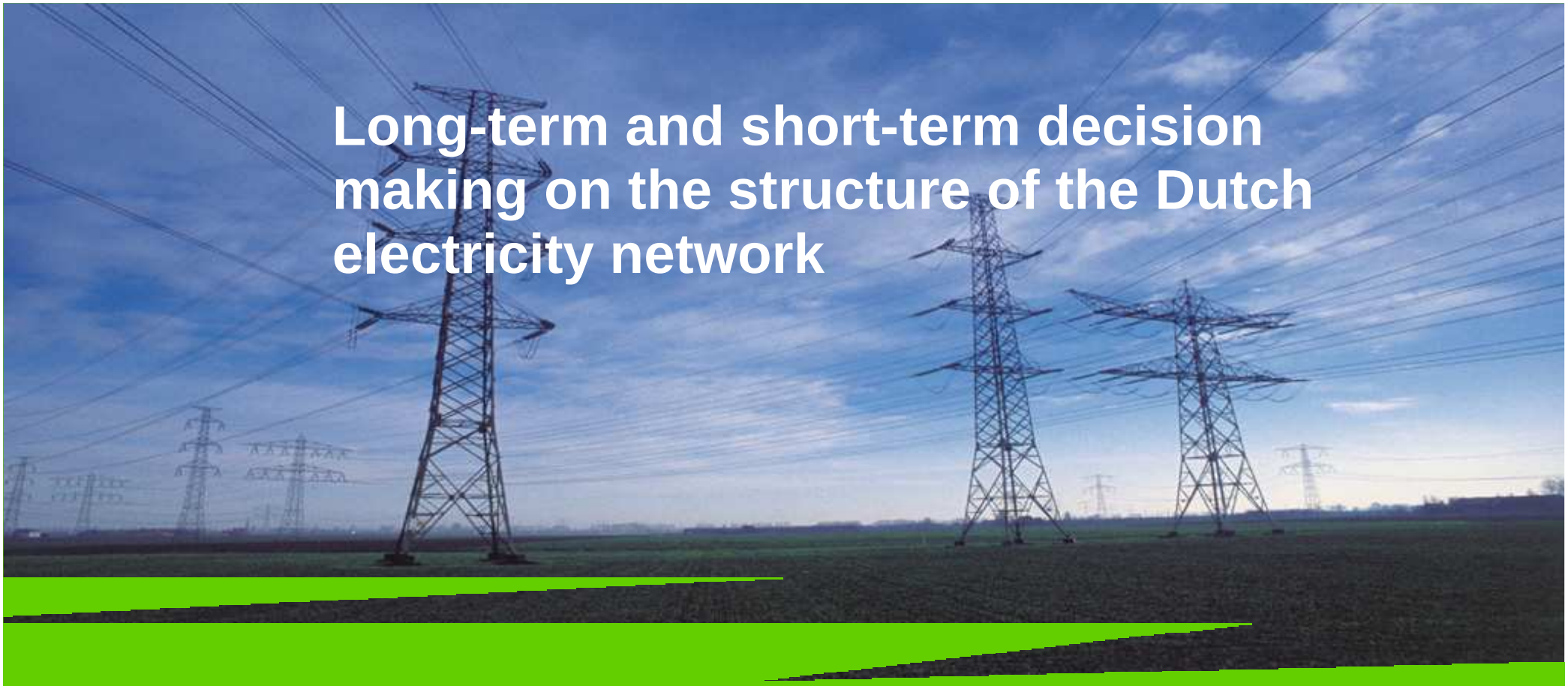


Long-term and short-term decision making on the structure of the Dutch electricity network

NGB/LNMB Seminar “Operations Research and Energy”

Wil Kling

Lunteren, 17 January 2008

TenneT

Organisation of the Electricity Supply System (1)

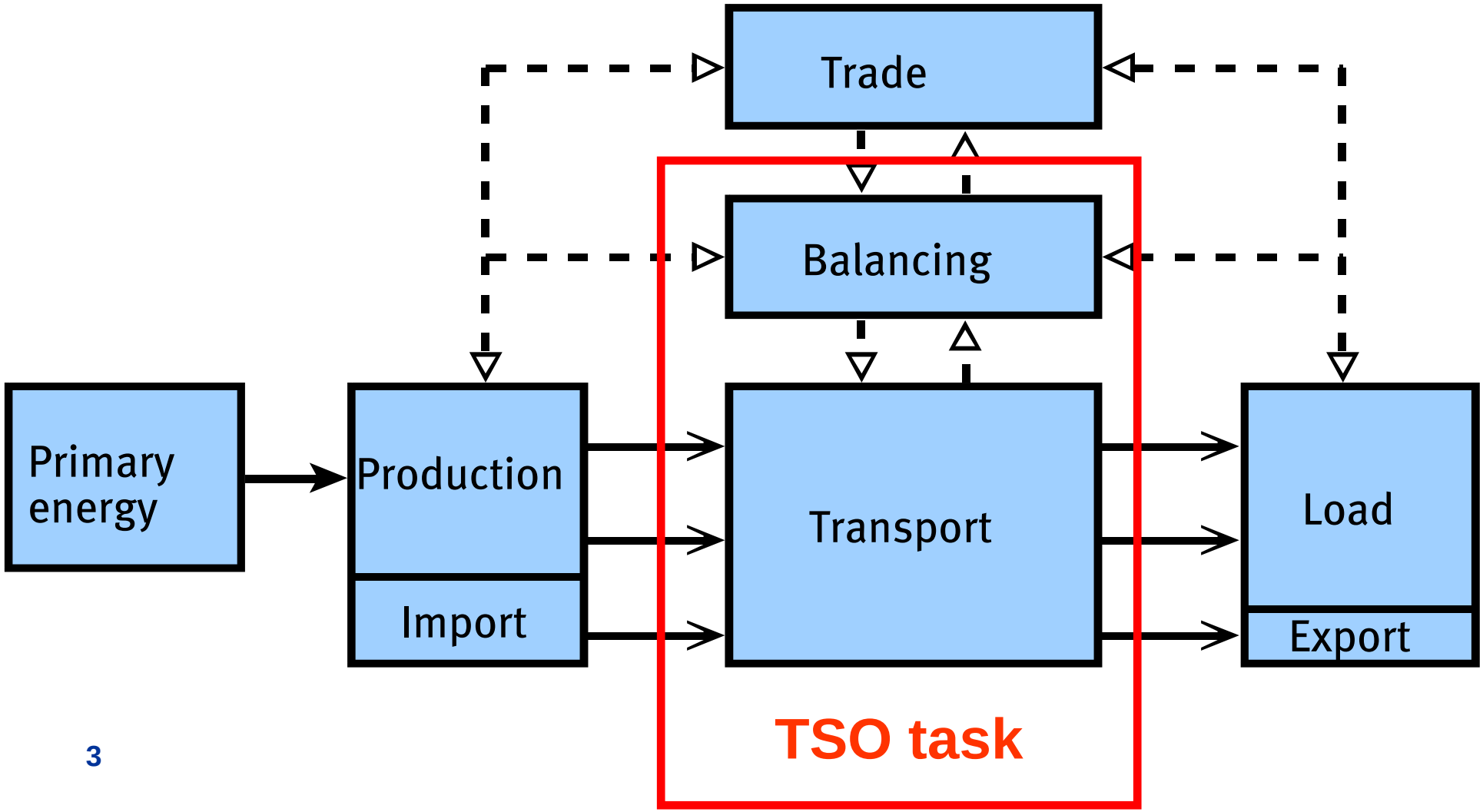
Base is:

