Critical situations and the need for adaptive pathways in the Danish energy transition

Pathways to a fossil free, integrated energy system
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Scenarios as modelled futures

- the vision: a fossil free and zero CO2 emission future is the backdrop/condition of this presentation
- a series number of complex, well researched scenarios combining technical models of a Danish integrated energy system and socio-economic analysis have been produced
- IDA: Vision (1999), Plan 2030 (2006), Climate (2009) and Plan 2050 (2015)
- DEA: Scenarios 2035 and 2050 (2014)
- Energinet: Scenarios 2030 (2016) - and several more

Pathways to realise the vision

- the SEN Partnership has produced its vision and RD&D action plan within this perspective
- my concern: how to translate these scenarios of energy system futures into pathways of actions that realise the vision
- stepping stone: identify ‘critical situations’ using a back-casting methodology asking: if in 2050 the energy system shall include X, which actions are needed and at what time
- translation from technical and socio-economic models to actors, investments choices, operational costs and regulation

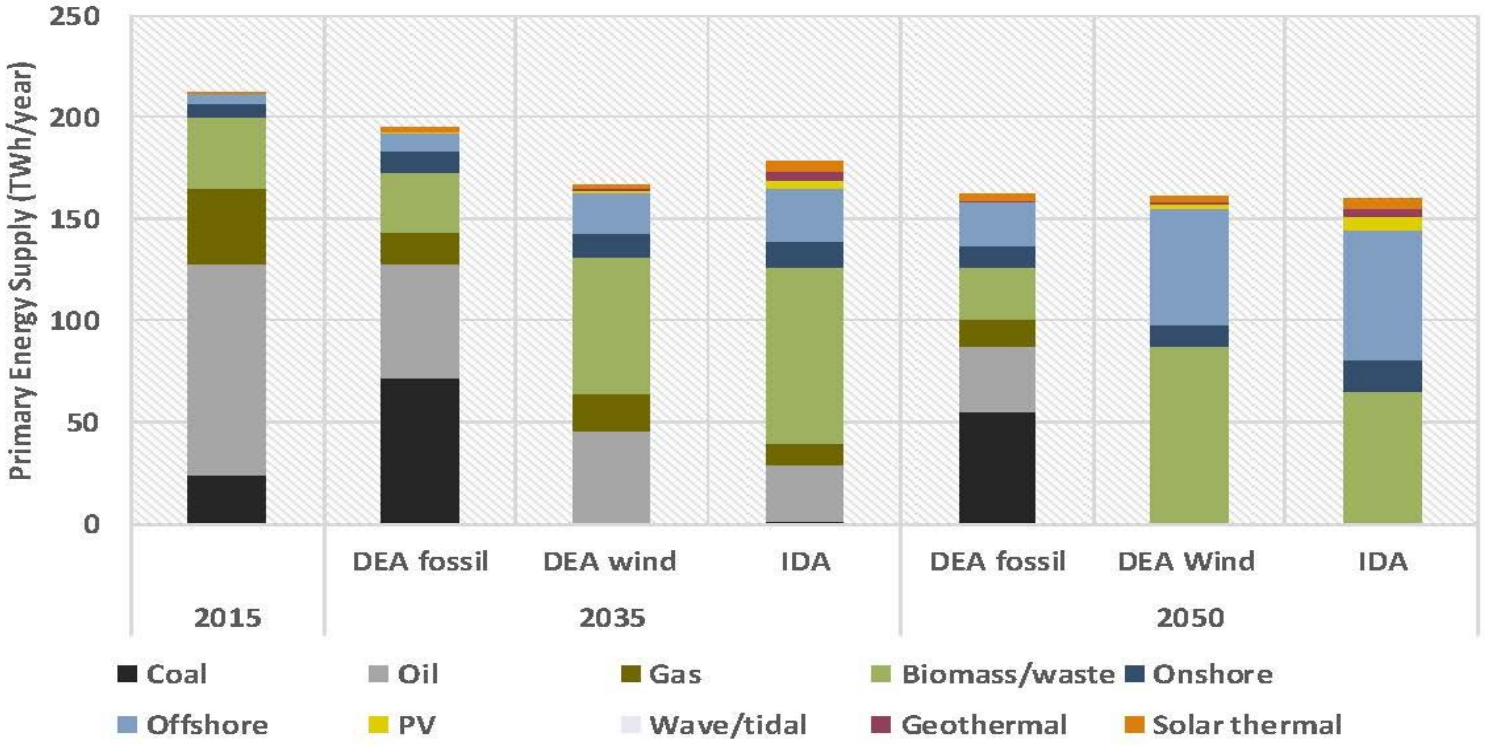
Some basic choices and assumptions

- the DEA scenario report stages a basic choice to be made between wind-based and bio-mass based pathways
- limitations in access and as extended use of bio-mass is not CO_2 neutral, wind-based pathways most often are preferred
- this implies that new ‘critical situations’ will appear when the wind-penetration continue to grow beyond the actual 50%
- cross-border trading of power from hydro and baseload nuclear plants are realistic, but challenges will be similar
- not least bio- and electro-fuels are open for futures trading

