

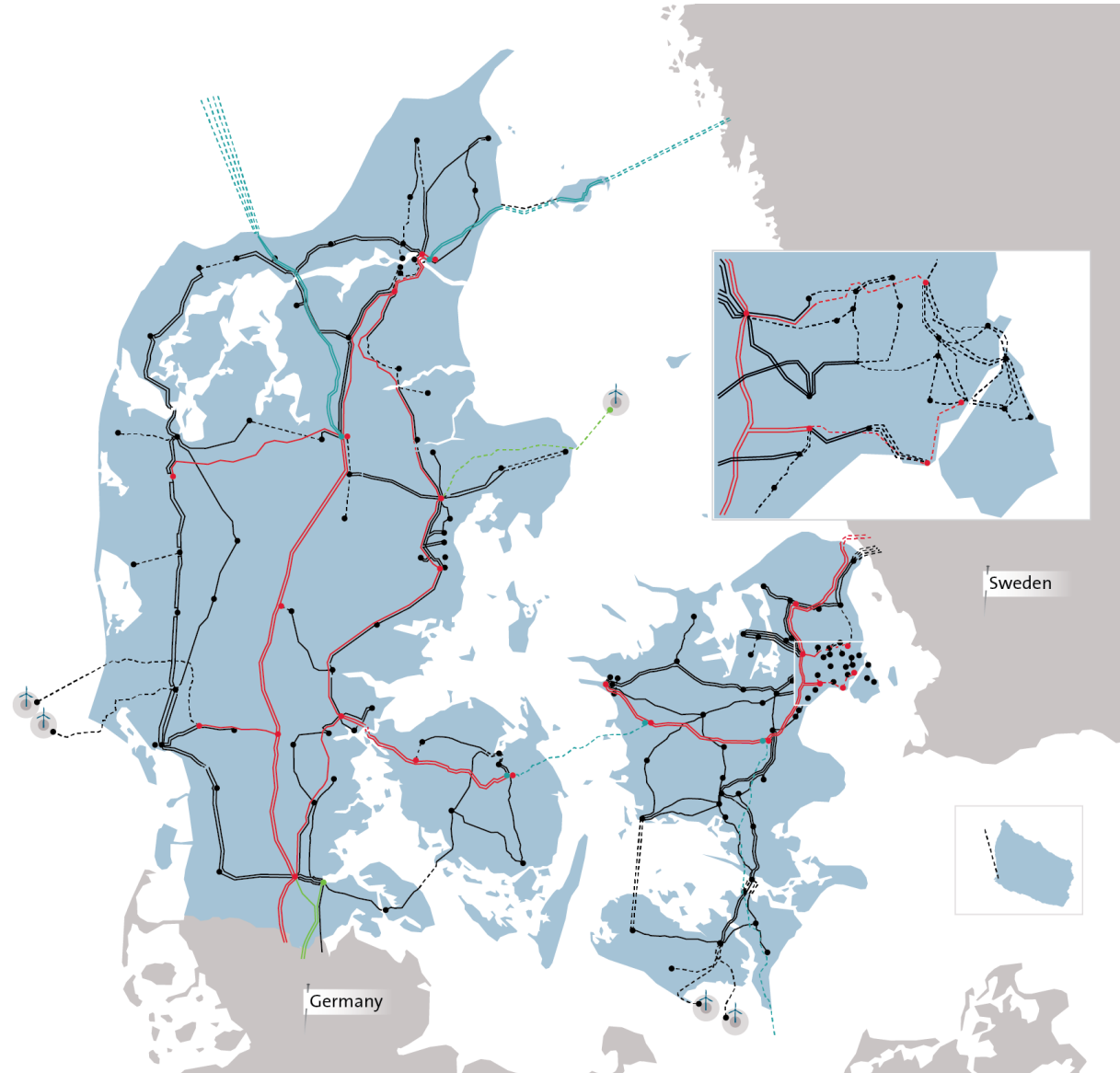
POWER SYSTEM BALANCING WITH WIND POWER

Balancing at Energinet

Bent Myllerup – Senior Director of Controlcenter at Energinet

ELECTRICITY GRID

POWER		Transmission grid	
400 kV AC	● Substation	— Overhead line	- - - Cable
400 kV DC	● Converter station	— Overhead line	- - - Cable
220 kV AC	● Substation	— Overhead line	- - - Cable
132/150 kV AC	● Substation	— Overhead line	- - - Cable
 Offshore wind farm (owned by other companies)			
Last update: beginning of 2013			



PARALLEL DEVELOPMENTS

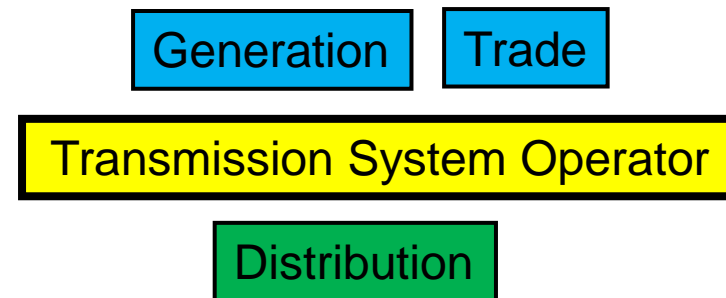
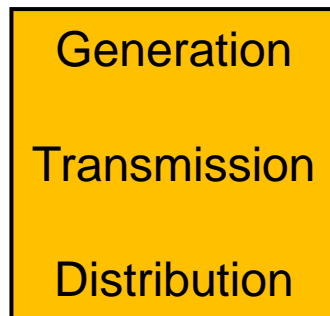
- TOWARDS RENEWABLE ENERGY AND OPEN MARKETS



From primary coal fired to local CHP, wind power and PV

2000

From vertically integrated monopoly to competitive electricity market



THE CHANGES OF THE POWER SYSTEM

ENERGINET

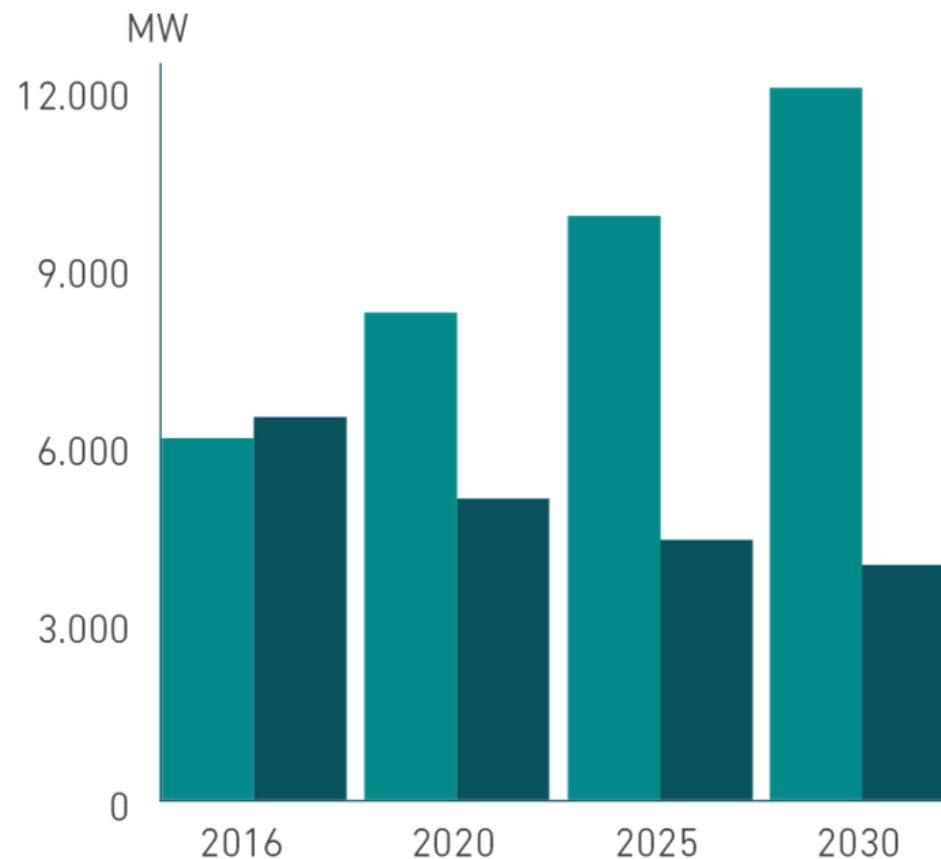


SOLAR AND WIND POWER IS SHARED ACROSS BORDERS

We cannot simply dial output up and down

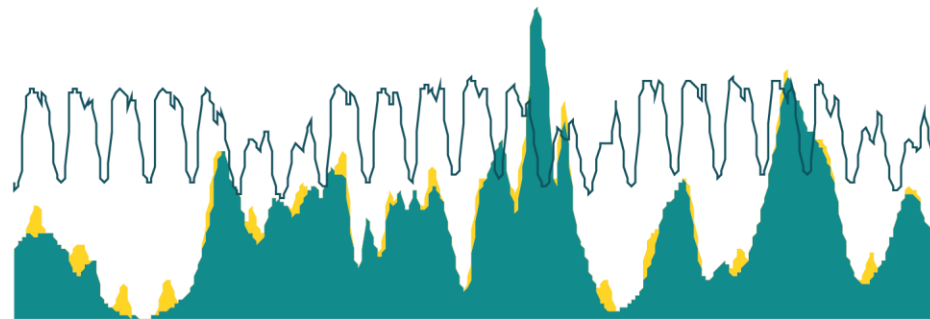
- Wind and solar power (fluctuating generation)
- Power stations (dispatchable generation)

A much greater share of future electricity generation is expected to come from wind and solar power rather than from CHP plants.



