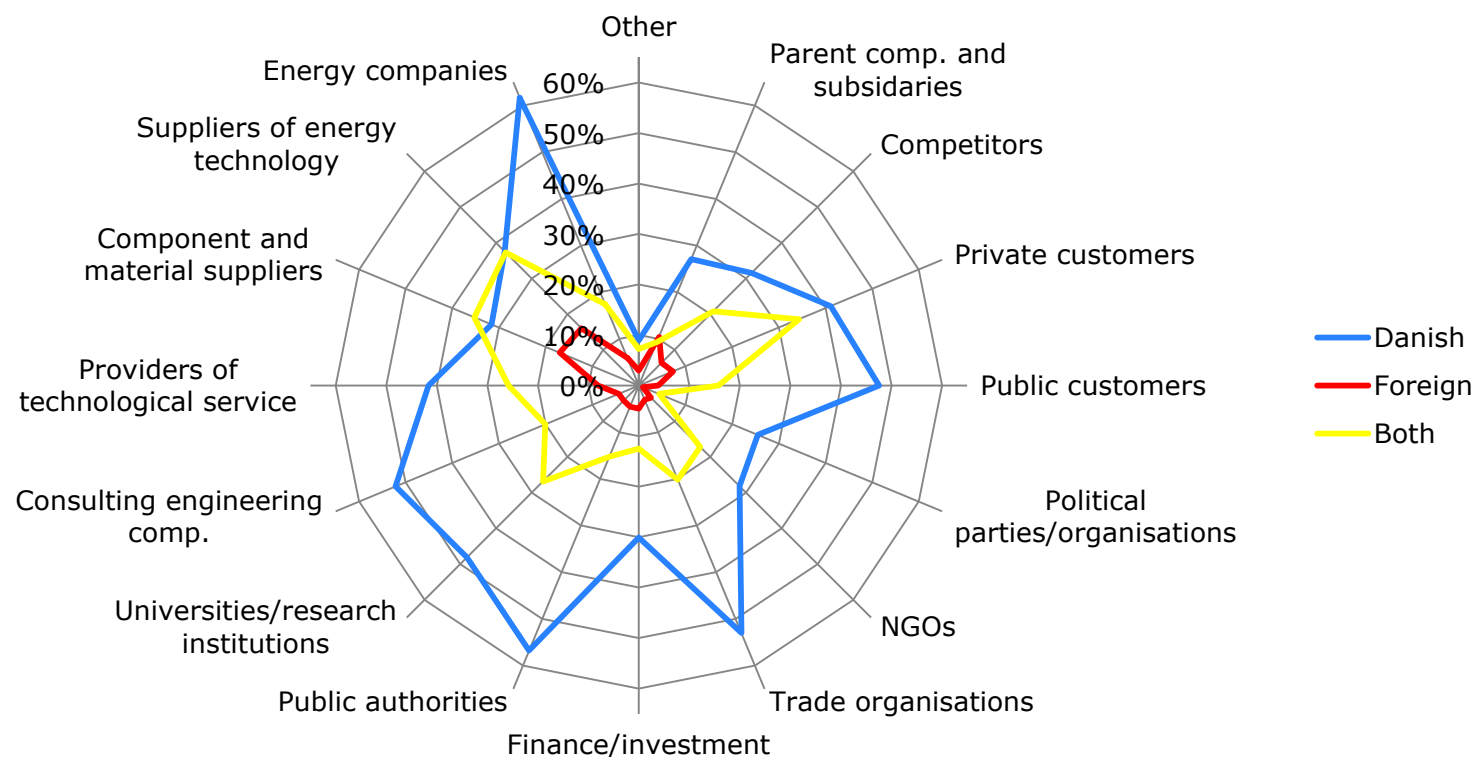
Cooperation patterns in R&D programmes



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

