Dynamics in the Energy System of 2035

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Value chain – from energy ressources to energy services

Energy ressources (RE)

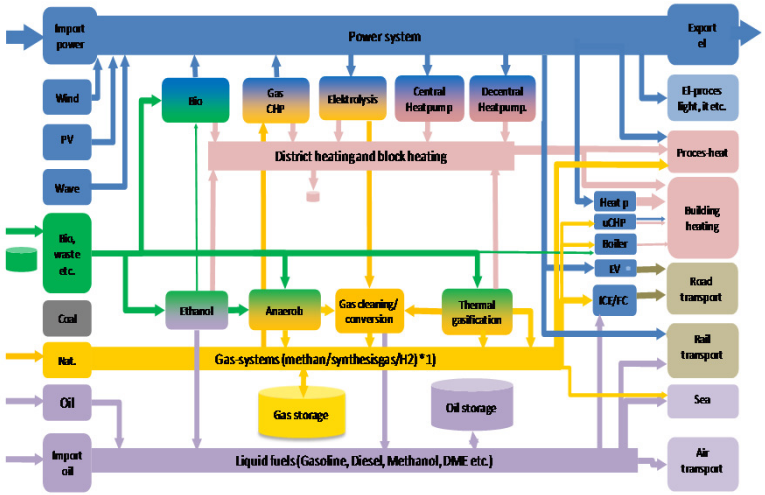
- Wind
- Photovoltaic
- Wave..

- Biomass
- Bio residues
- Waste

- Solar heat
- Geothermal

1. **Renewable ressources**
2. **Sustainable use**

Energy system dynamics ?

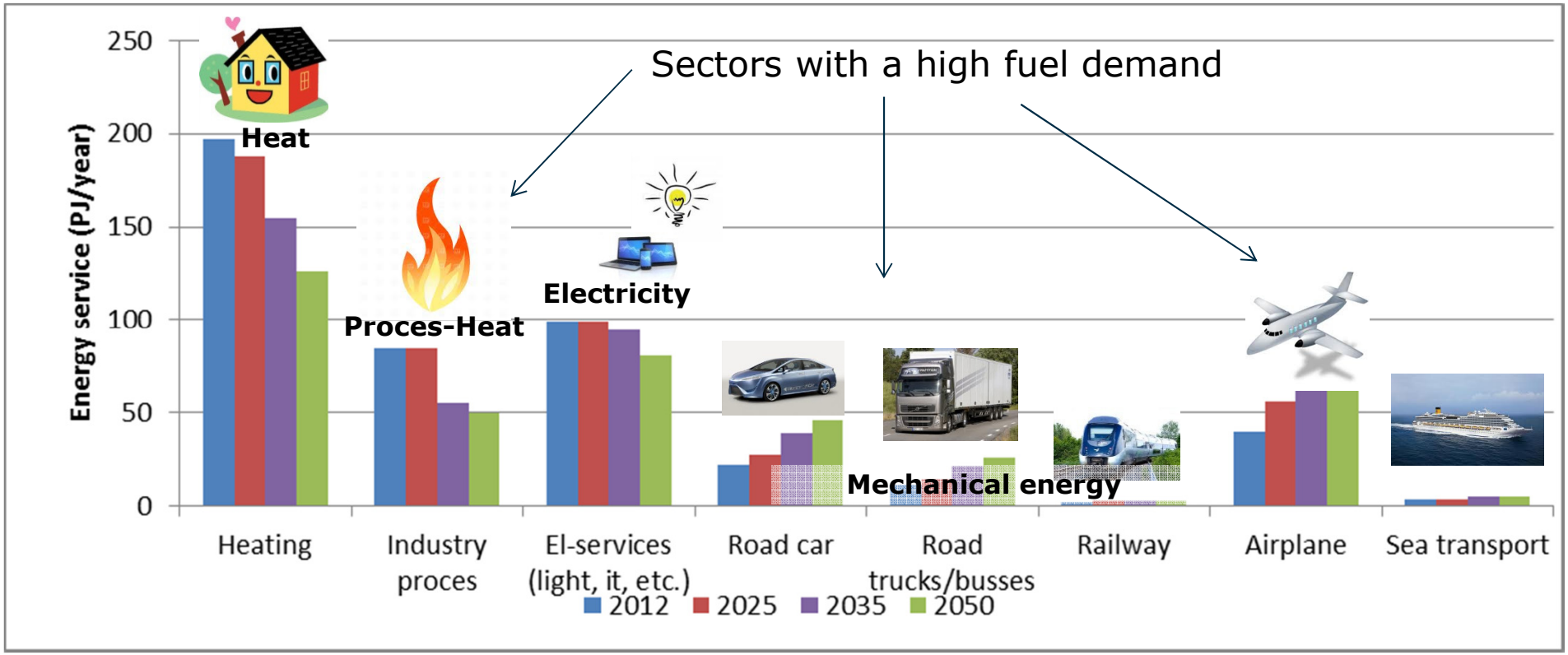


Energy services

- Electric (light, it, process..)
- Transport
- Industry proces energy
- Heating
- Cooling

1. **Competitive and stable prices on energy services - based on RE**
2. **Security of supply**