CONSUMPTION AND GENERATION ARE OUT OF STEP

2019

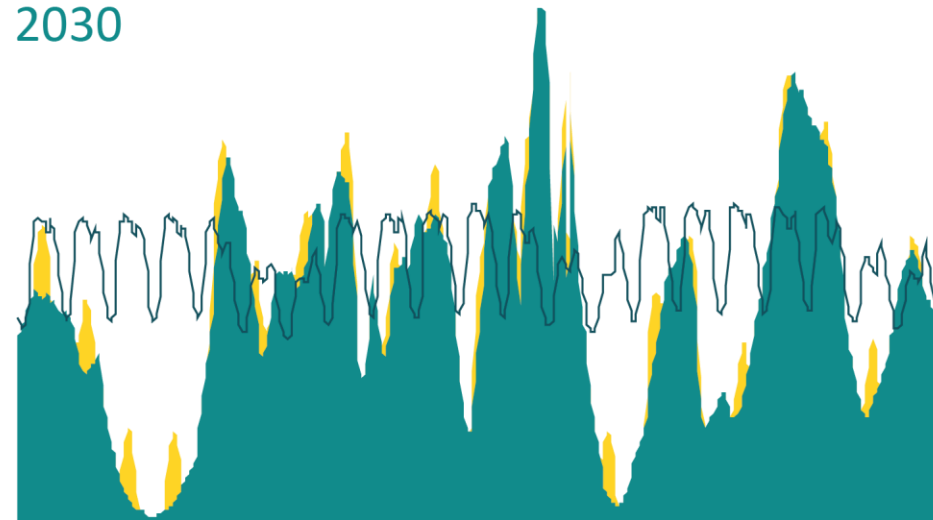


WEEK 1

WEEK 1

WEEK 1

2030



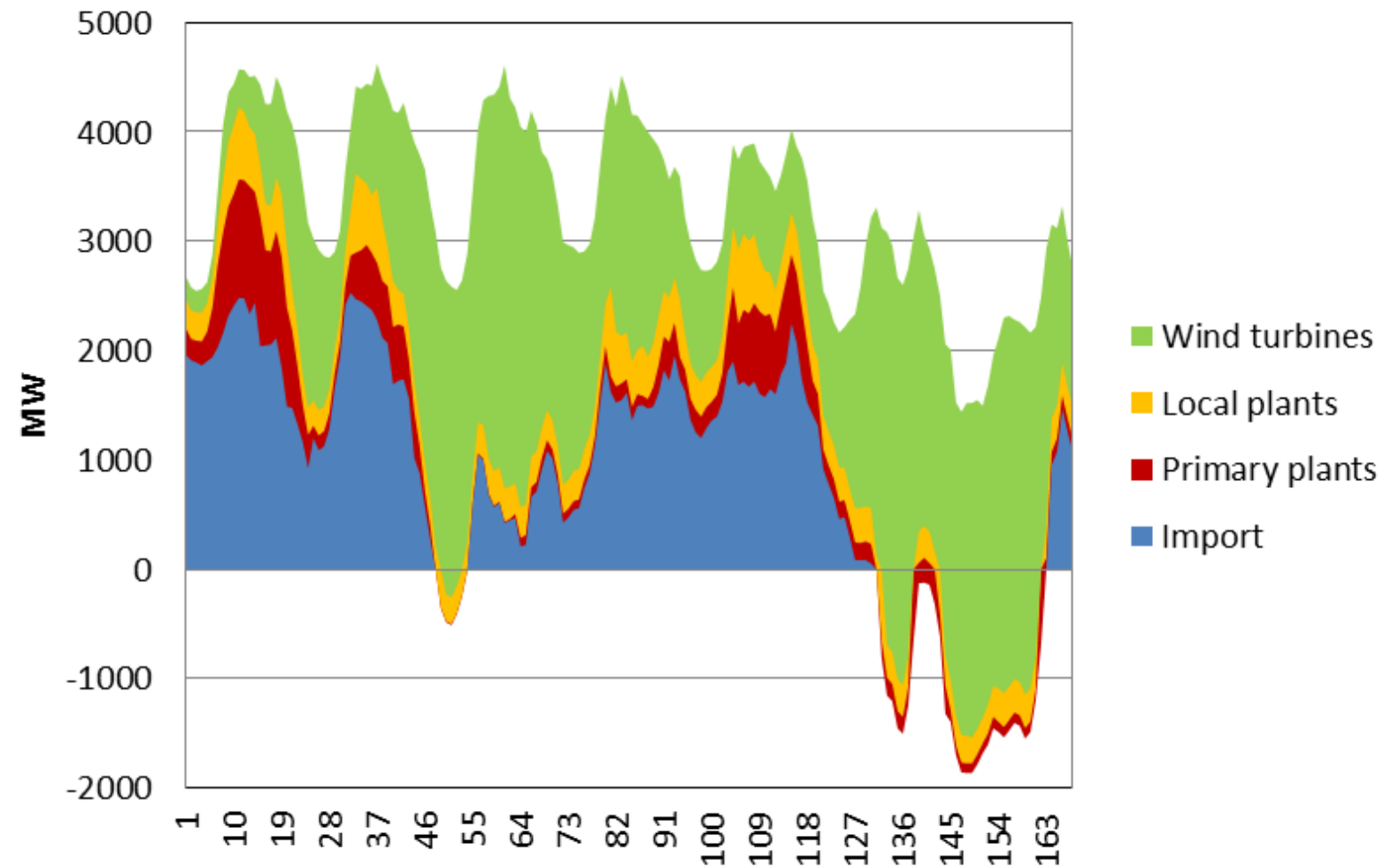
WEEK 1

WEEK 1

WEEK 1

— Power consumption ■ Wind power ■ Solar power (PV)

FLEXIBILITY IN THE ELECTRICITY SYSTEM



FORECAST

WIND POWER FORECAST

We use two forecasting tools – one external and one internal.

External forecast

- Online forecast (0-12 hours) every 15 minutes
- Day ahead forecast (0-48 hours) every hour

Internal forecast

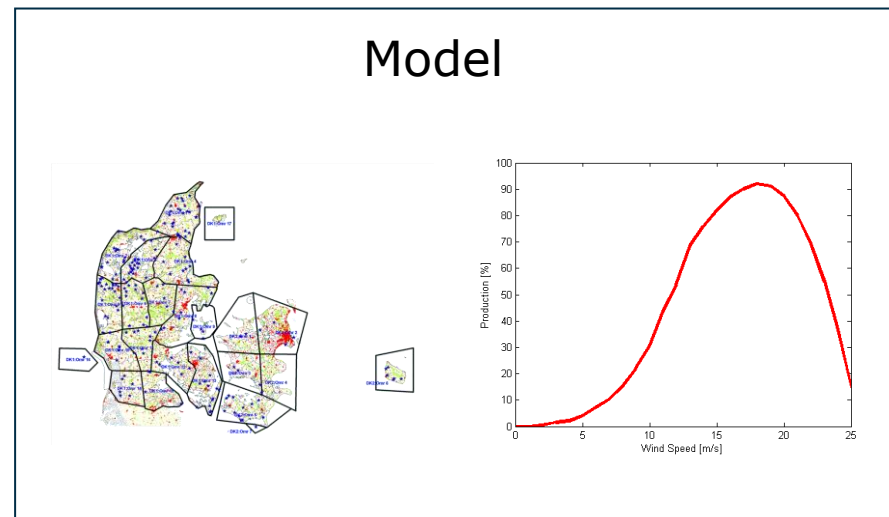
- Online forecast (0-10 hours) every 5 minutes
- Day ahead forecast (0-192 hours), triggered by new weather prognosis