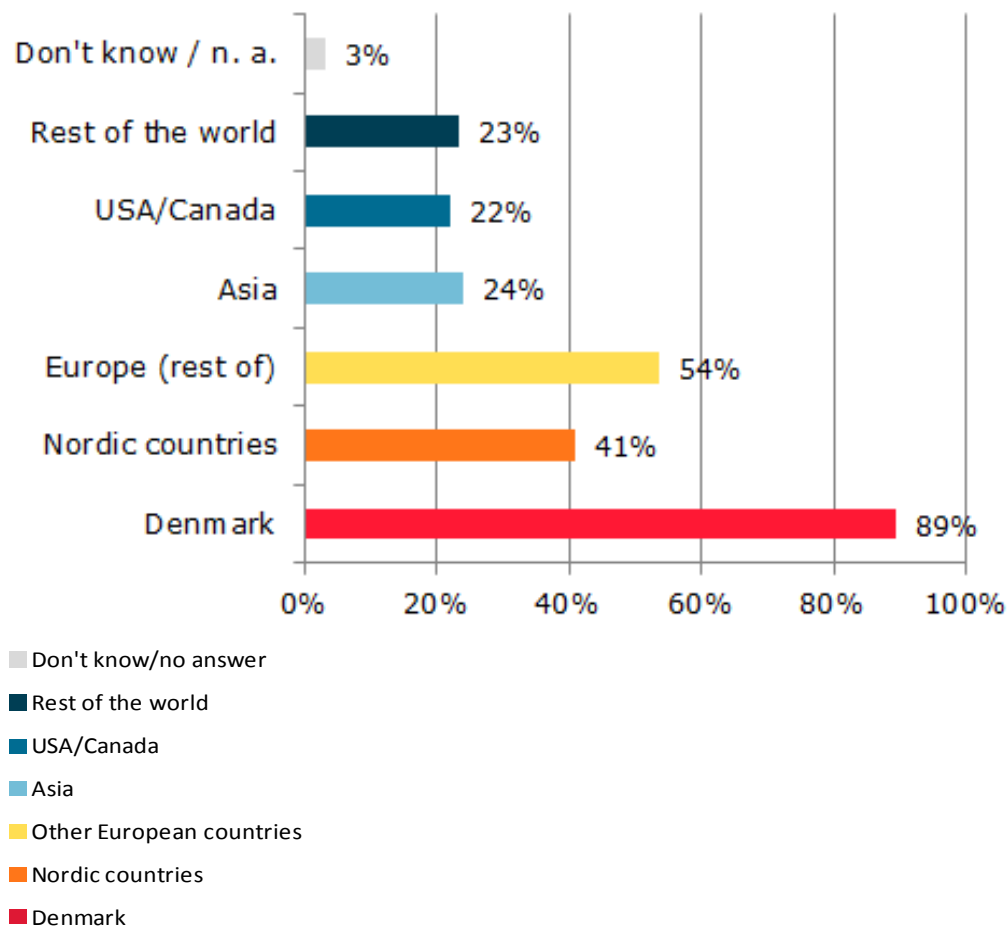
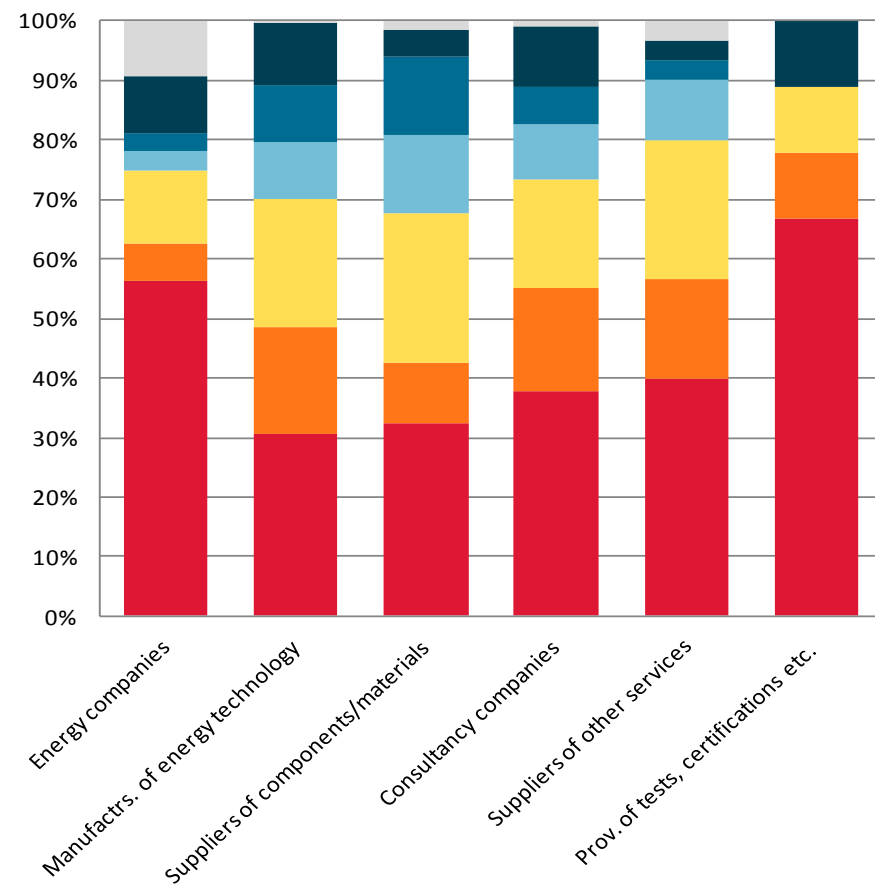
Inno. Fund DK conf. Nov. 2014 - Borup