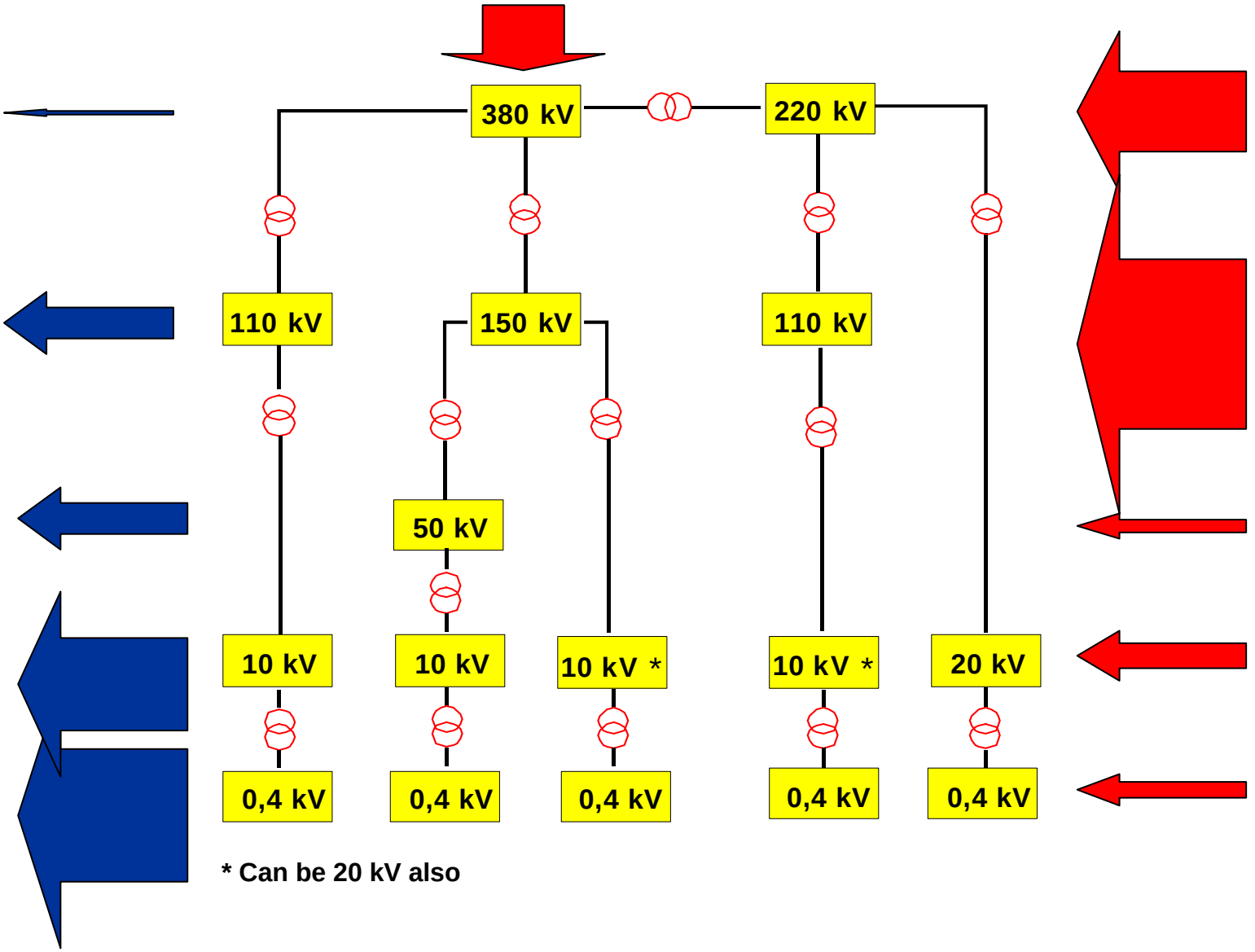
– Directive nr. 96/92 of the European Union
– The Dutch Electricity Law of 1998
– Changes in the Law in 1999, 2004 and 2006

The aim of the Law is:

– Free market of Generation, Trade and Supply of electricity
– Non-discriminatory use and independent management of the electricity networks