Each forecast is based on weather prognoses from three providers



INTERNAL FORECAST

Wind speed
Production data
Installed capacity
UTM coordinates



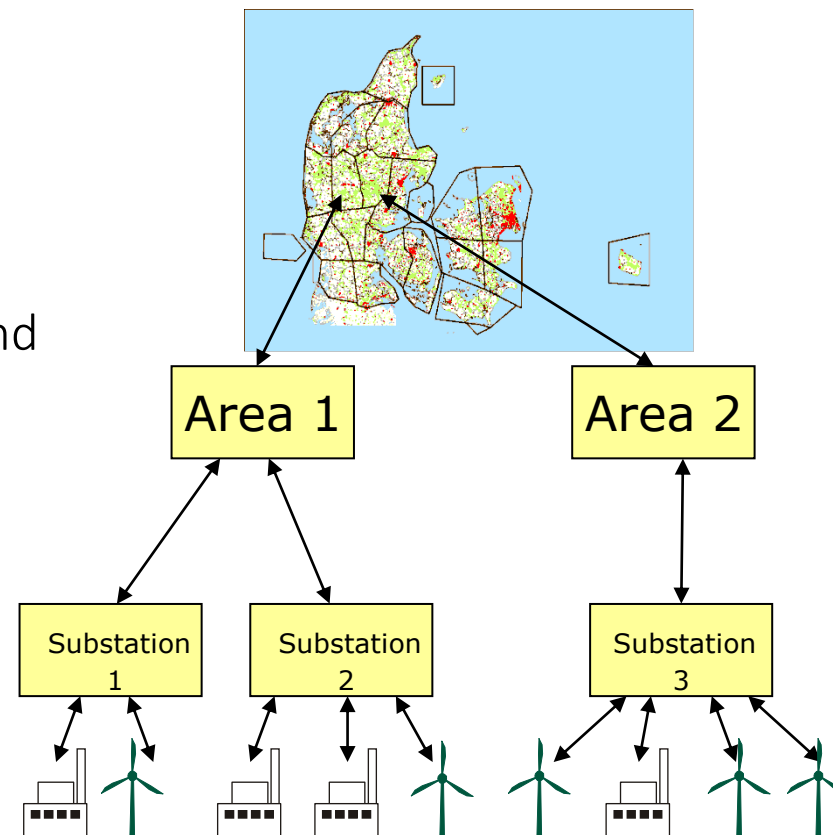
Wind power
forecast

DISTRIBUTED GENERATION MANAGEMENT SYSTEM

- 6300 generators on 4600 'plants'
- 18 Balance Responsible Parties for Production (PBR)
- 75 plants with individual schedules and 4525 plants without!

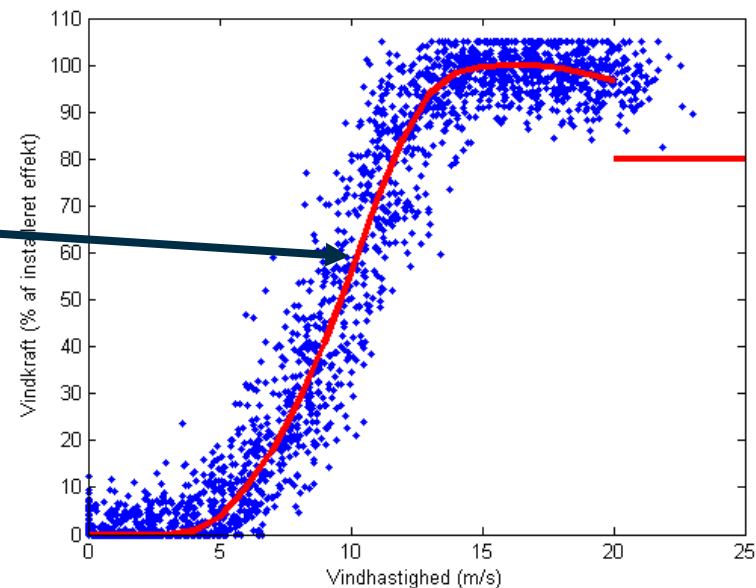
Data management for

- Generation forecast
- Load flow analysis



CHALLENGES

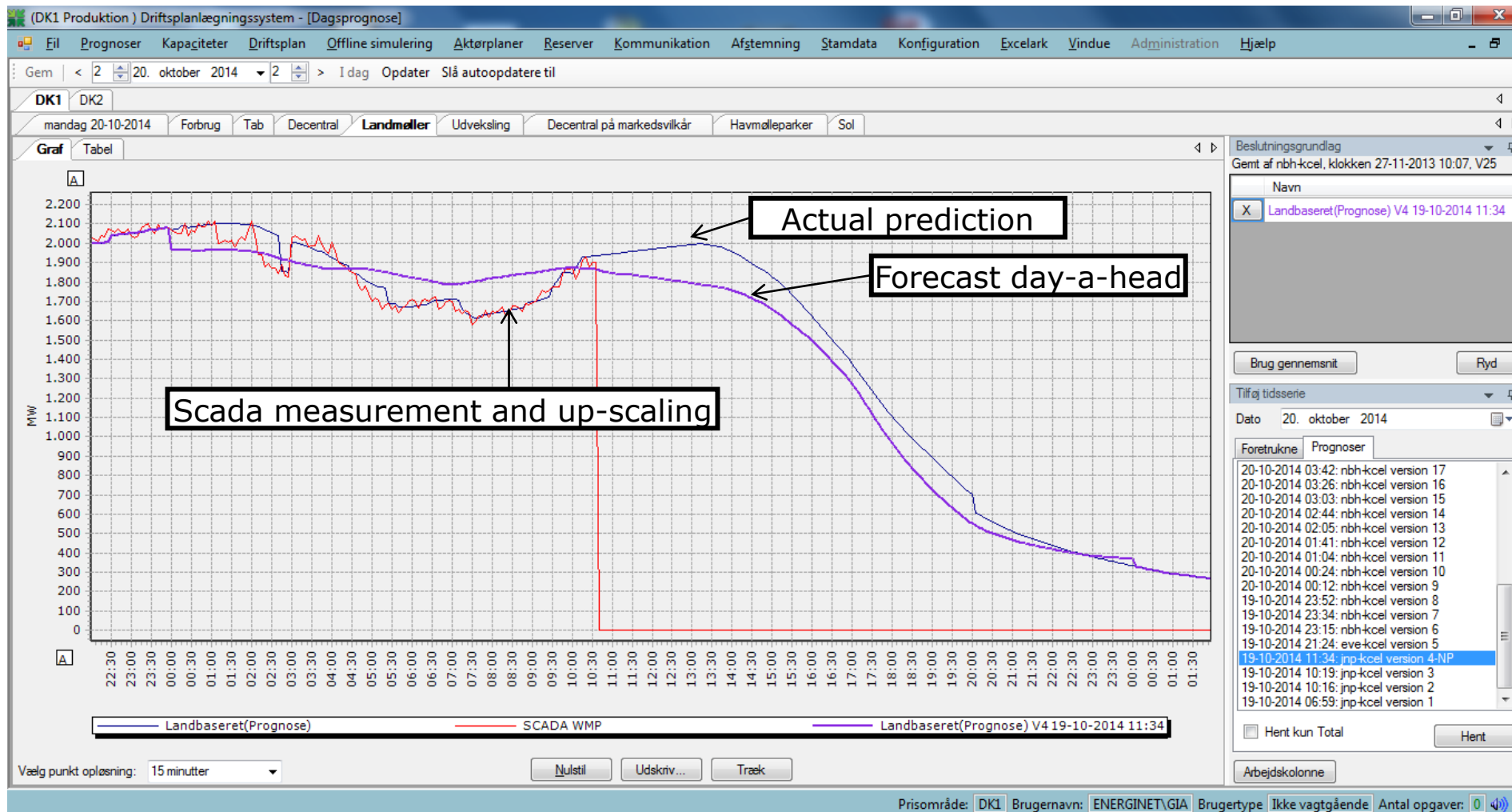
- Having 4,9GW wind power installed in the system, a change of **1 m/s** in wind speed can result in a change of **> 650 MW** generation



- The meteorological forecasts rarely agree on the same wind speed.