Energy services forecast example for DK



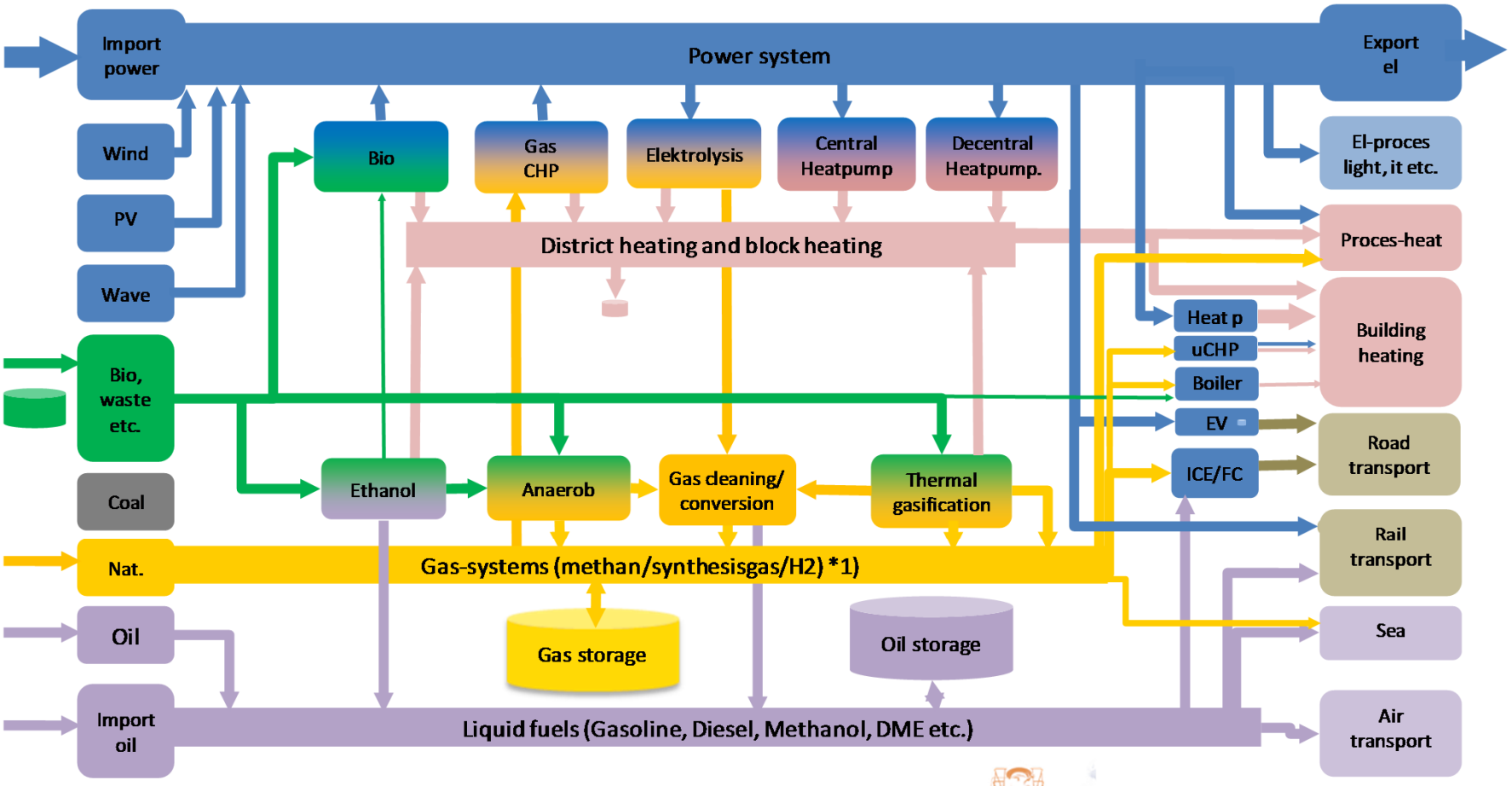
A future need for sustainable fuels in non-electrified services

Energy flows in system (not scaled)

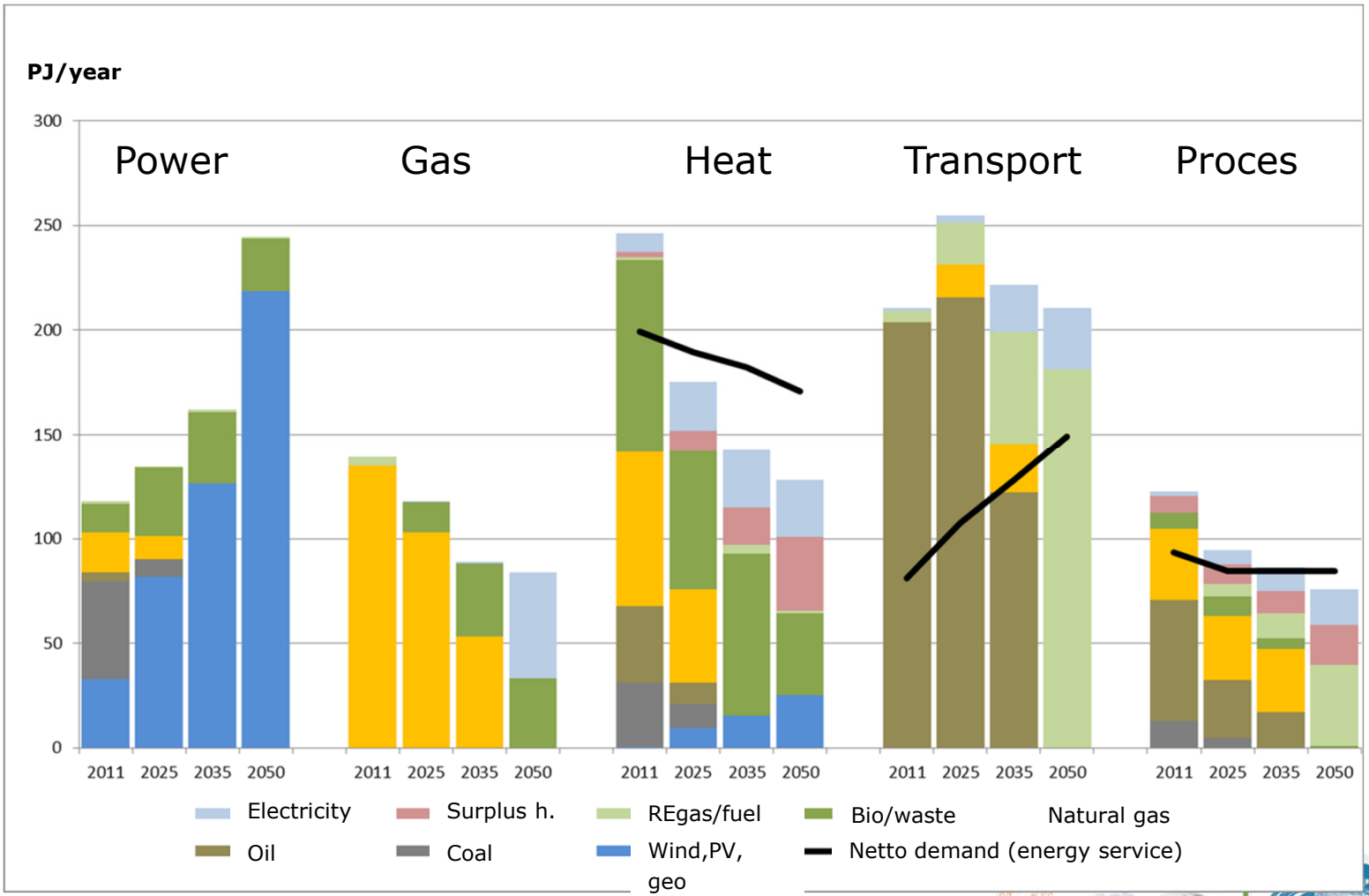
Ressource
Sustainable energy

Energy-system
Flexible and efficient (economy and energy)