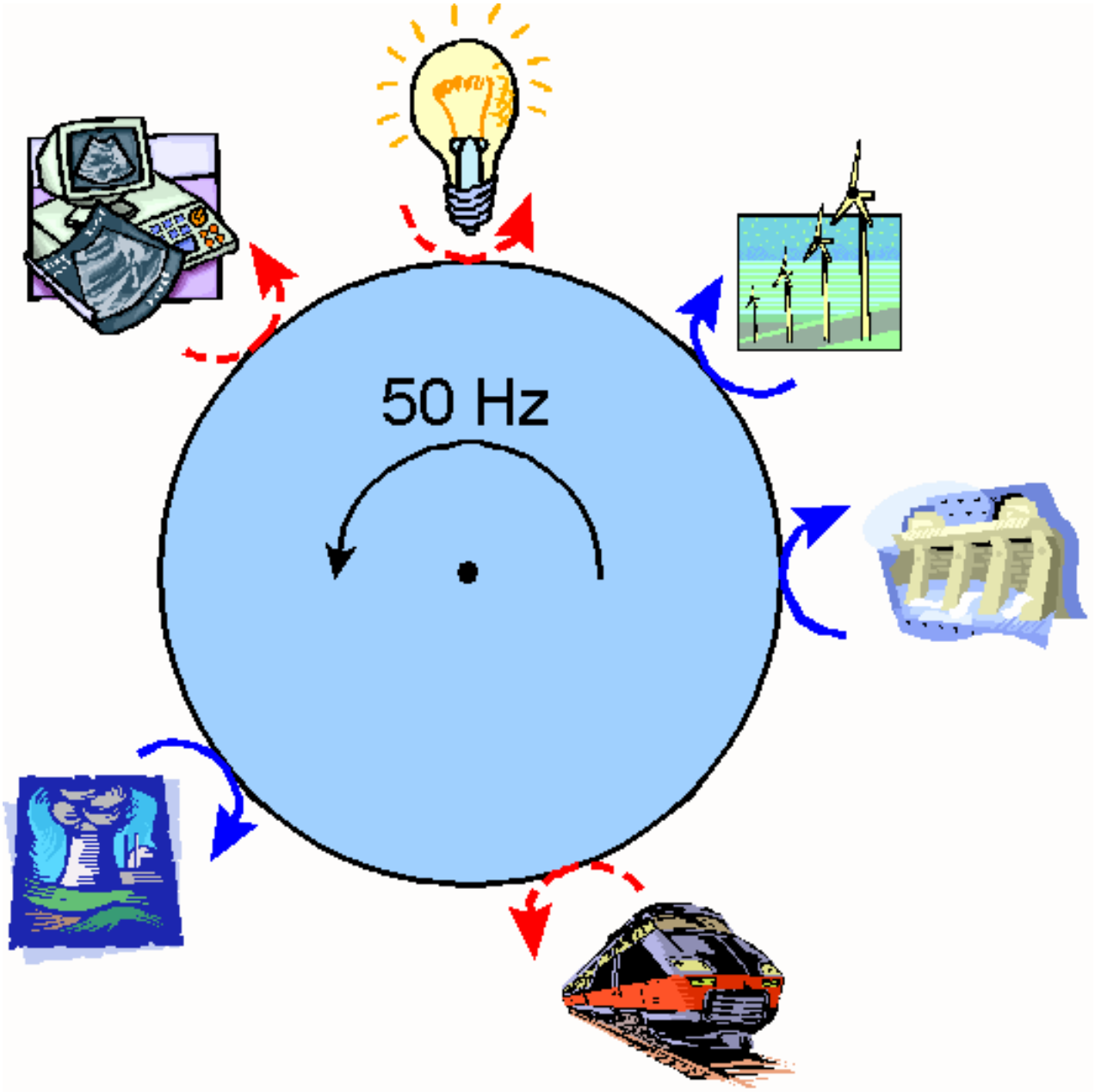
Organisation electricity supply system (2)





Voltage levels and transformation steps

(including Load en Generation)


50 Hz

Who and what is TenneT?

– Transmission System Operator (TSO) for the Netherlands
– Independent operator of the national Dutch transmission grid: 380kV and 220kV (150kV and 110kV as well from 2008)
– Owned by the State of the Netherlands
– Number of staff: 490
– 2006 turnover: 417 million euros

Strategy TenneT TSO

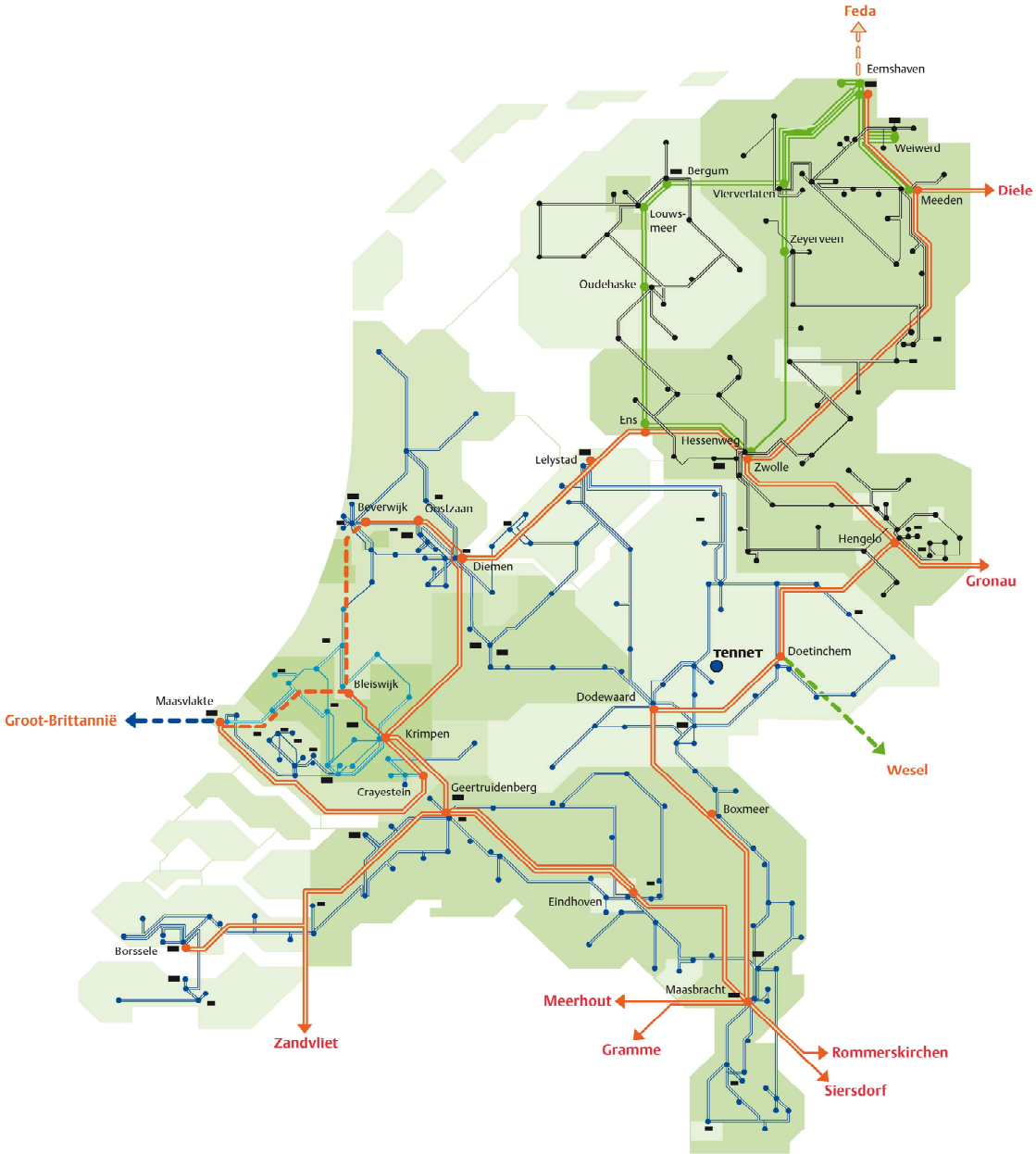
Developments: What is the environment

– Formation of regional markets
– High demand for interconnection capacity
– Supply reliability is important issue