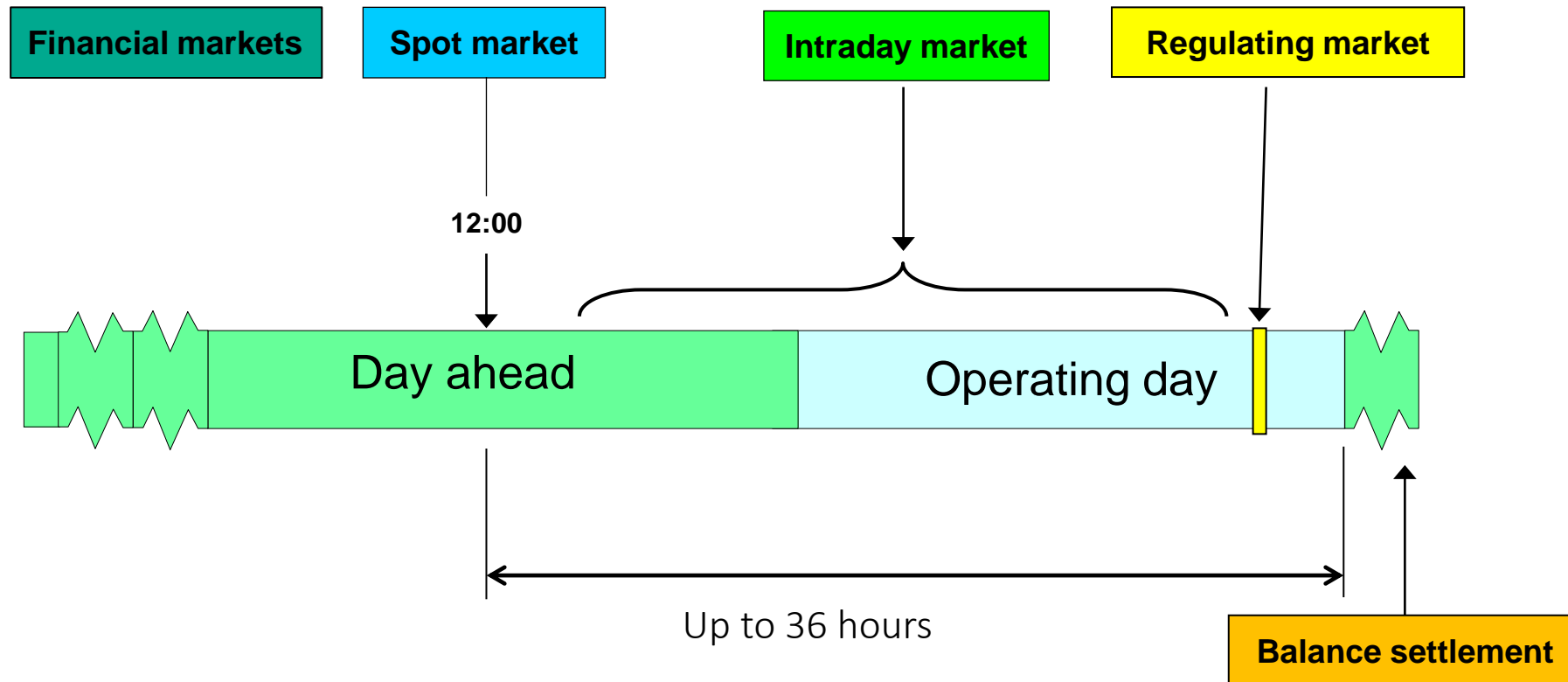
OPERATIONAL PLANNING TOOL

- CONTINUOUSLY UPDATED SCHEDULES AND FORECASTS

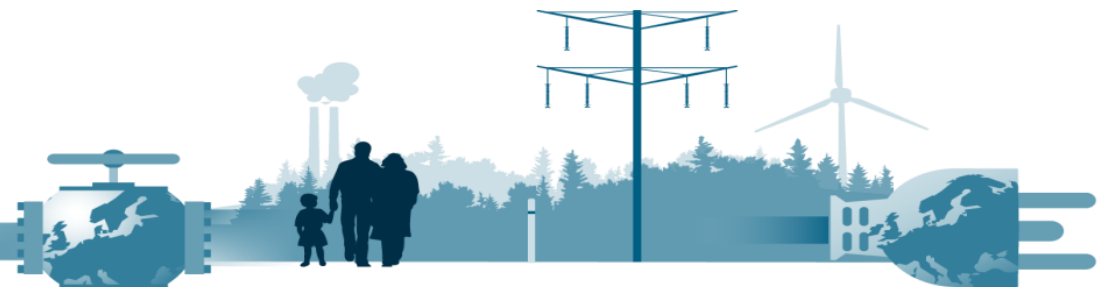


POWER MARKET

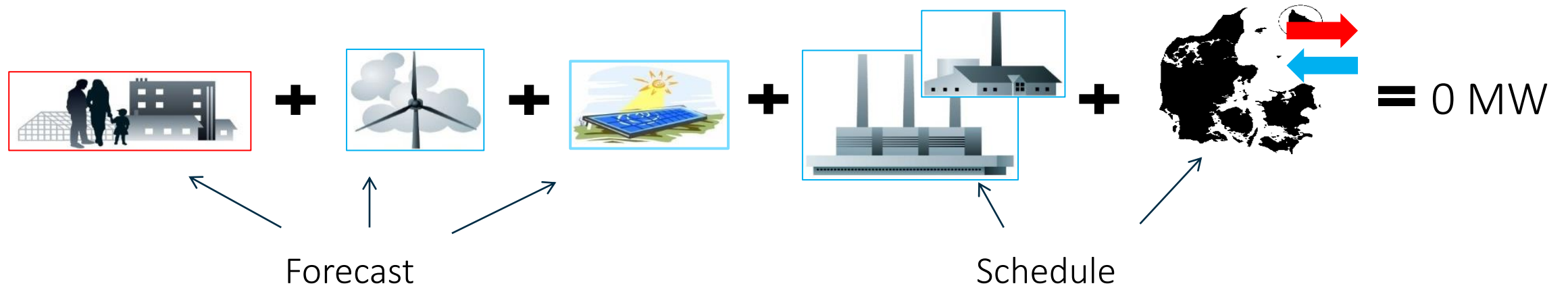
THE DAILY POWER MARKETS



BALANCING



BALANCE



Positive

Negative

BALANCING

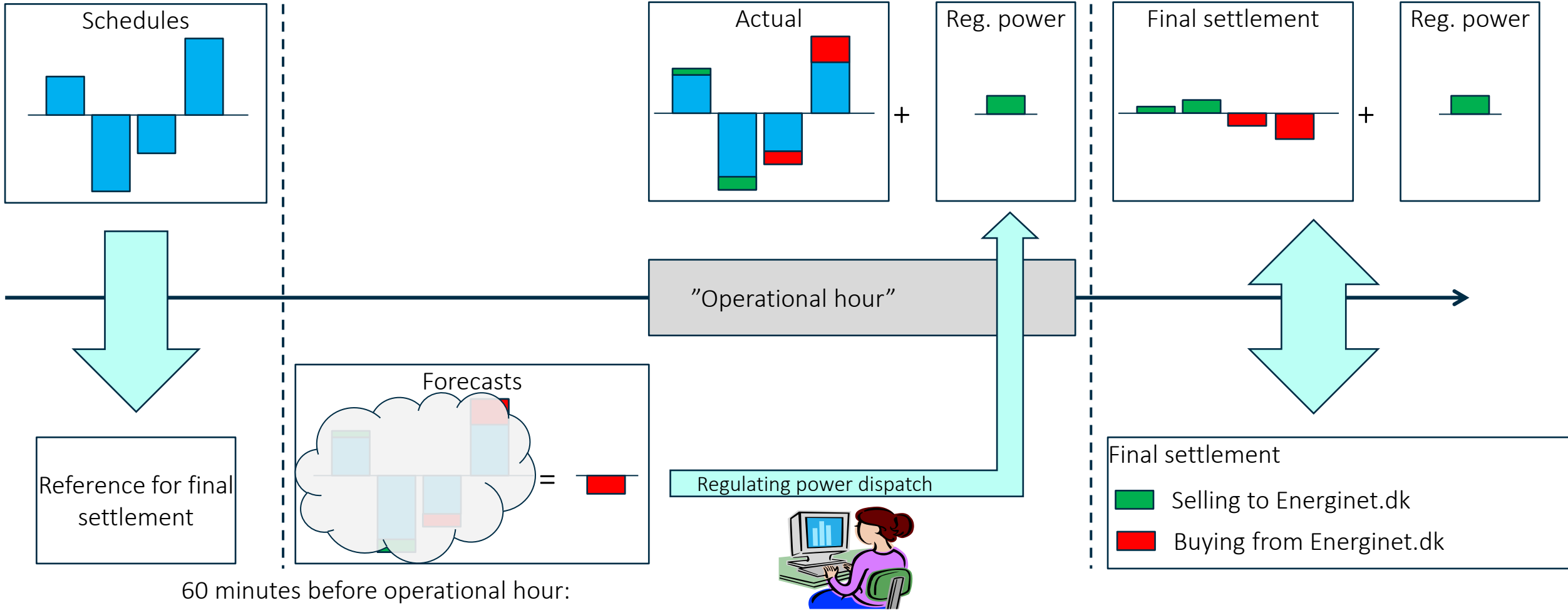
Balance = Demand + Wind Power + CHP + Conventional Power + Exchange,

- Demand is negative
- Production is positive
- Exchange is calculated with sign
 - import is positive
 - export is negative

Demand, On-shore Wind Power and a part of CHP is based on predictions. The rest: CHP, Off-shore wind power, Conventional power and exchange is scheduled by the market players. The schedules are updated if they deviate more than 10 MW.