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



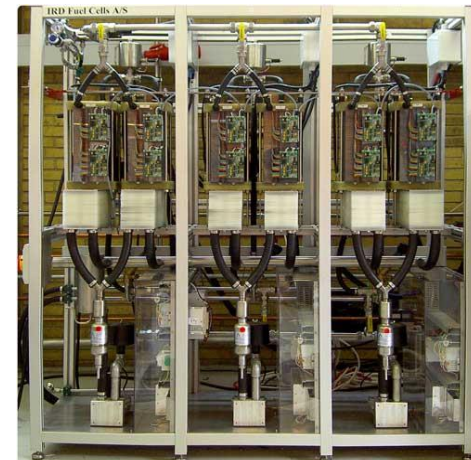
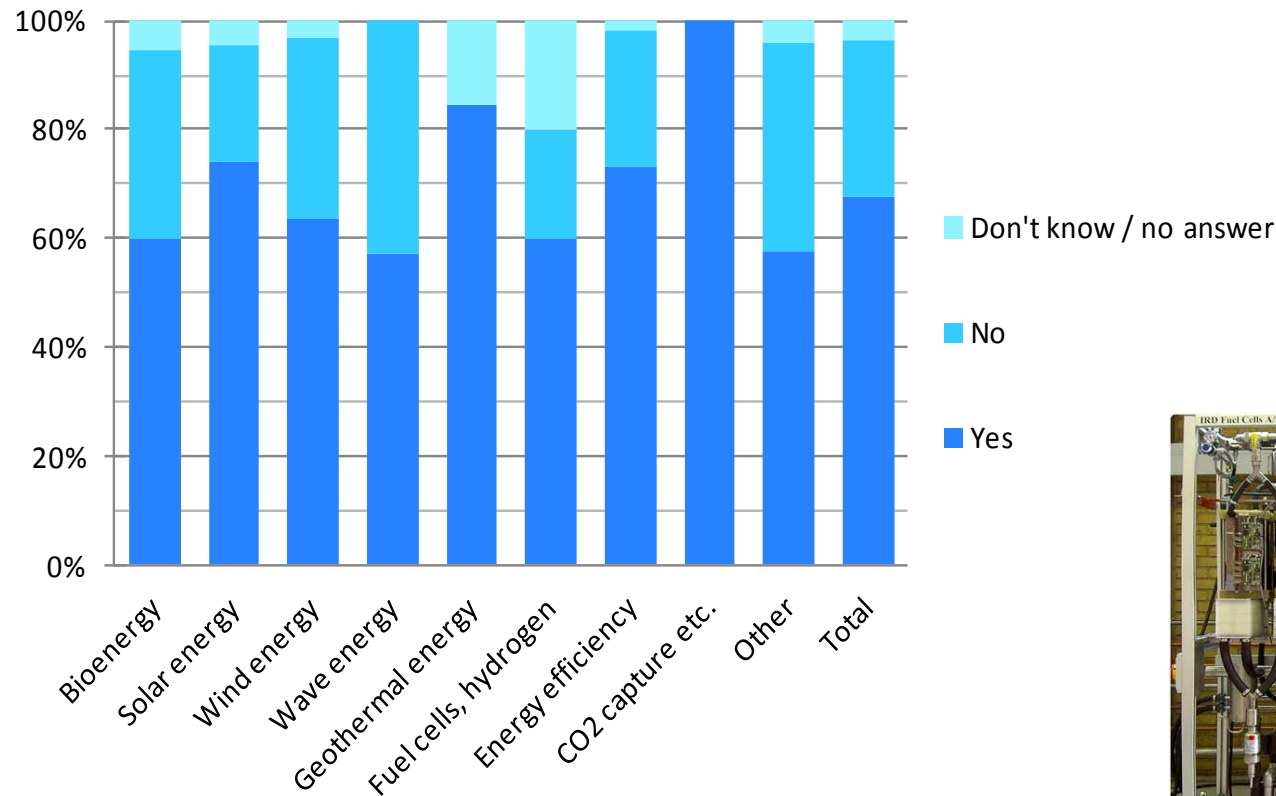
Markets for new products and services from Danish companies



"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)