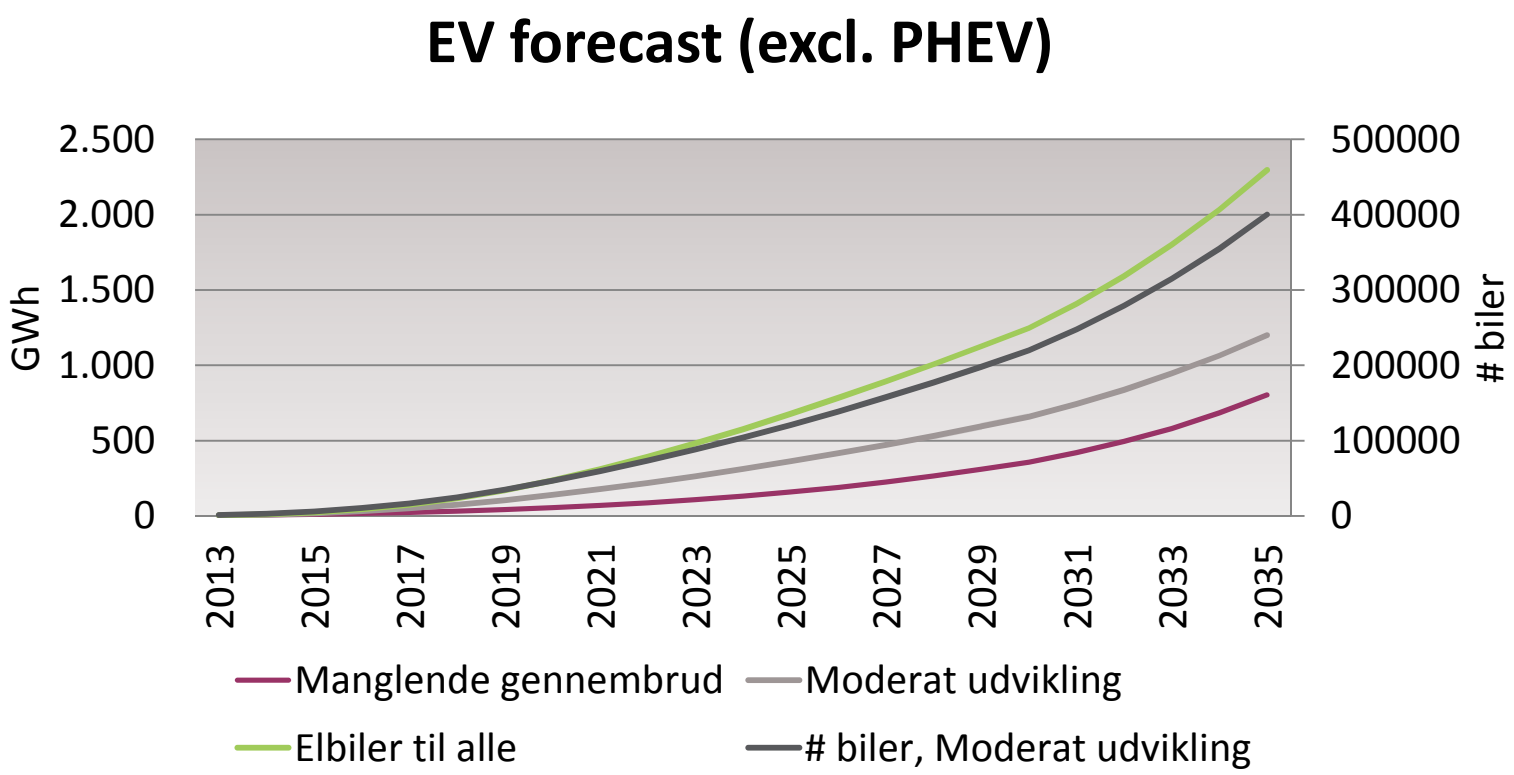
Energy service
Low and stable costs



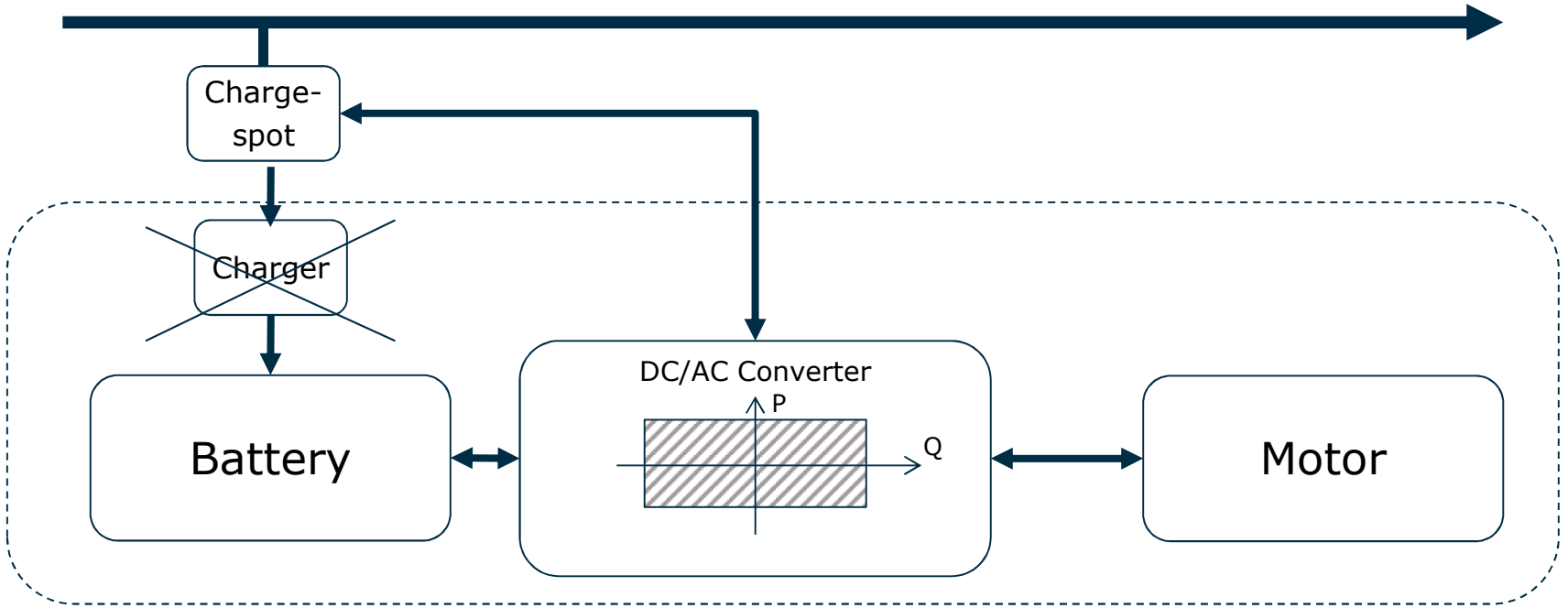
Development of production and use of energy (example)