Strategy: Reinforcement and expansion

– Play an active role in North-western Europe
– Expansion of market facilitator role
– New interconnections
– Strengthening internal grid
– ‘Value creation’ for shareholders: efficiency

EHV and HV network as per 01-01-2007



Physical energy flows

2006

Dutch Power System Overview
Production and Load

- Thermal generation system
- ~21 GW installed
- Large share of CHP
- No storage possibilities
- Annual consumption 115 TWh
- Annual Peak ~15 GW
- Heavy imports in recent years

	GW	%
Gas	10.3	49
Coal	4.1	19
Cokes Gas	1.0	5
Nuclear	0.4	2
DG	5.3	25
	21.1	100

Import in relation to consumption in the Netherlands

year	Consumption GWh	Import GWh	% Import
1980	55785	-15	0
1989	65010	4950	7,6
1995	89136	11393	12,8
1998	99292	11815	11,9
2000	104687	18915	18,1
2006	124300	21459	17,2

Design of the system

- Amount of installed generation capacity in relation to the demand for electricity (the load)
- The transmission way from power plants to the customers

The measure for redundancy (reserves) in the generation is not described in the Netherlands but is part of market economy → monitored by TenneT.

For the redundancy in the networks there are criteria set in the grid code (netcode) → set by the regulator.

Planning process

Planning is a decision process with the aim to get the most efficient system which fulfils the requirements of reliability (adequate and secure).

Measures to improve adequacy are taken in the planning phase, while measures for improving security are taken both in planning as in operations.

Evaluation reliability of the system (1)

- On the basis of a deterministic approach
- With a probabilistic method

Going from a deterministic to a probabilistic approach means going from a small set of critical situations to the analysis of a large set of system states (in principal all).

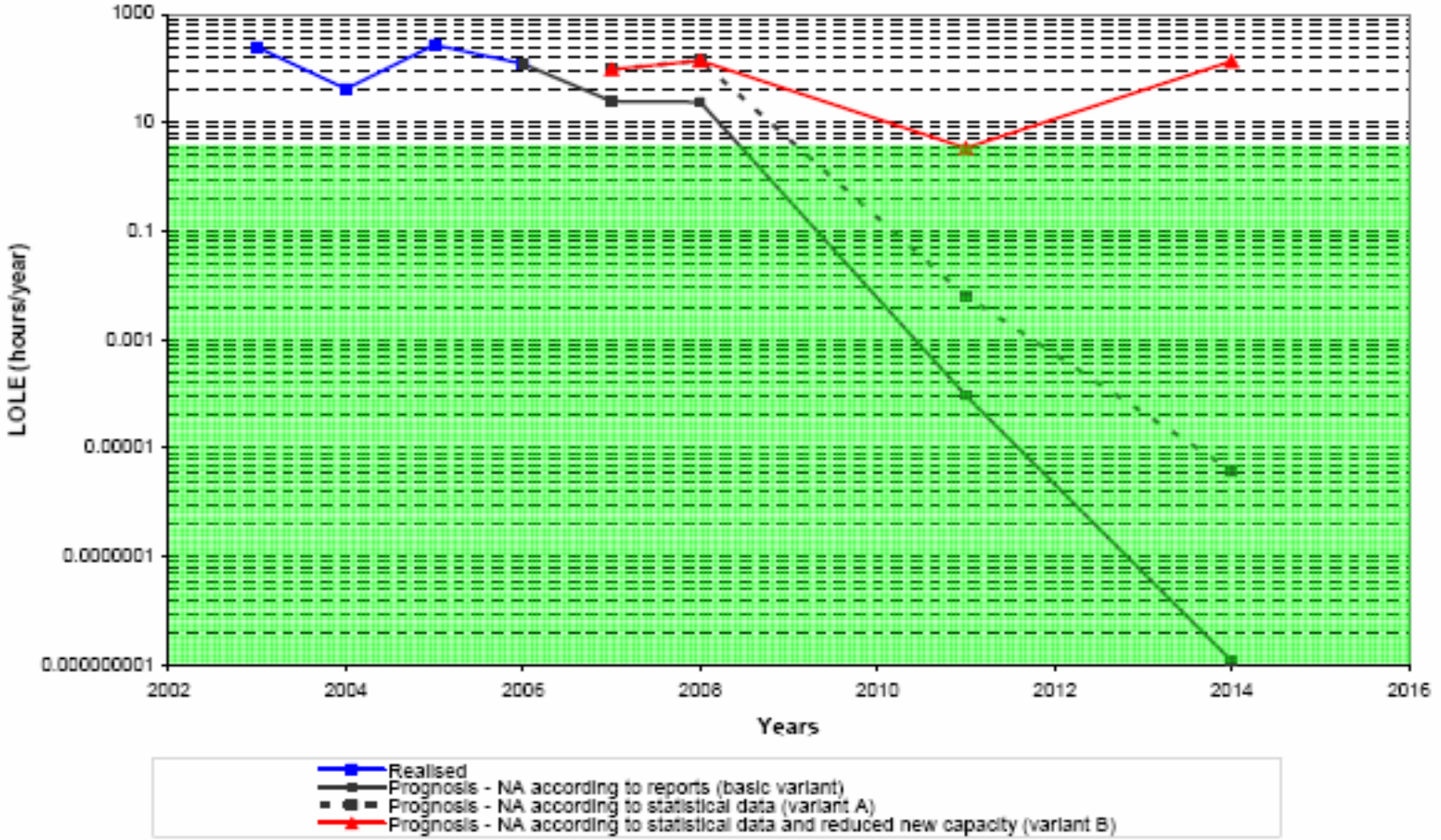
Evaluation reliability of the system (2)

A probabilistic approach is normally used when evaluating reliability of the generation supply system.