Investment horizons and experiments

- 30 years is not much in relation to investment horizons of utilities, wind turbines, heat pumps, etc.
- though cars may have a horizon of 15 years and trucks even shorter all decisions can’t be postponed into the future
- many technologies of future energy systems are known
- innovations and experimentations are needed for regulation and markets to be designed to support the transition
- also technologies especially in bio- and electro-fuels need further innovation and experimentation

DEA and IDA scenario comparison



Critical capacity demands

- a first observation is that the extension of wind-turbine capacity on land and off-shore must more than double to approx. 700 MW per year to meet the needed capacity
- energy savings in building and monitoring outcomes as well as involving dwellers and managers in meeting the targets
- a further increase of the district heating coverage above 60%
- phasing out individual oil and gas fired heating systems and substitute these with heat-pumps
- substitute large CHG plants with flexible gas-generator

Preparing a transition of transport

- electric personal transport is a cornerstone in the fossil free energy system which demands that electric car take over
- due to the life time of cars more than a third of the next cars bought should be electric and this proportion must increase
- also the transfer of public transportation though having shorter life times need a much higher growth to be electric
- not least the electrification of trains needs priority to prepare for a heavy cargo transports to be moved from trucks to trains during the coming decades, not least to gain flexibility

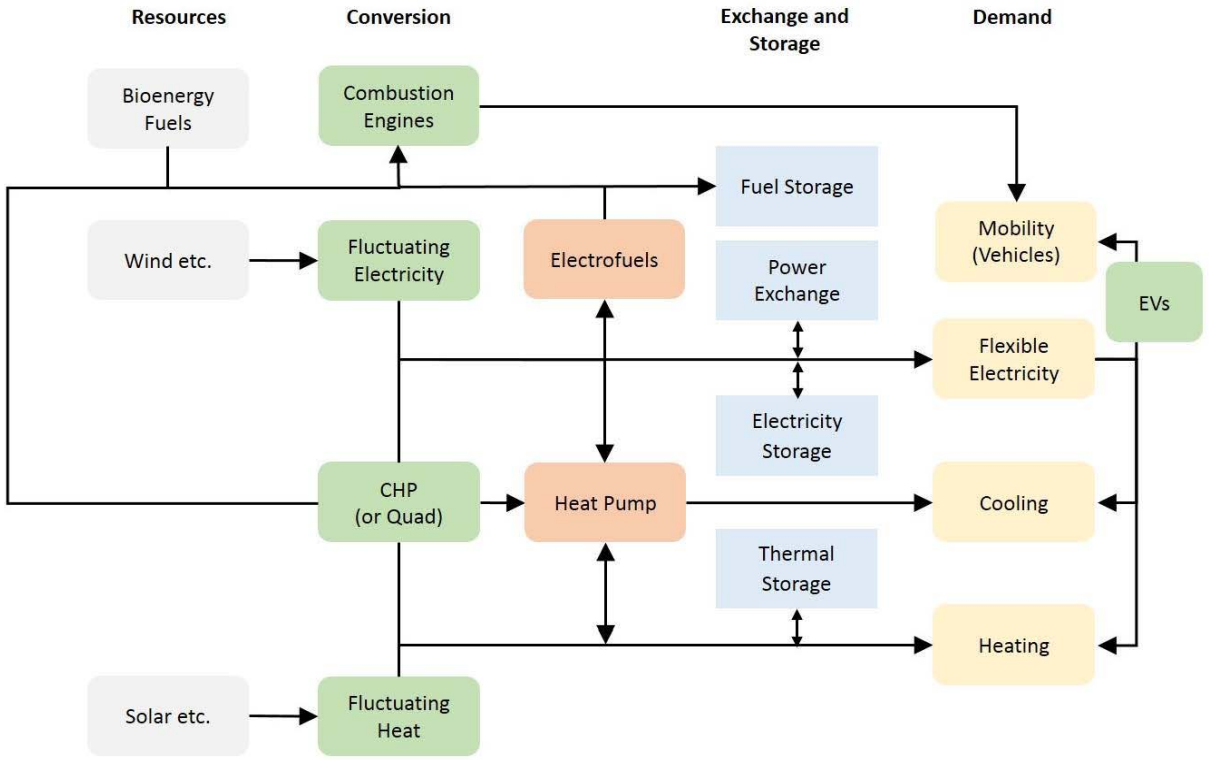
First step regulatory reforms

- remake the systems of taxes and charges to support energy transition and not least the integration of surplus heat from industry and to make heat-pump investments feasible
- change the car taxes to support a transition away from fossil fuel based personal cars and force the industry to improve the efficiency and lower prices on electric cars
- monitor the relationship between operational costs and price bits for e.g. electricity and heat to avoid a cannibalisation of exiting or future investments needed for the transition