Scenarios for EV penetration 2014-2035

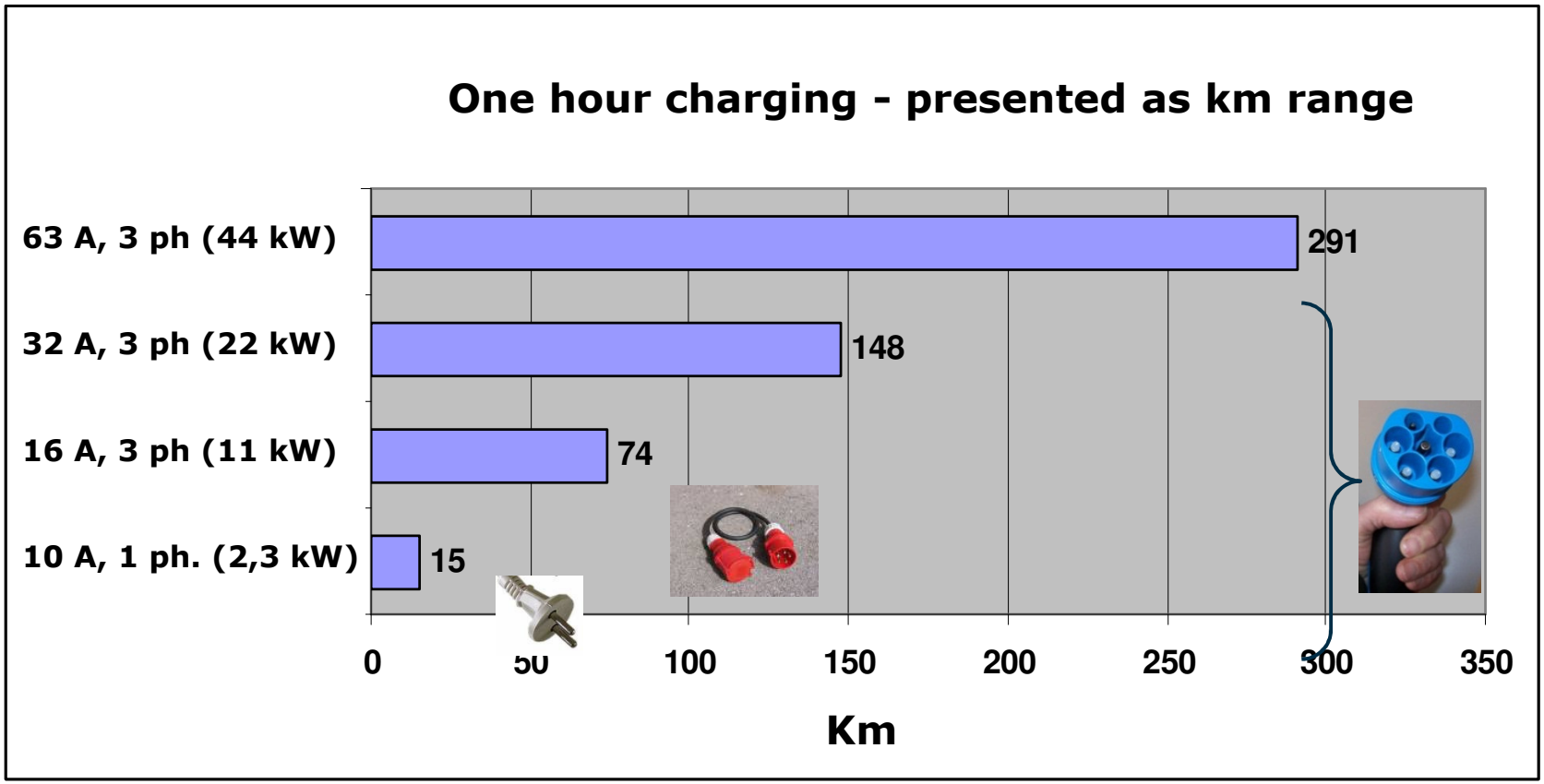


Is there a future for V2G ?



- How much is the additional EV cost for V2G
- What will be the standard after 2025 ?
- Should the power system be ready to handle the feature ?