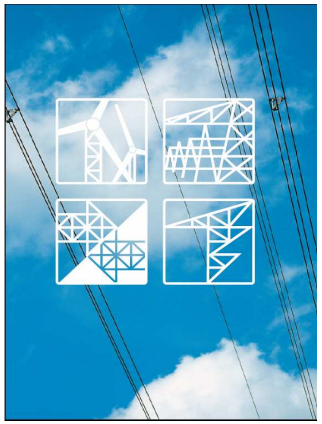
An N-1 or N-2 deterministic approach is mostly used evaluating network adequacy and security.

A risk evaluation might be used to support the decision process leading to overall asset management.

Results monitoring LOLE 2006-2014



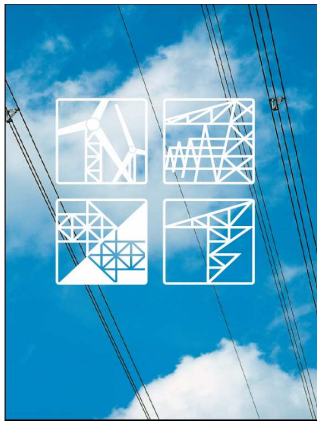
Capacity plan

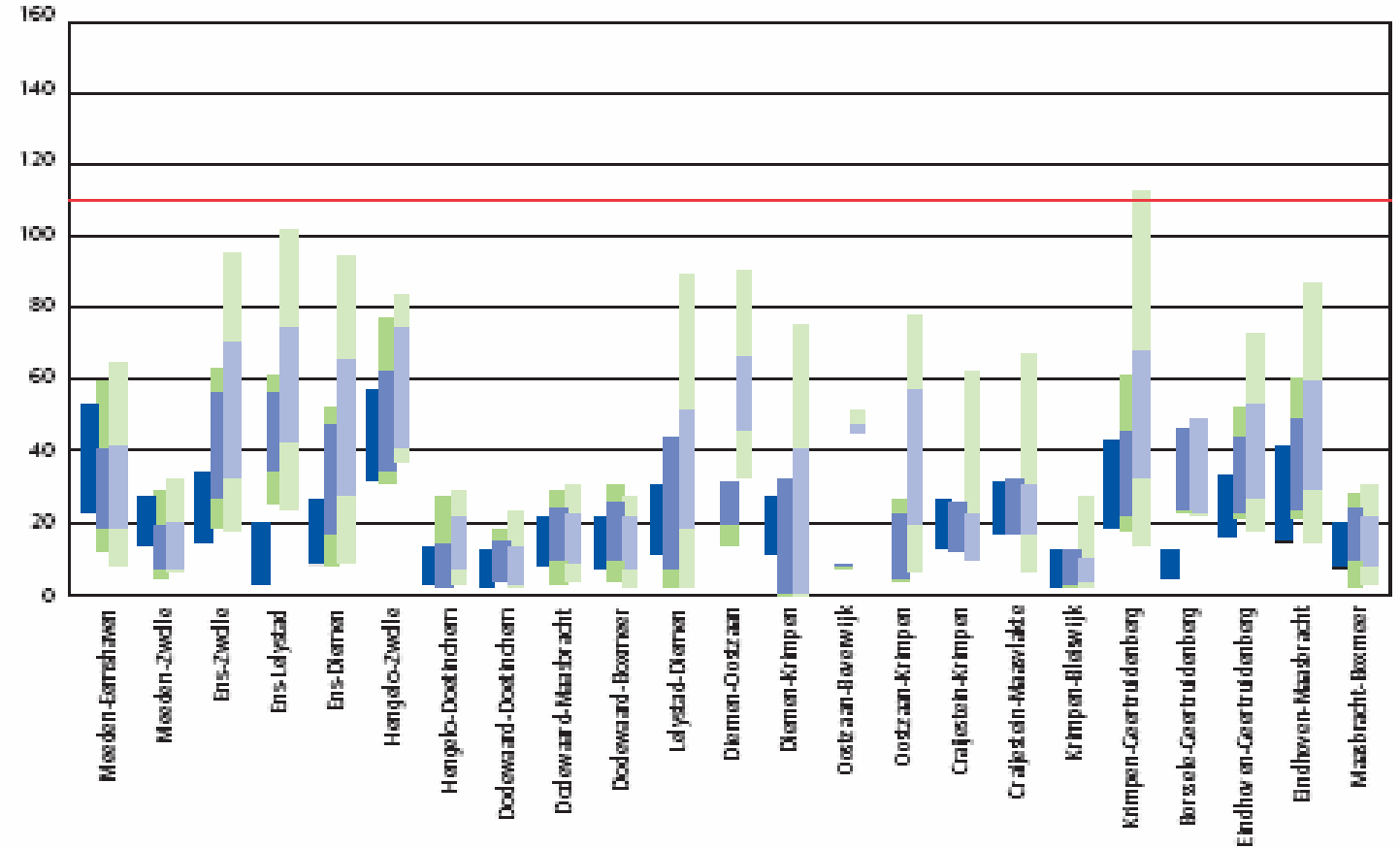


– Each network company is obliged to produce a capacity plan every two years
– The regulator receives this plan and makes a judgement on it, according to the rules set for it
– The plan gives the provision of the market parties for transmission capacity and shows how the network companies are going to handle the resulting transports

Results Capacity plan 2006-2012

Loading of 380 kV circuits as percentage of nominal transmission capacity





Power System Operations (1)

– Operational planning
  - evaluating transmission prognosis and energy programs

– Actual operations
  - take actions based on on-line information and computer analysis