The goal for balance is ~ 0

BALANCING MARKET OPERATION

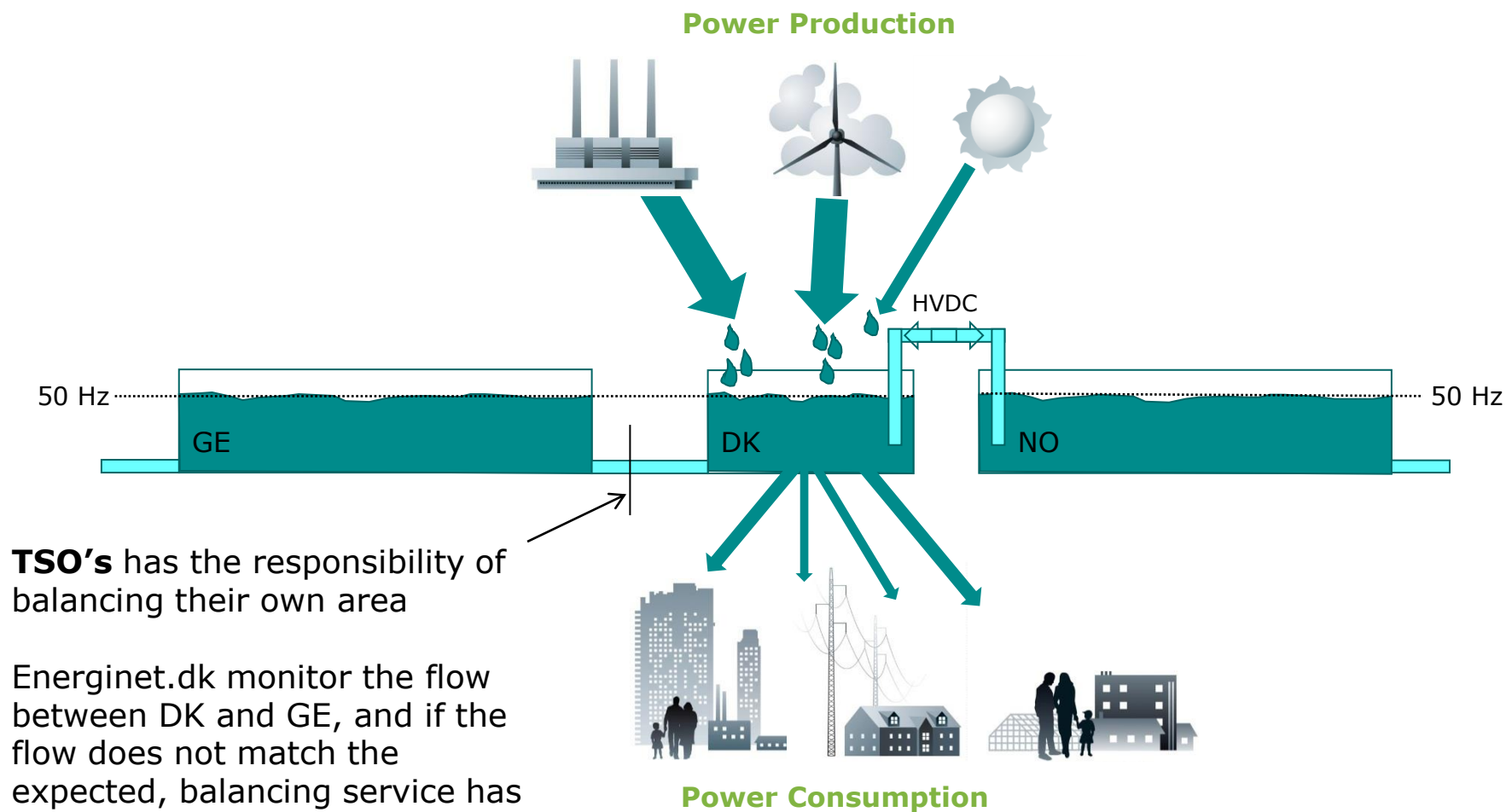


60 minutes before operational hour:
Market is closed, and Energinet.dk takes over
the balancing

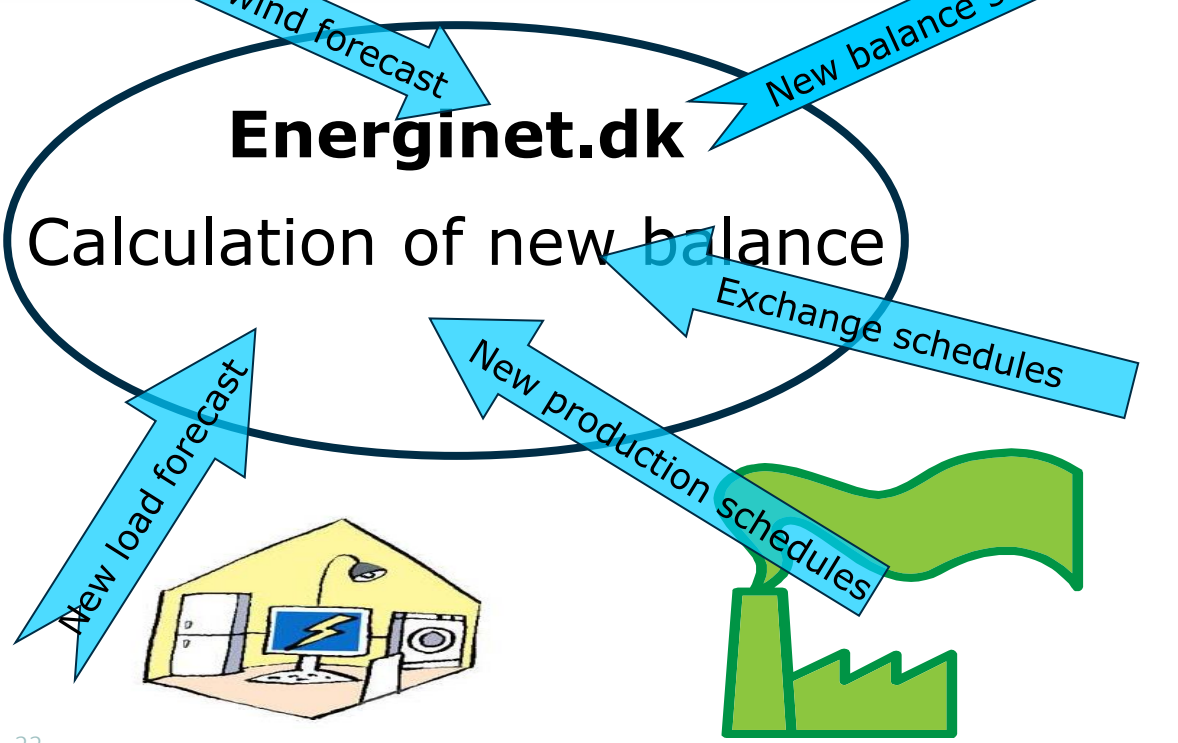
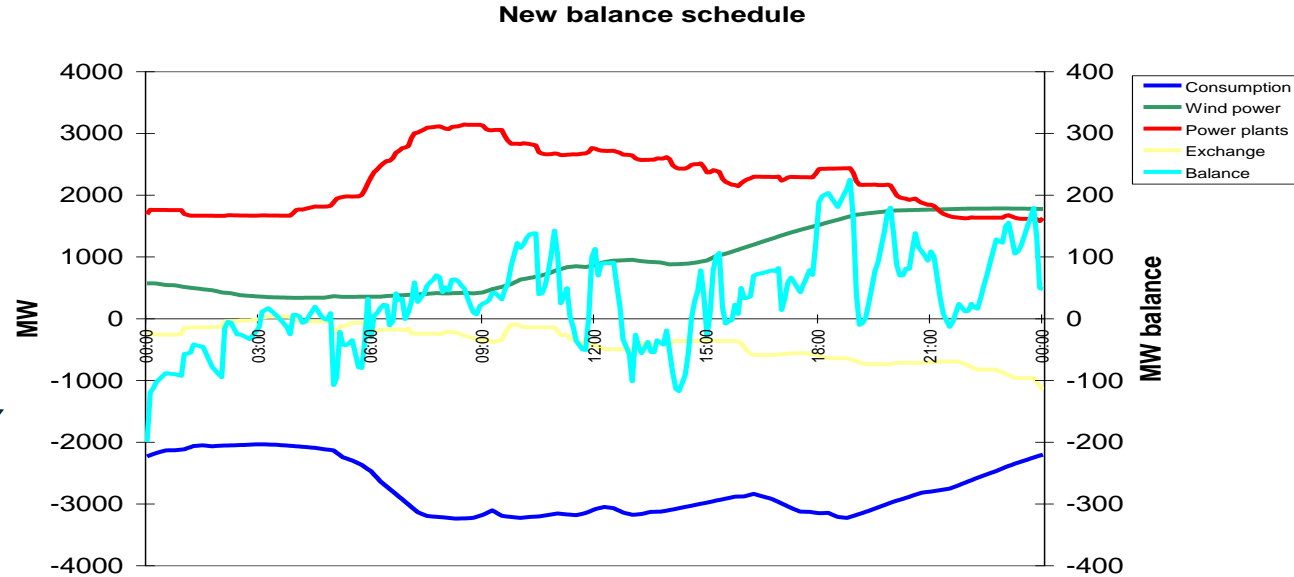
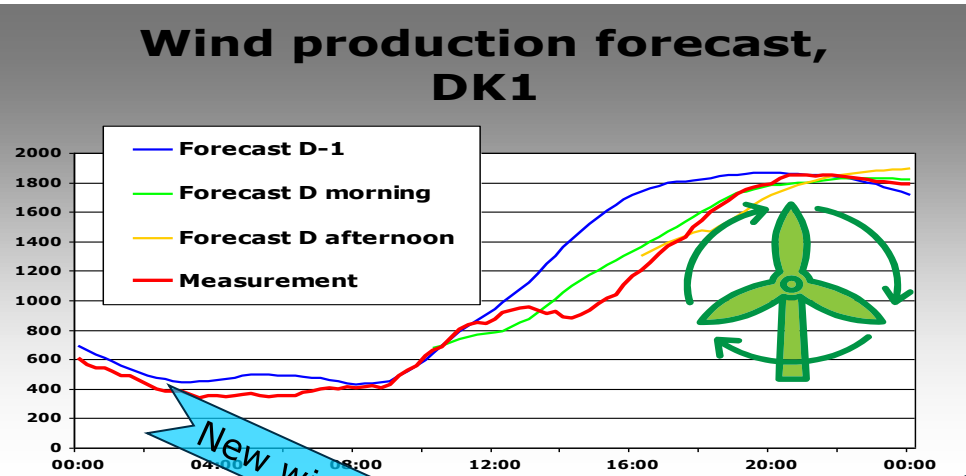
BALANCING THE SYSTEM