Charging power– how far on one hour charging

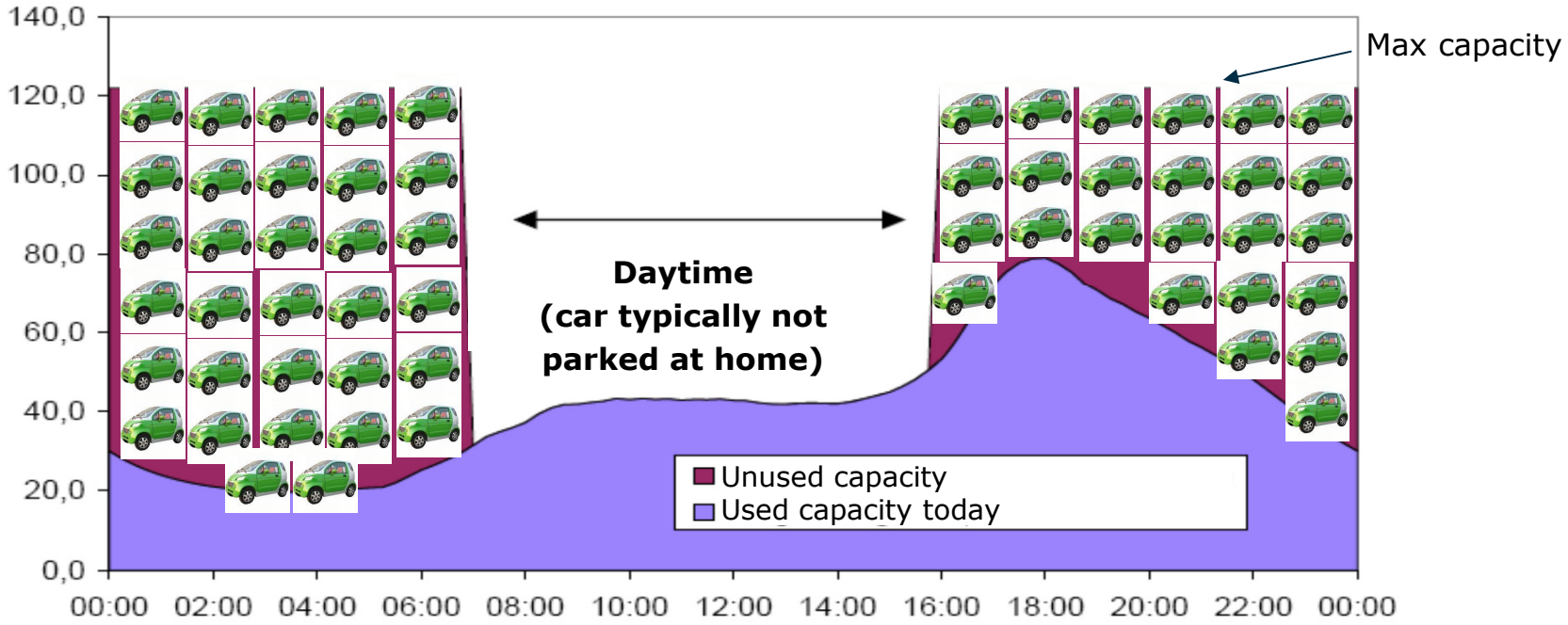


- The IEC 62196-2 type II plug can handle 50 km charging at 10-15 min!
- If the power grid and the EV can handle the power capacity !
- A need for an intelligent grid (Smart Grid) to manage this power

Capacity in the distribution grid to EV charging

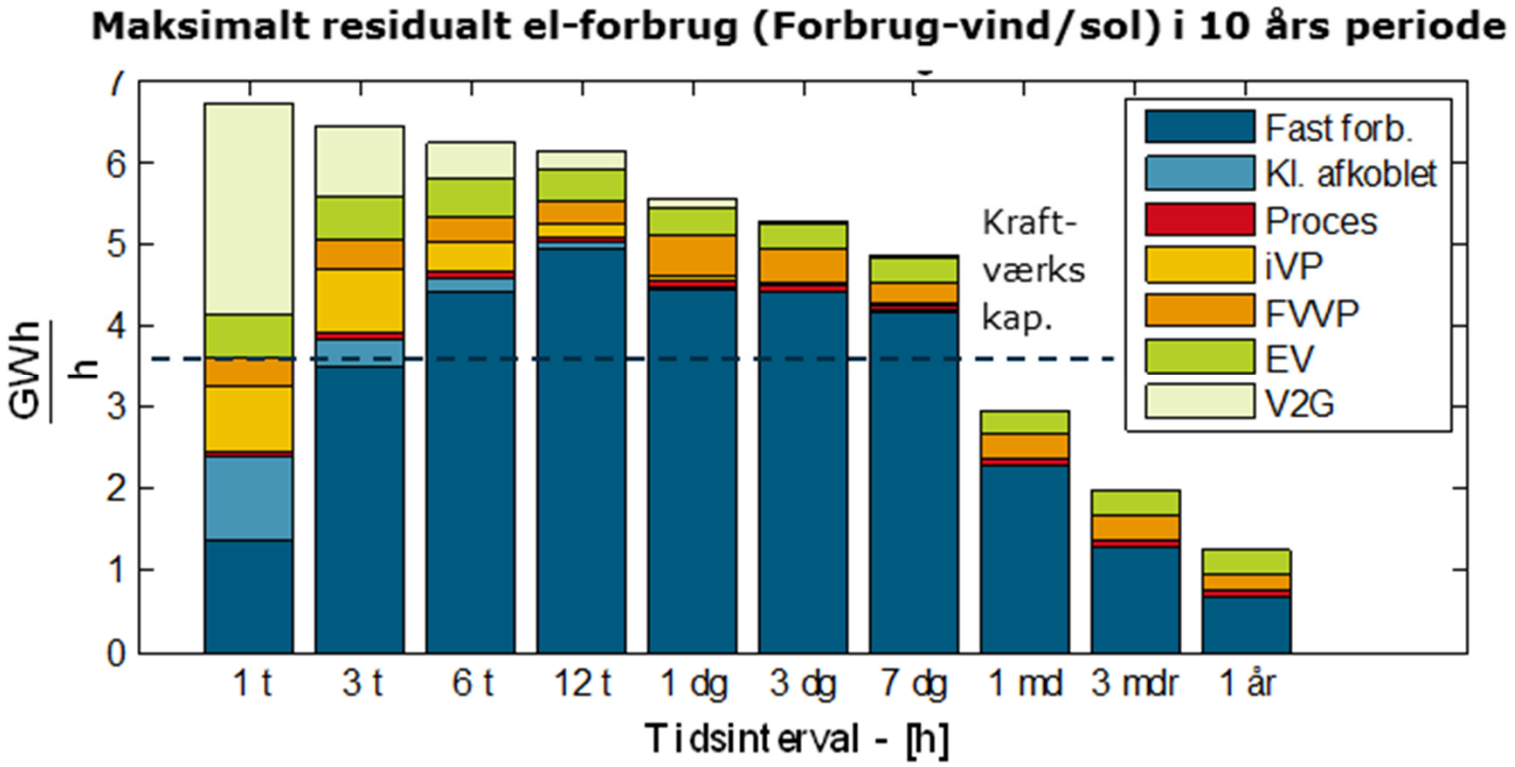
Case study in a low voltage distribution net (0,4 kV in DK)
16 Amps 3-phase charging example
Obs – this example is for a local grid with low capacity

Current in radial [A]



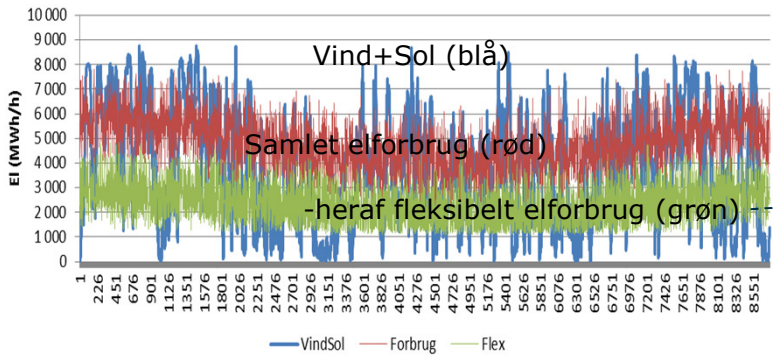
Only 3 cars with 16Amp 3-phase can charge in peak hours at 17-18
But: More than 50 cars evenly distributed
A high value of Smart Grid to control the charging !