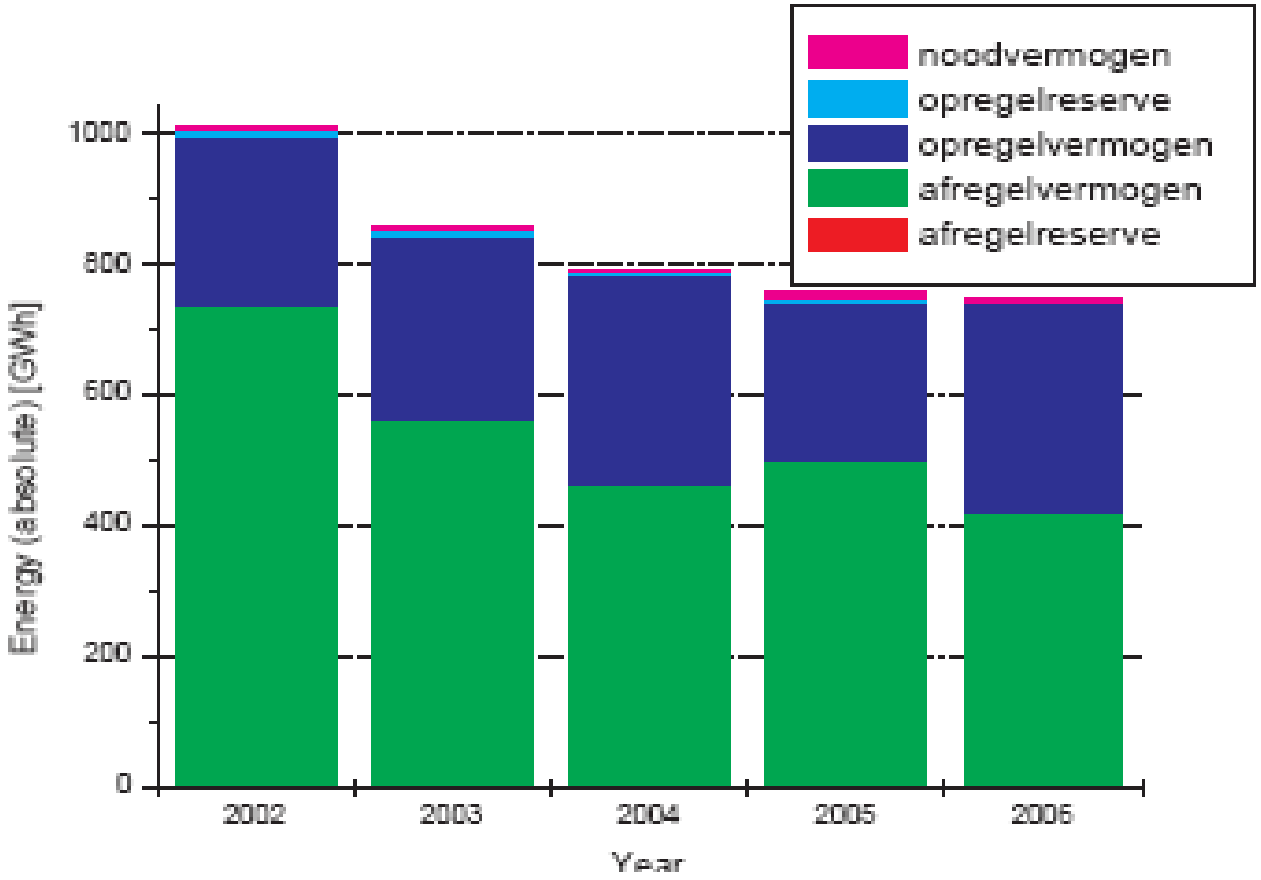
Power System Operations (2)

- Network operators analyse whether transmission constraints might be expected. They use operating criteria for this, for instance (N-1)
- In case of constraints the network operator takes measures, for instance redispatch of generation
- In case of emergency load can be shed

Program Responsibility

- Actual purchase / production (by definition) differs from program: imbalance
- Imbalance becomes energy transaction with the SO (TenneT); TenneT organizes an imbalance market
- Each individual customer is program responsible for its connection to the grid, but this can be outsourced to so called Program Responsible Parties
- Program Responsible involves drafting and submitting programs and bearing the financial consequences of any discrepancy from the program (imbalance)

Deployment of control power in the years 2002-2006



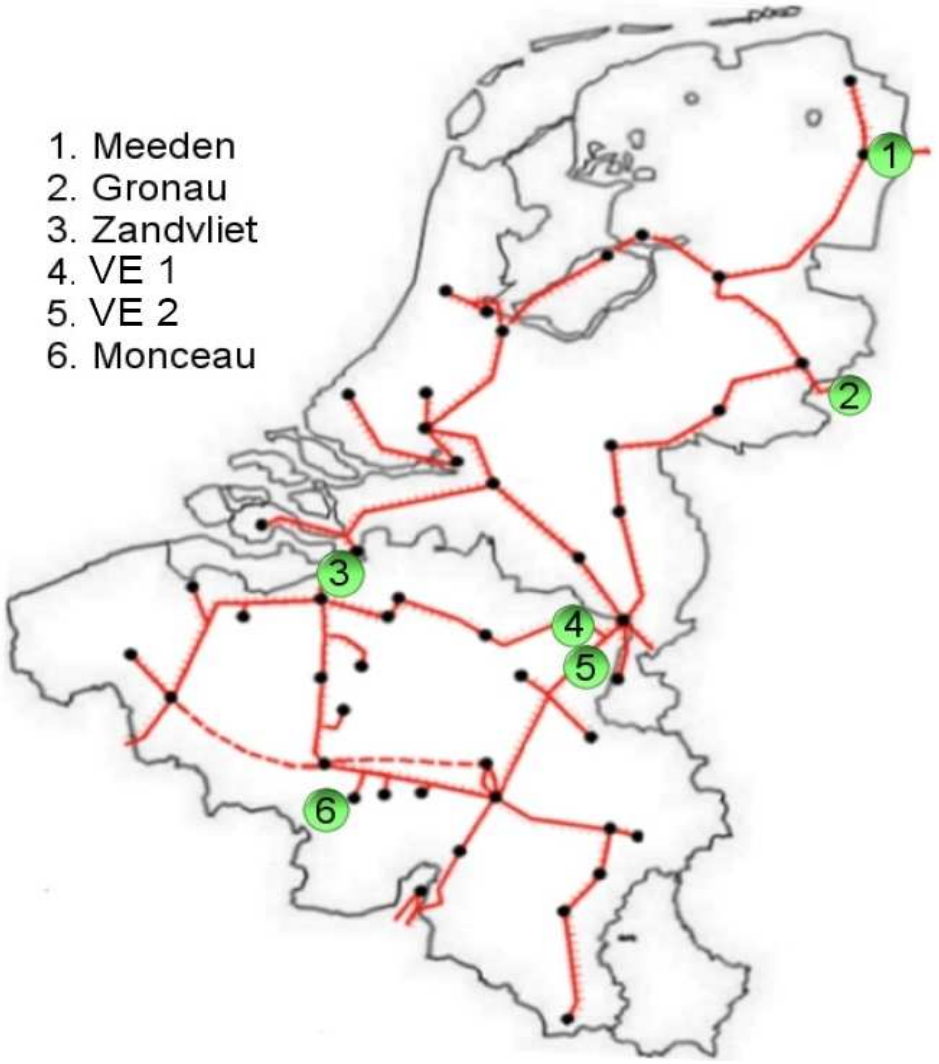
Some projects

- Phase-shifters at the international borders
- Network reinforcement in the Randstad
- NorNed interconnector