- DK east is balanced together with the Scandinavian system and is controlled by frequency.
 - It is balanced from Sweden or Norway altering on regular basis
- DK west is balanced by ENDK and is ACE controlled
 - We want to know the balance in advance to be able to control the system in the most effective way.
 - Gives us an opportunity to manage the system balancing proactively and cost-efficiently.
 - We can use slow and cheap regulation.
 - With an increasing amount of wind power we need all possible regulating reserves in the system.
 - Detailed knowledge of production, consumption and exchange provides the basis for good grid security calculations which allow us to operate the grid closer to the limit.
 - Wind is treated as all other production (schedules, regulating market, online measures etc.)
 - PV is predicted from metrological forecast, and “online measurement” unscaled from measures collected by the manufactures of PVs and forwarded to END

Balancing the electricity system DK1



OPERATIONAL PLANNING – BALANCE MANAGEMENT



- Around 80 new balance schedules a day
- Production responsible market players must update and submit new production schedules equal to expected operation of the power plants
- All schedules, exchange, power plant production schedules, consumption forecasts and wind forecasts are **5 min. resolute power schedules**
- The balance schedule is used to trade the imbalance in the common Nordic regulating power market (manual reserve).

BALANCE MANAGEMENT – THE PUZZLE

- **Forecast**
 - Wind power
 - Load
 - Local CHP (ENDK BR)



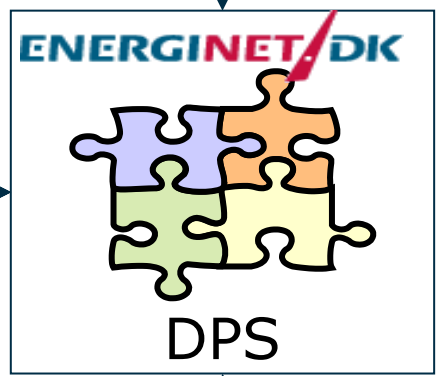
- **PBR production schedules**
 - Planned production
 - Technical min. and max.



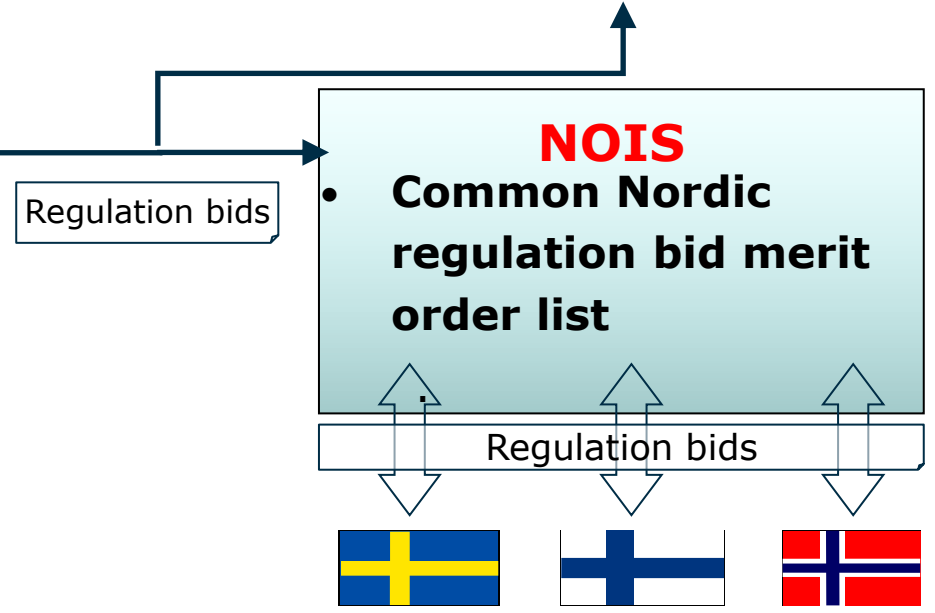
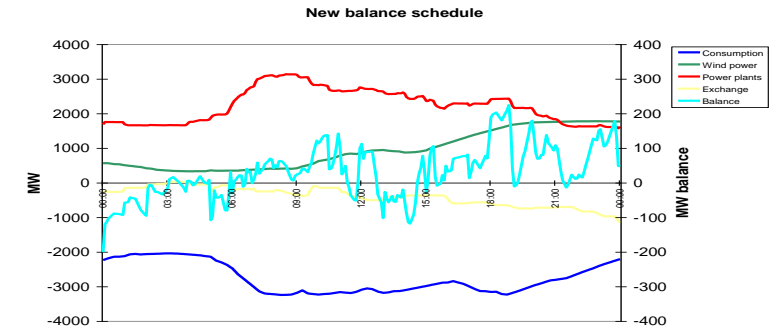
- **Interconnector schedules**
 - German
 - Sweden
 - Norway
 - DK1-DK2

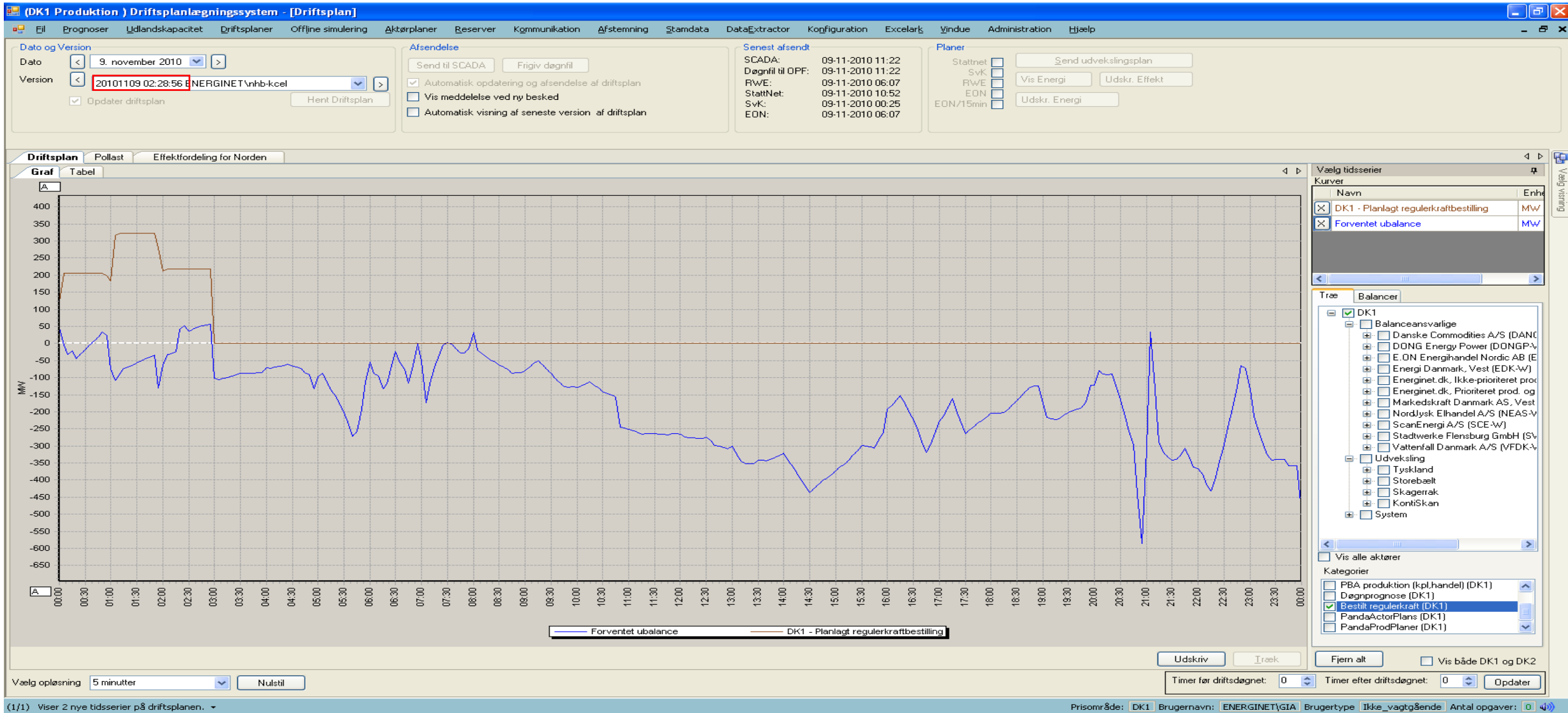


- **SCADA online measurements**
 - Production
 - Exchange
 - "Load"



- **BR regulation bids**
 - Price
 - Volume
 - Ramp etc.