A conceptual transformation

- in EU scenarios and several economic and political we find assumptions about an ability of single energy commodity markets as futures allocation mechanism
- in contrast, the DEA and IDA wind-based scenarios share a profound consequence for the regulatory concept of the future integration of the three basic energy systems
- IDA vision 2050: *a sector integrated smart energy system strategy is more robust than a single-sector focused approach* – lower costs, efficient biomass use, and international markets balancing electiricity

Energy flows in the DEA/IDA model



Smart integration?

- the notion ‘smart’ is quite flexible in use and often stands for the use of data and IT to regulate systems, but is also used in connection with the idea that data optimise markets
- in the integrated energy system heat production will change its status from being a by-product and efficiency gain to be delivered by an increasingly varied set of technologies
- need to operate as a backup-capacity for low wind periods utilising heat storage capacities
- combined with electricity from dedicated gas-generators

New regulatory framework needed

- integration implies that optimal use of the electricity produced is dependent of a backup:

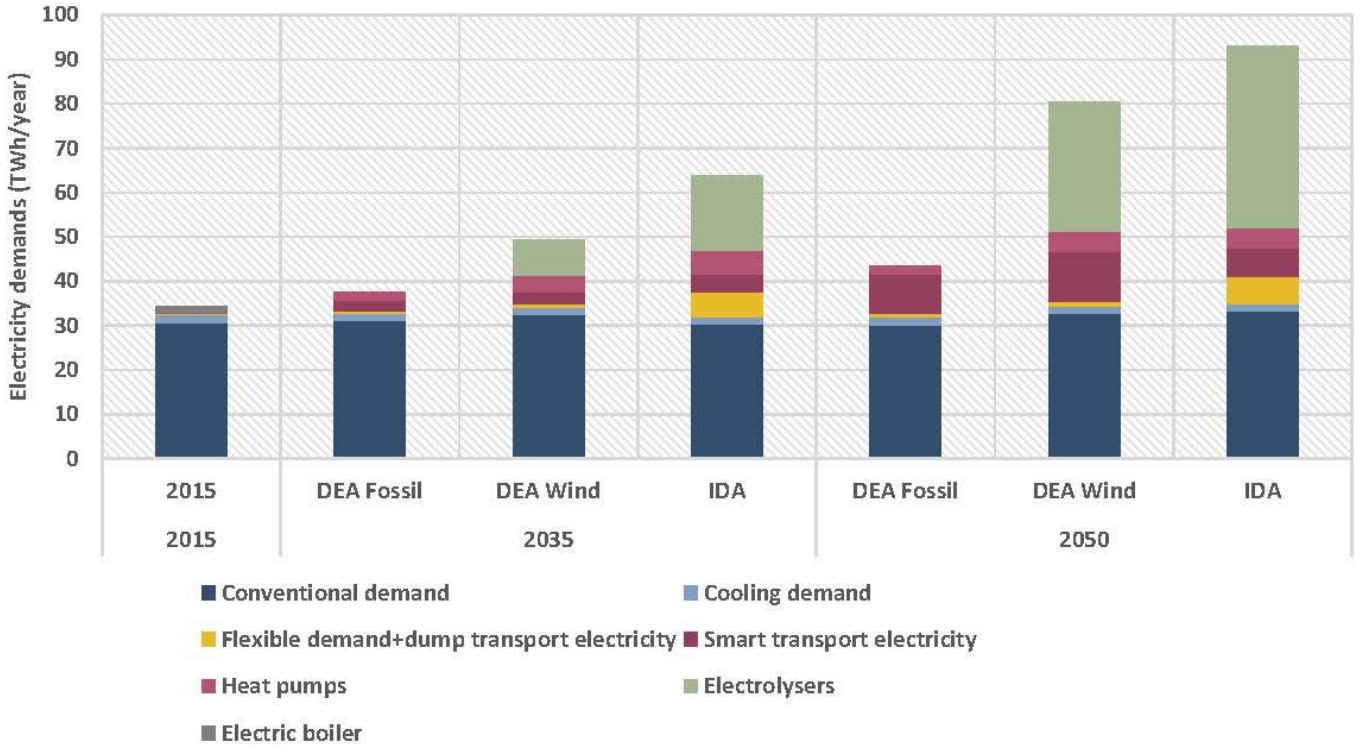
  - timely utilisation of the heating systems flexible generators in low wind periods and

  - use of electricity for heat-pumps and not least the production of electro-fuels
- demands a structure of ownership or an institutional setup that can handle such market conditions
- demonstrates difference between socio-economic and a single-commodity market model