Case 2035 – flexibility from EV's and other sources

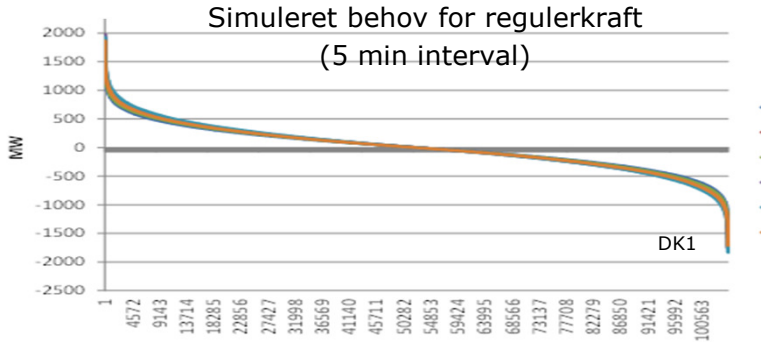


Fleksibelt el-forbrug vil kunne supportere balancering og netreserve i el-systemet frem mod 2035

Fleksibelt elforbrug i 2035 typisk over 1500 MW



Fleksibelt elforbrug kan potentielt dække behov

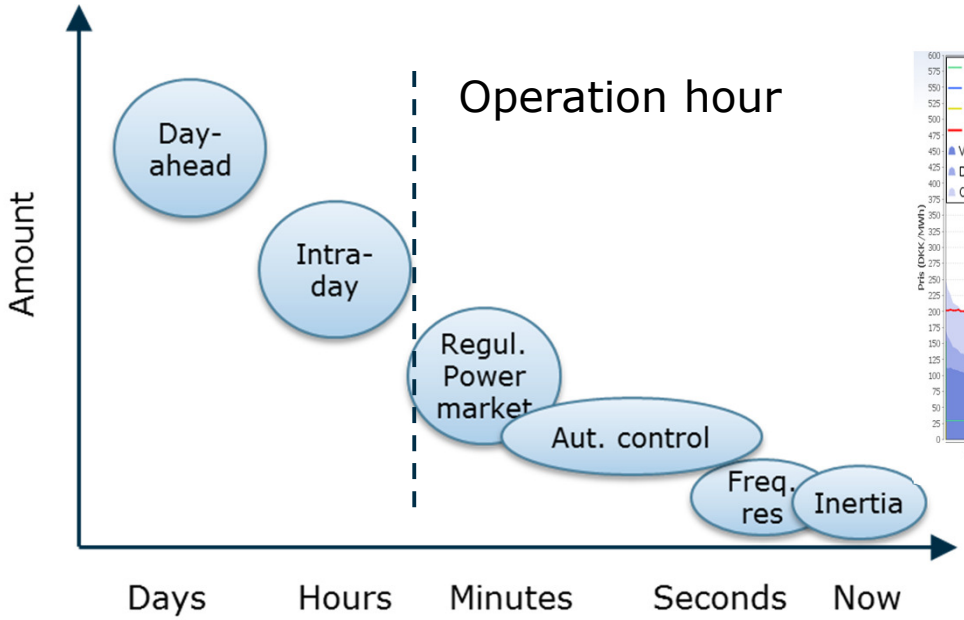


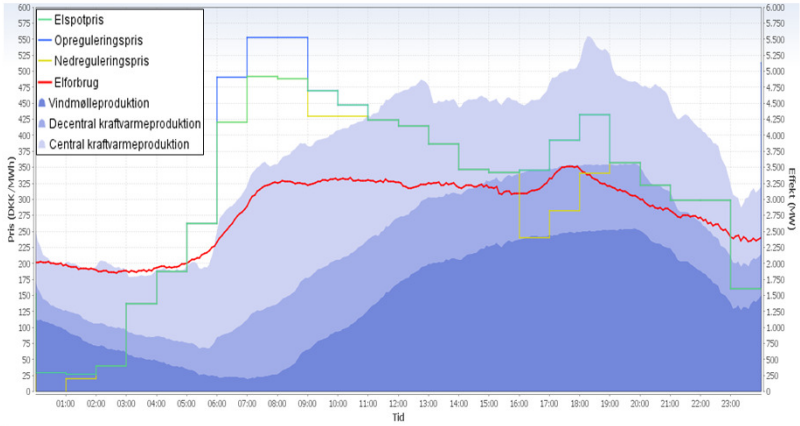
Fleksibelt elforbrug som netreserve kan øge udnyttelsen af transmission

Fleksibelt elforbrug som net-reserve

- Det fleksible elforbrug i 2035 er relativt stort, og størrelsen er analyseret ift. brug som:
  - Regulerkraftydelser
  - Som supplerende netreserve i transmission.
- Anvendt som netreserve kan behov for traditionel netreserve reduceres, og udnyttelsen af nettet derved øges.
- Enkelte foreløbige vurderinger af fleksibelt forbrug som netreserve gennemført. Behov for nærmere analyser og vurderinger af forskellige principper

Keeping the system in balance, market solutions





Normal use of reserves

1. Primary reserves (frequency reserves)
2. Secondary reserves (automatic control)
3. Tertiary reserves (Reg. power market)