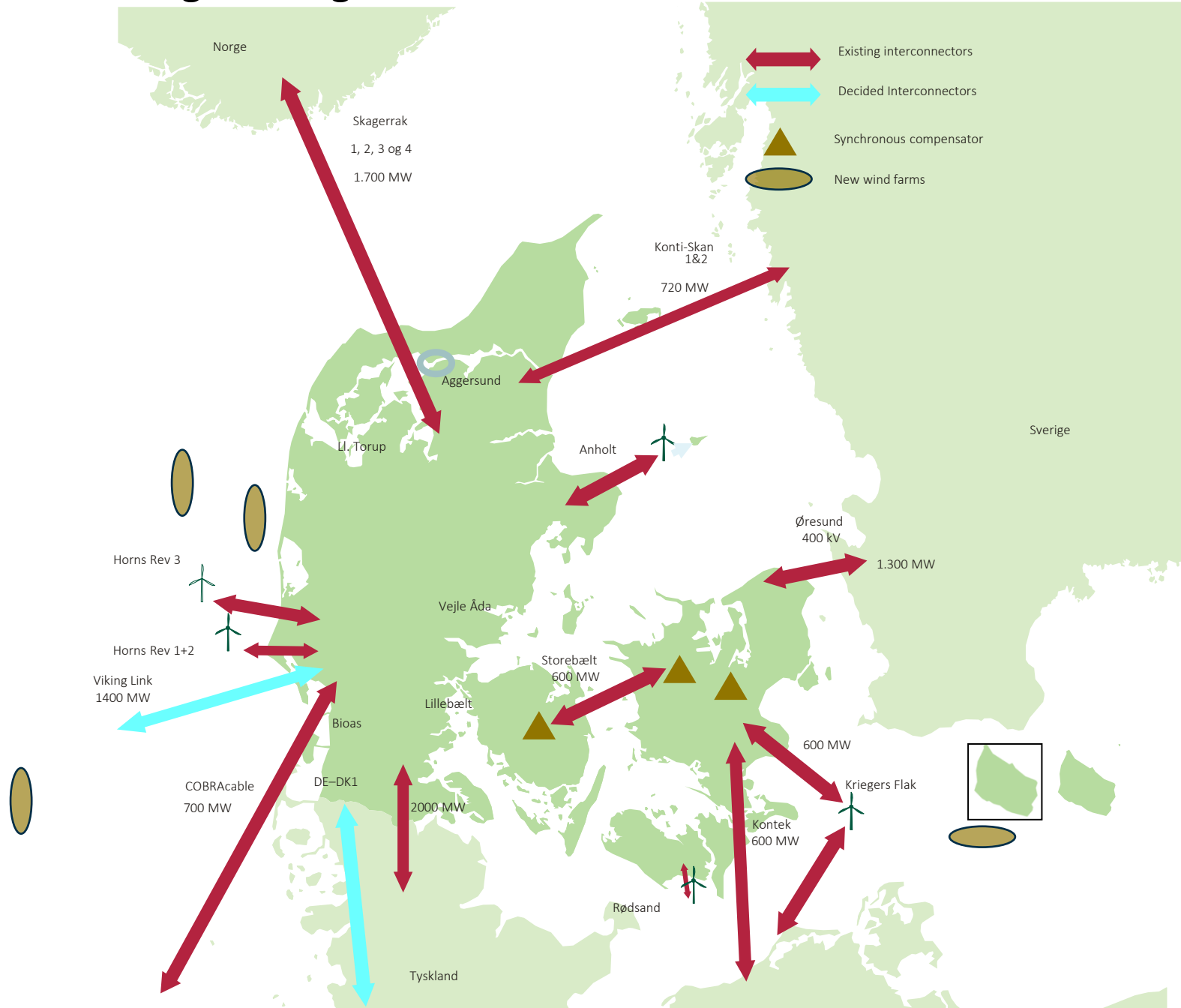


COMMON NORDIC BID LIST.

Grid: last refresh 11:01:49, day 14. juli 2011, hour 21-22

	Ti ck	Ear Mark	Price / EUR	Price / DKK	Amount / MW	ELSPOT area	Bid type	Activation time	Balance	Special	Bid unavailable	Power Plant	Duration time	Resting time	Us
	<input type="checkbox"/>	<input type="checkbox"/>	50,53	377	38	SE	CIAL	10			<input type="checkbox"/>	Klarälven	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,98	373	10	SE	CIAL	10			<input type="checkbox"/>	Byälven	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,90	372	16	SE	CIAL	10			<input type="checkbox"/>	Letsi	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,83	372	40	NO4	CIAL	15			<input type="checkbox"/>	Siso	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,55	369	73	SE	CIAL	10	++++		<input type="checkbox"/>	Trängslet BKB	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,19	367	75	NO2	CIAL	15	+++++		<input type="checkbox"/>	Rjukanverkene	120	240	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,01	365	77	SE	CIAL	10	+++++		<input type="checkbox"/>	Ljusnan Övre	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	49,00	365	20	FI	CIAL	15	+++++		<input type="checkbox"/>		60	10	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	48,90	365	40	SE	CIAL	3	+++++		<input type="checkbox"/>	Blåsjön	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	47,90	357	12	SE	CIAL	10	+++++		<input type="checkbox"/>	Letsi	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	47,81	356	60	SE	CIAL	3	+++++		<input type="checkbox"/>	Blåsjön	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	47,28	353	25	NO5	CIAL	15			<input type="checkbox"/>	BKK	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	47,28	353	58	NO2	CIAL	15	+++++		<input type="checkbox"/>	Brokke	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	46,00	343	10	NO5	CIAL	15			<input type="checkbox"/>	Svelgen	1440	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	45,64	340	10	SE	CIAL	5	+++++		<input type="checkbox"/>	Faxälven Nedre	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	44,72	333	30	NO5	CIAL	15			<input type="checkbox"/>	Naddvik	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	44,41	331	14	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
	<input type="checkbox"/>	<input type="checkbox"/>	44,40	331	10	SE	CIAL	10	+++++		<input type="checkbox"/>	Nedre ume älv	0	0	Hydr
	<input type="checkbox"/>	<input type="checkbox"/>	44,27	330	22	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
	<input type="checkbox"/>	<input type="checkbox"/>	44,14	329	14	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
	<input type="checkbox"/>	<input type="checkbox"/>	44,00	328	25	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
Up	<input type="checkbox"/>	<input type="checkbox"/>	43,87	327	14	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
Up	<input type="checkbox"/>	<input type="checkbox"/>	43,87	327	11	DK1	CIAL	15	+++++		<input type="checkbox"/>	DONGP-W	1	1	Ther
Down	<input type="checkbox"/>	<input checked="" type="checkbox"/>	43,40	324	-10	SE	CIAL	10			<input checked="" type="checkbox"/>	Nedre ume älv	0	0	Hydr
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	<input type="checkbox"/>	<input type="checkbox"/>	40,30	300	-20	DK1	CIAL	15			<input type="checkbox"/>	VFDK-W	1	1	Ther
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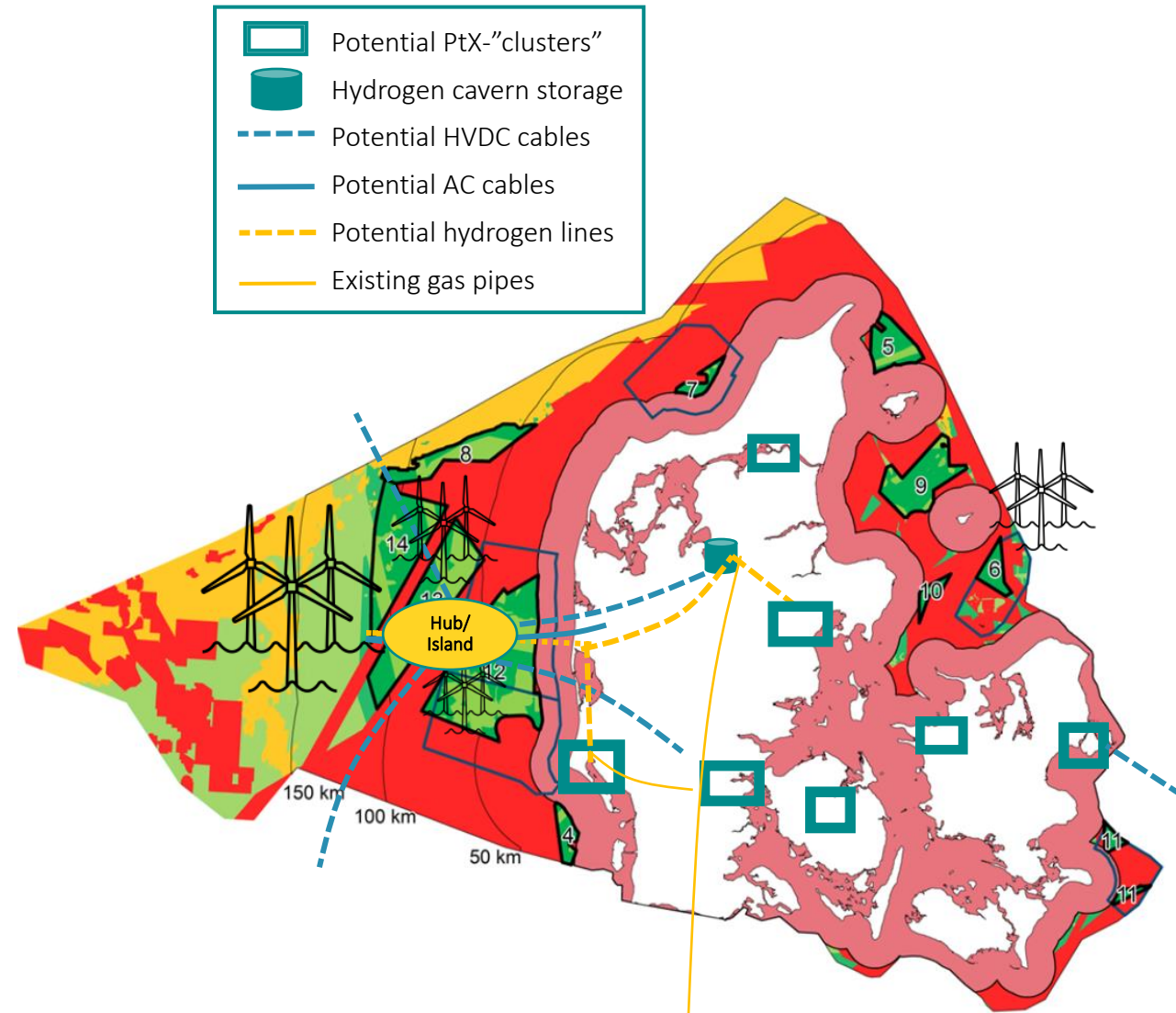
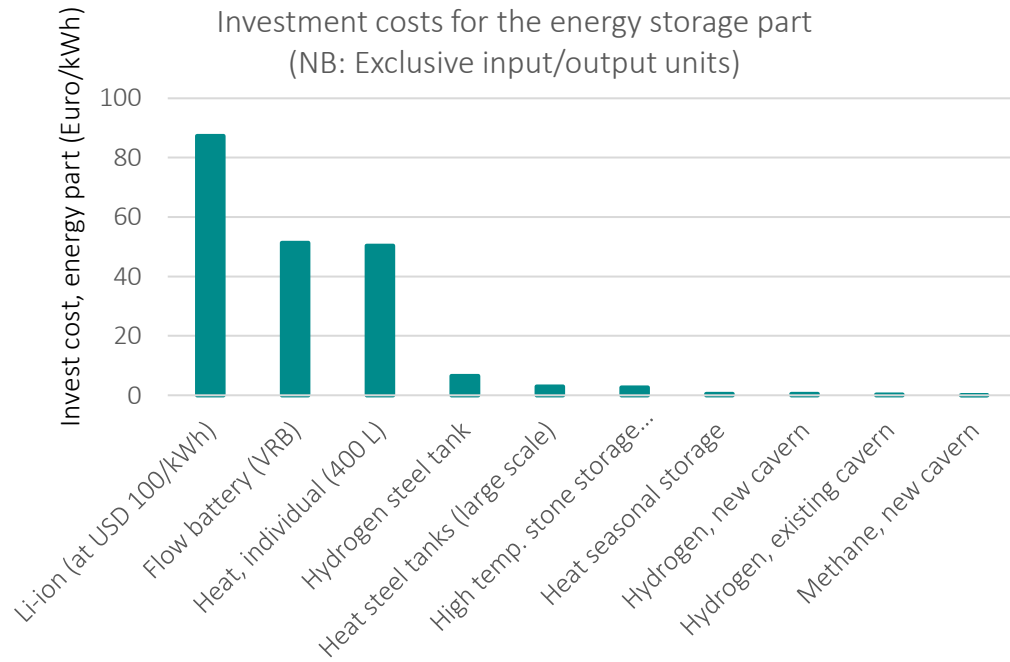
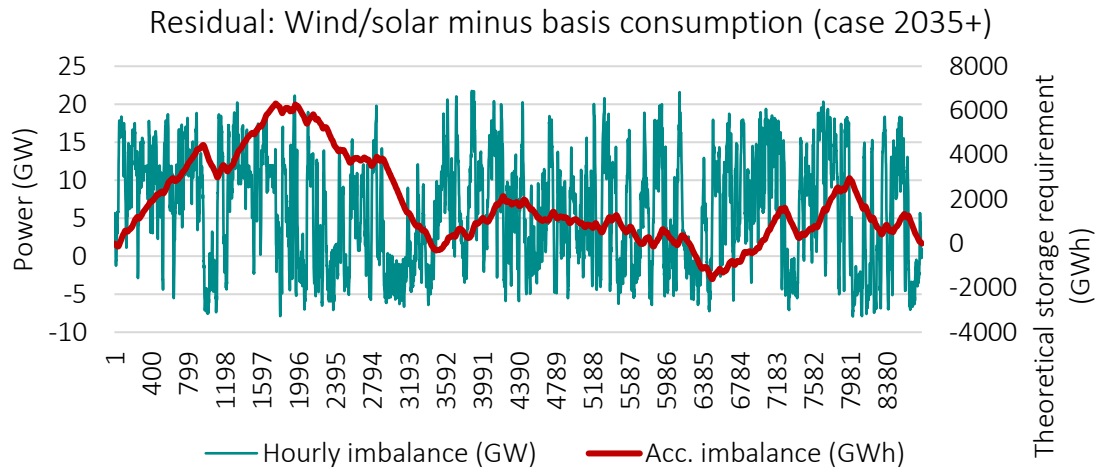
Transmission to neighboring countries and offshore wind farms