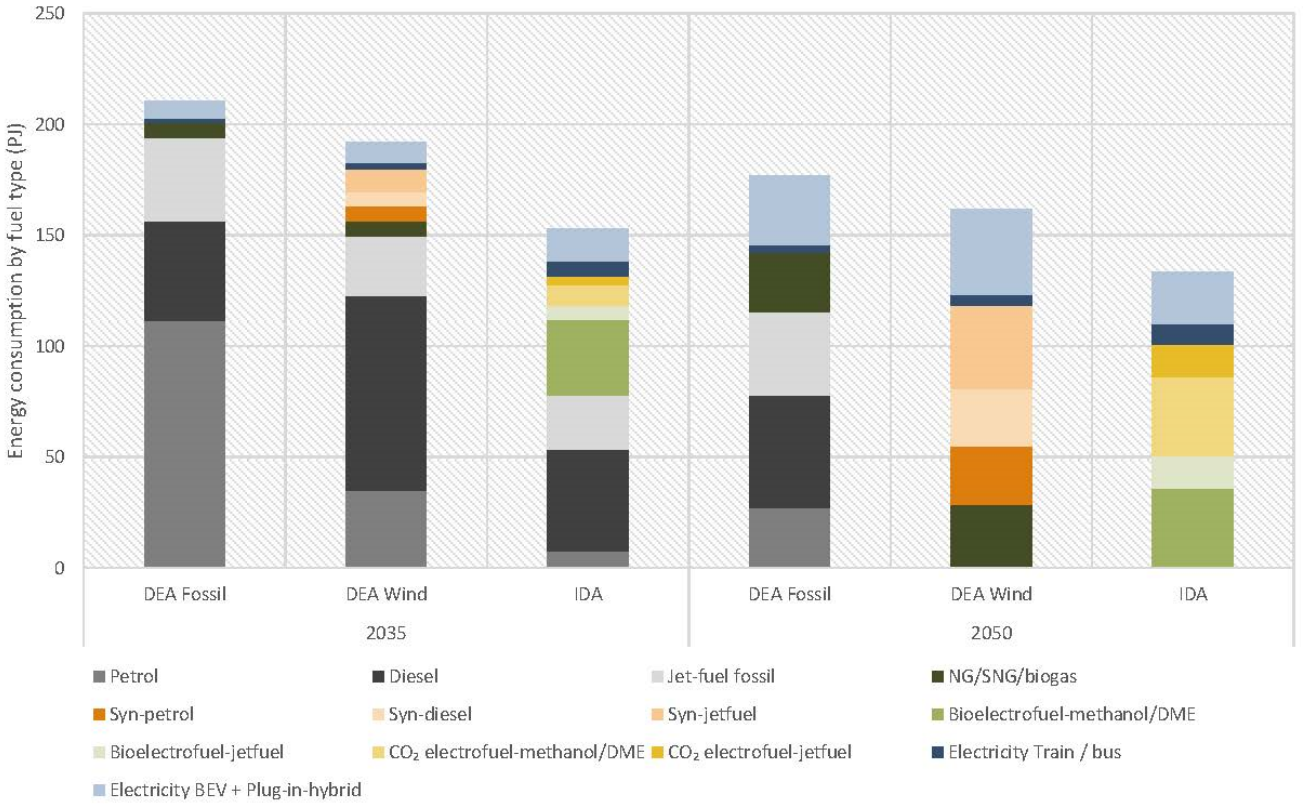
Transports: curse or blessing?

- transportation is due to the need for fuel efficiency and mobility is a challenge to the transition especially after 2035
- especially heavy cargo, heavy machinery and airborne transports require special fuels
- this opens for an important use of the surplus power from renewable sources in the production of electro-fuels in various combinations of gas, hydrogen, etc.
- this production is feasible if electricity is available at low, marginal costs, but it demands a regulated, flexible market

Use of electricity in the scenarios



No consensus about transport energy



Challenges to the transport transition

- the future choice of fuels – e.g. liquid or gas – is an open issue with very different scenarios and priorities
- choices dependent of:

  - competition with existing fuels

  - ability to innovate and optimise productions of bio-gas, bio-diesel and electro-fuels

  - regulatory frameworks for transports use of fuels including charges on fossil based fuels
- differences between transition pathways among countries may affect this in profound ways

Robustness, cost and vulnerability

- a fossil free, smartly integrated energy system comprising of all core energy transmission forms: electricity, thermal and gas is technically possible and also socio-economic feasible
- organised as a robust system able to handle peak loads of various kind, but it requires adaptive regulatory frameworks handling gaps between investment and operations decisions
- though the pathways towards this end goal will be increasingly vulnerable along with the reduced dependency on fossil fuels