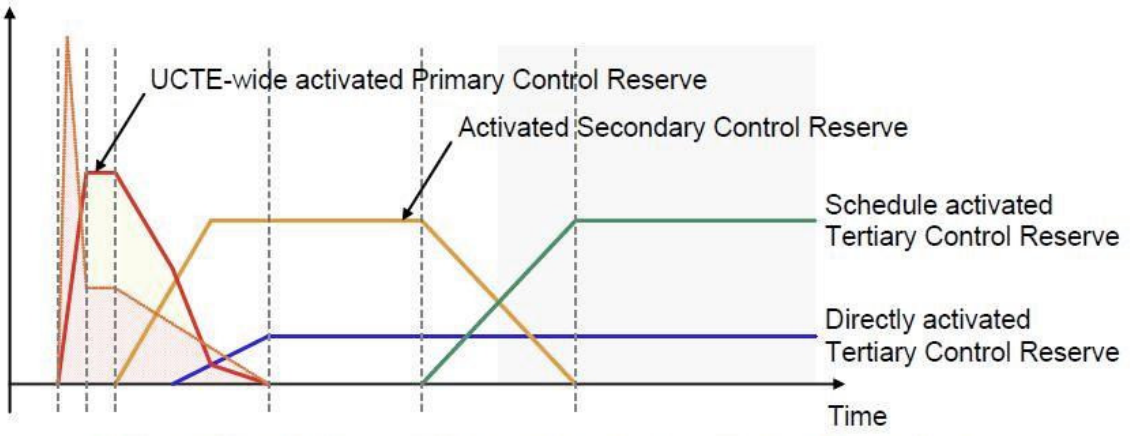


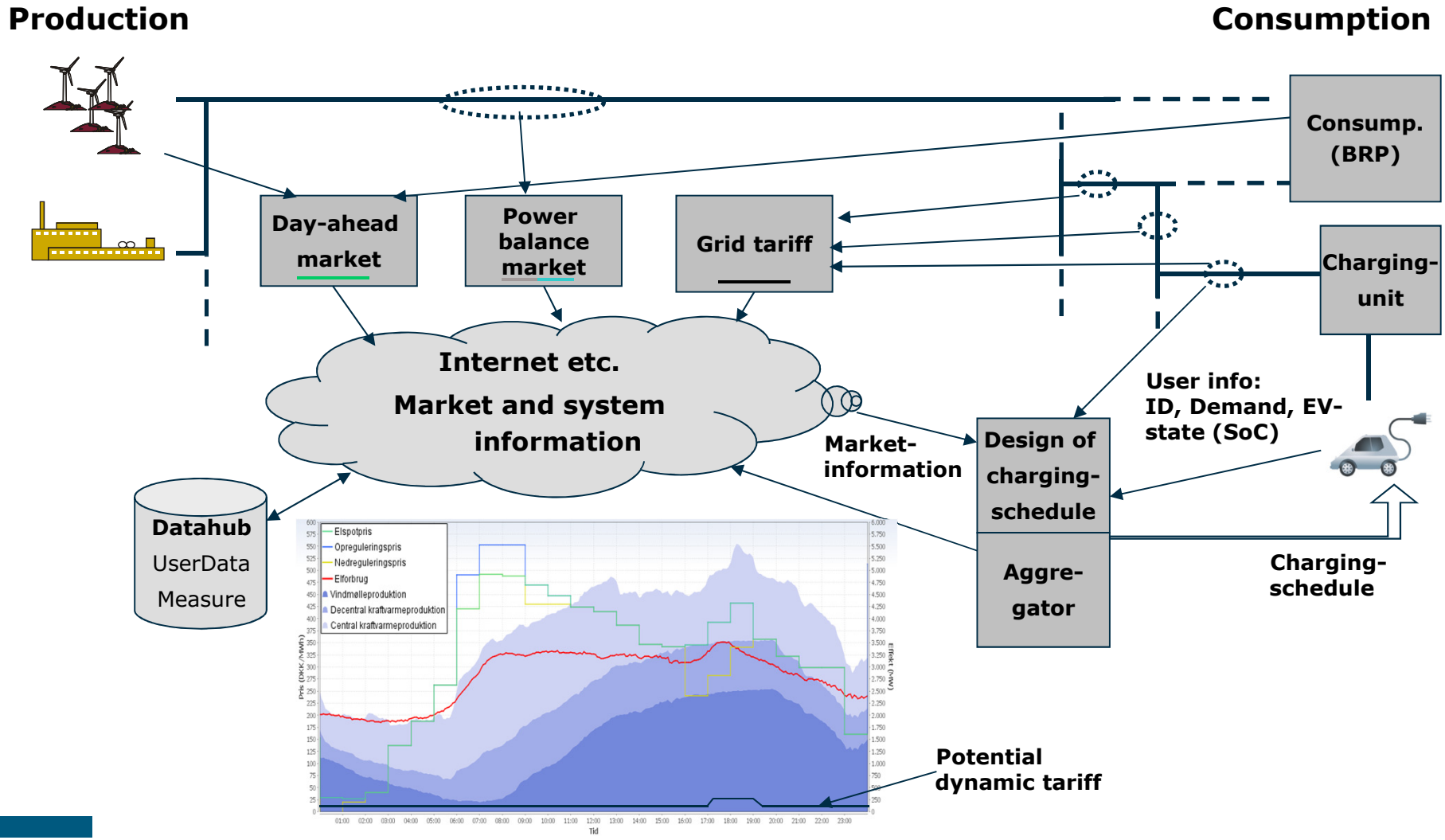
Figure 3: Principle frequency deviation and subsequent activation of reserves