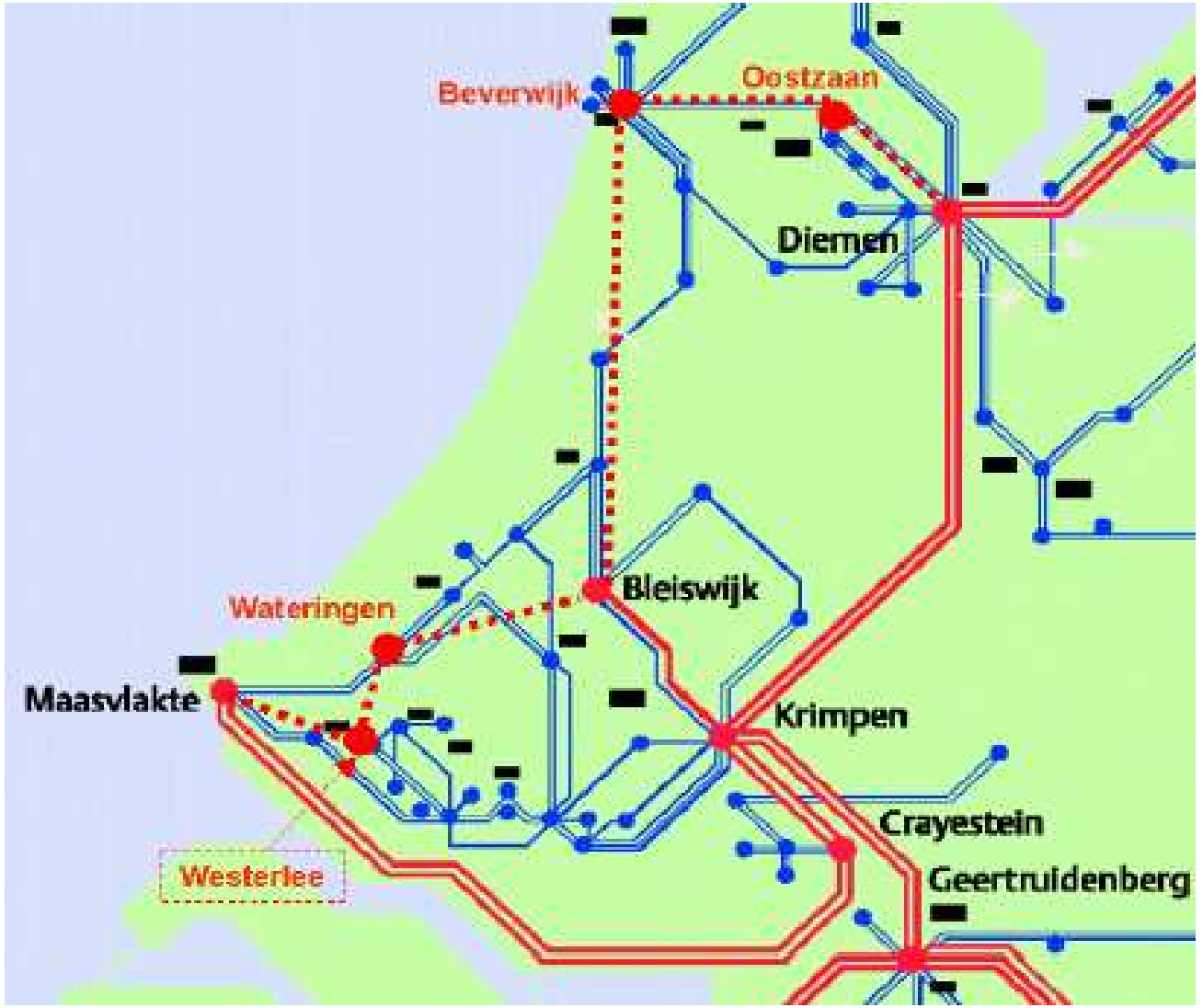
Loop flows!

Transits!