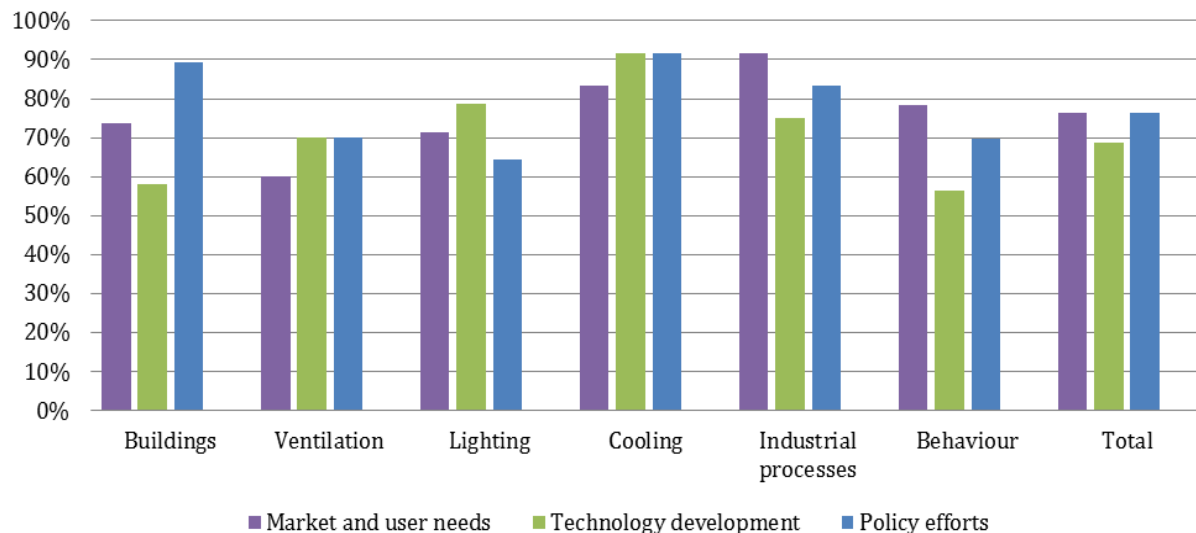
Technology	Keywords	Papers
Photovoltaics	PV, photovoltaic*	15
Wind power	wind, wind power	32
Biofuel	biofuel*, bioethanol	22
Biogas	Biogas	8
Hydrogen, fuel cells	fuel cell, hydrogen	17
CCS	CCS, carbon capture and storage	9
Combined heat and power	micro-CHP, CHP, combined heat and power	7
Electricity 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

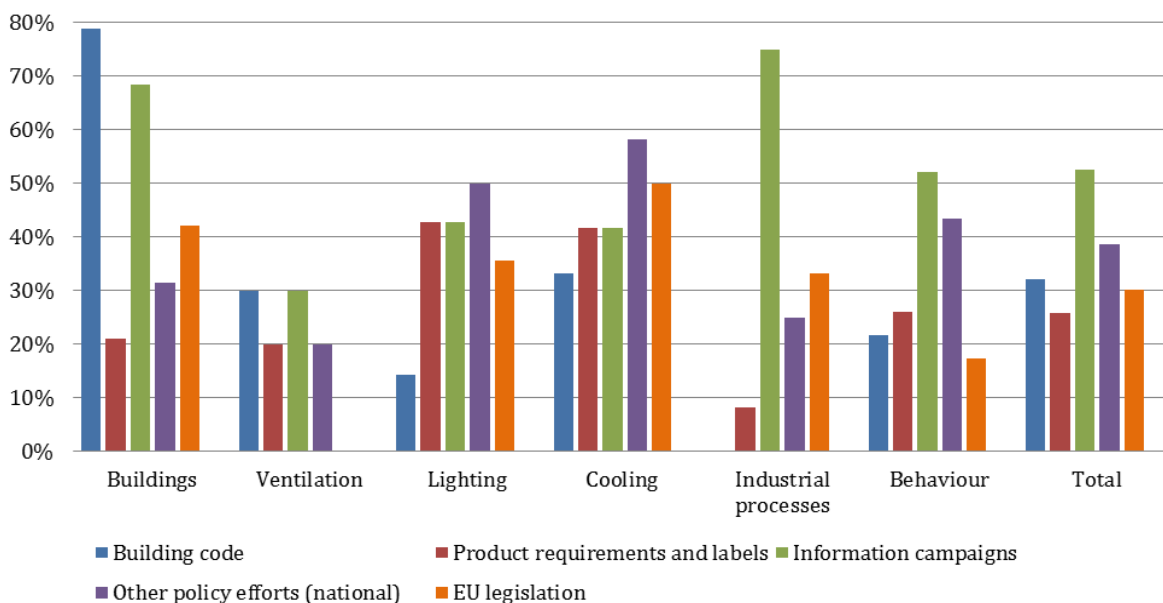
Energy efficiency innovation – example

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.