Danish perspectives on system support from different technologies

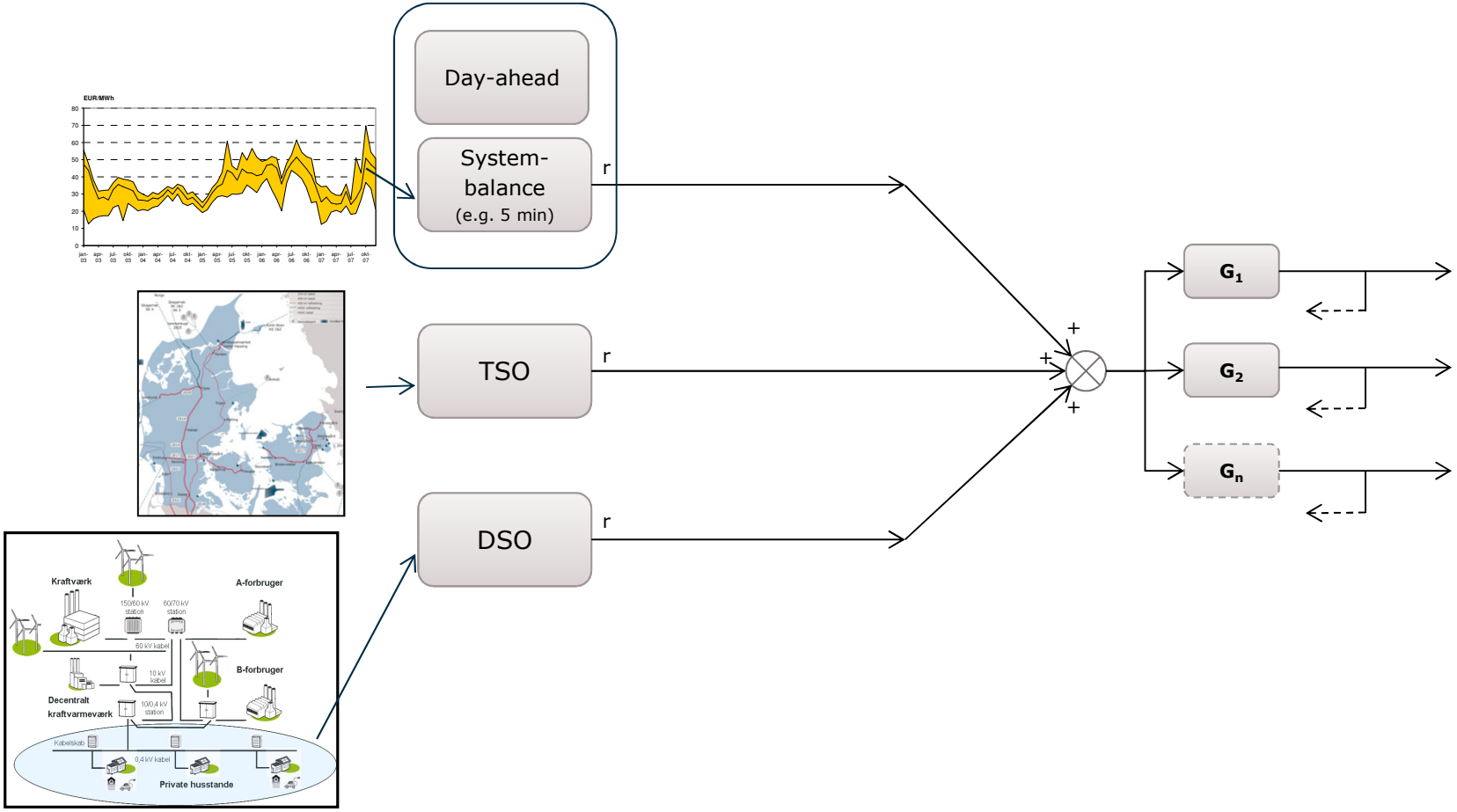
	Generator >100 kV	Generator <100 kV	WT >100 kV	WT <100 kV	Classical HVDC	New HVDC	SVC/ STATCOM	Synch. comp
Inertia	++	+	(+)	÷	(+)	(+)	÷	++
Short circuit power	++	+	(+)	÷	÷	(+)	÷	++
Black start	(++)	(+)	÷	÷	÷	(++)	÷/(+)	÷
Continious voltage control	++	(+)	(+)	÷	÷	++	++	++
Dynamic voltage support	++	÷	++	÷	÷	++	++	++
Damping of system oscillations (PSS)	+	÷	(+)	÷	(++)	(++)	(+)	÷

++	*Large contribution*
+	*Minor contribution*
(+/++)	*Conditionally available*
÷	*Unavailable*

EV's – example on integration in a Smart Grid



Example – control strategy



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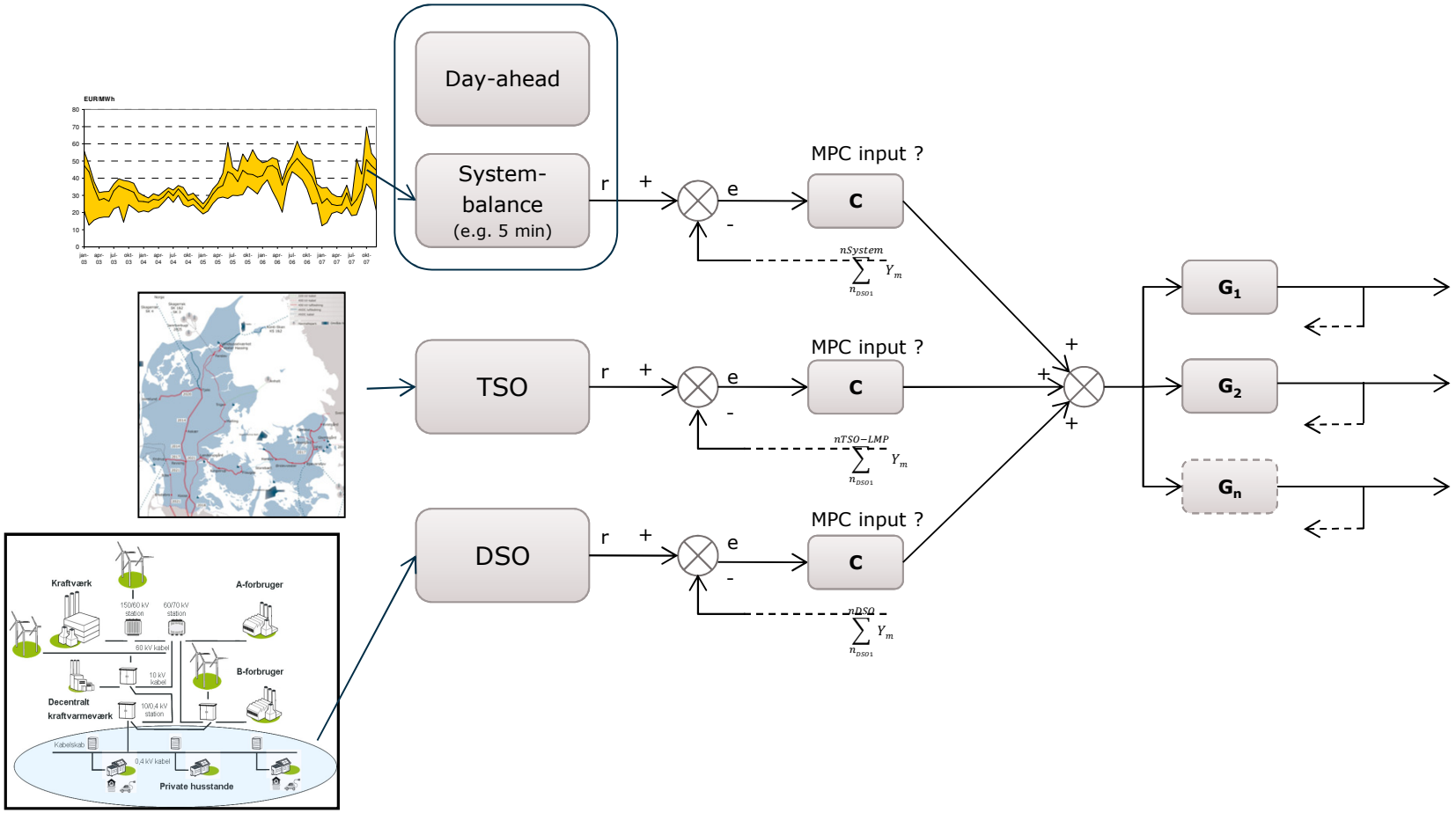

Thank you for your attention