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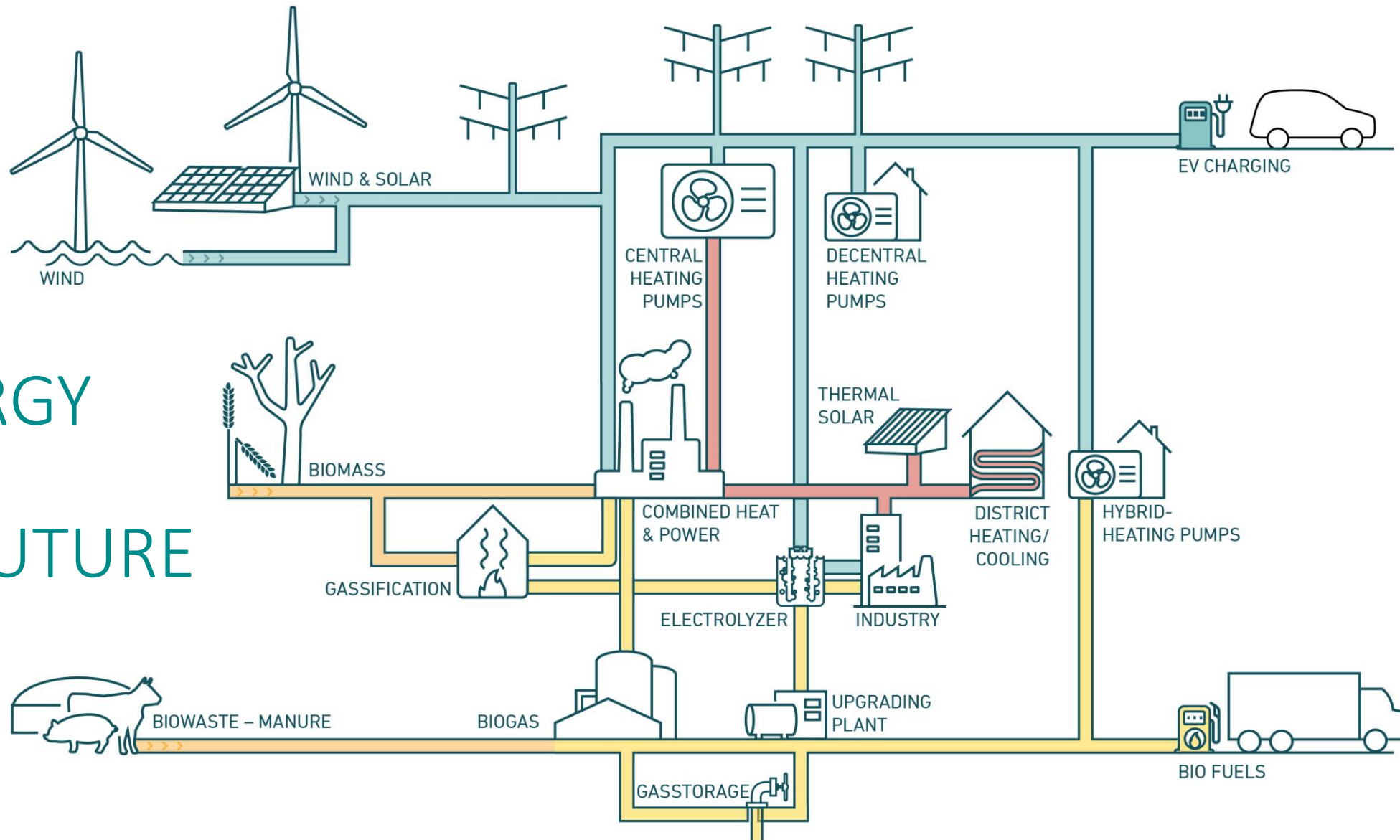
THE ENERGY SYSTEM OF THE FUTURE

BALANCING THE DANISH POWER SYSTEM



Further information at: <http://www.energinet.dk/Sys35>

THE ENERGY SYSTEM OF THE FUTURE



THANK YOU FOR YOUR ATTENTION