Phase shifters - locations anno 2008



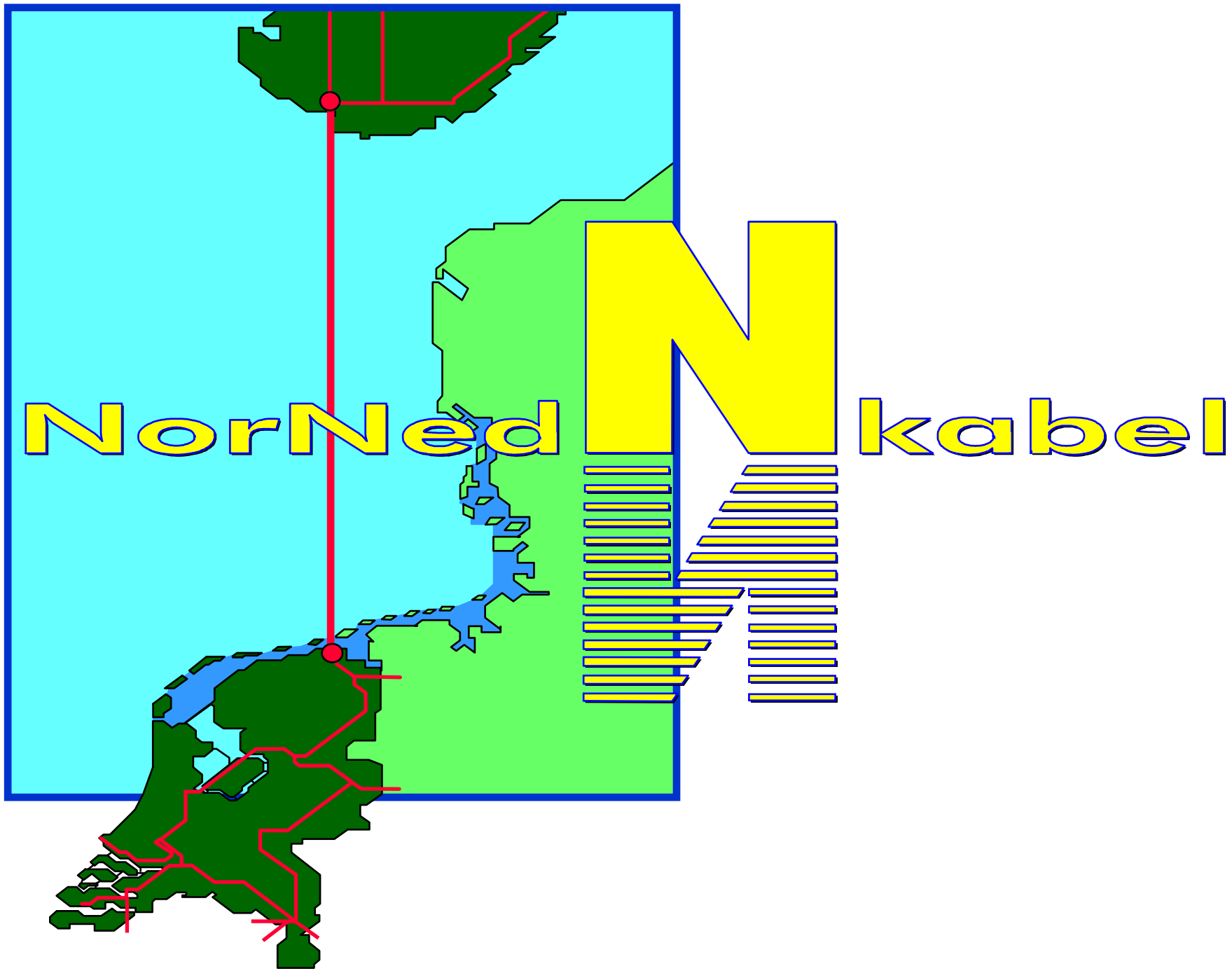
Randstad project



How much time does it take to build new lines?

- SEV 1-2 years
- RPP 3-4 years
- Building permits + 0.5 year
- Landowners + 0.75 year

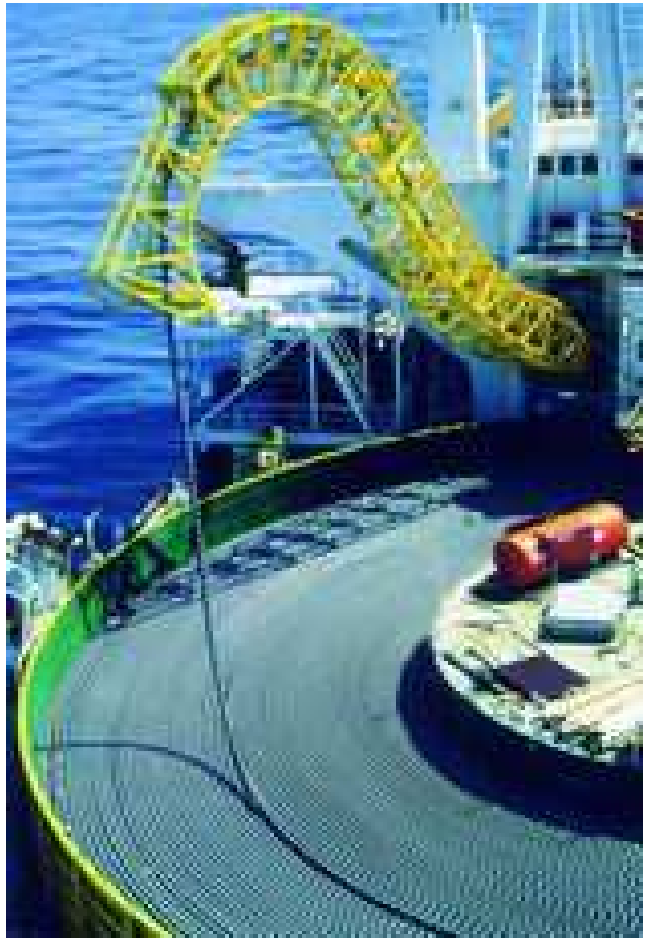
Total 5-8 years


NorNed
kabel

NorNed project

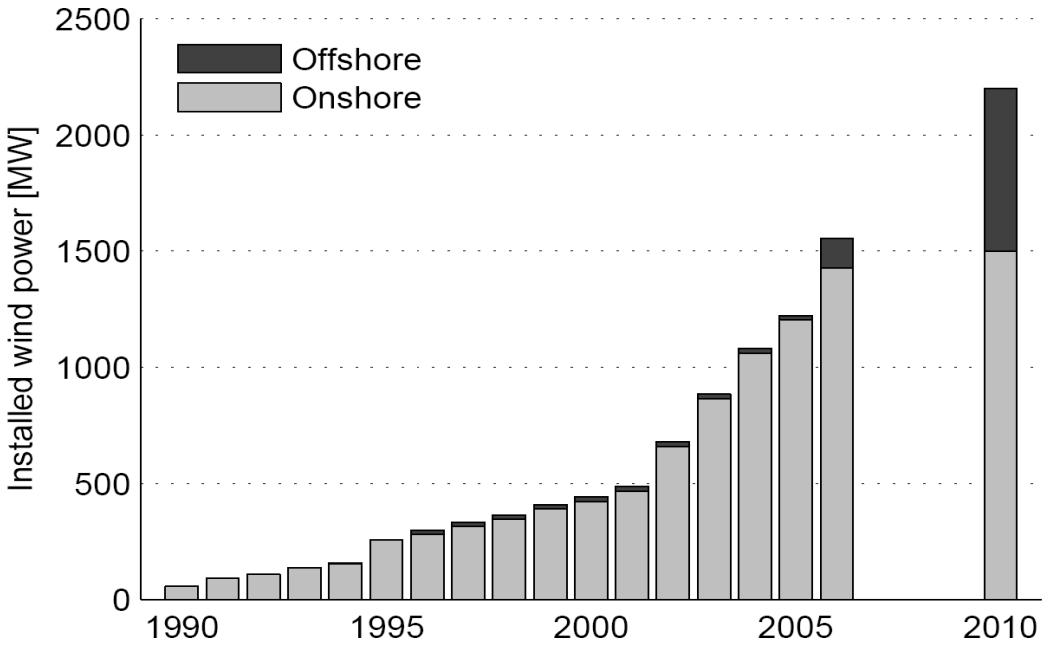
TenneT together with Norwegian TSO Statnett is constructing a 450kV interconnection between Norway and the Netherlands

- Intended for electricity imports and exports (700MW)
- EU policy: market coupling, enhancing liquidity
- Interconnection to be installed on the seabed (length of 580km)
- To be taken into operation early 2008



Wind Power in the Netherlands
Installed Capacity

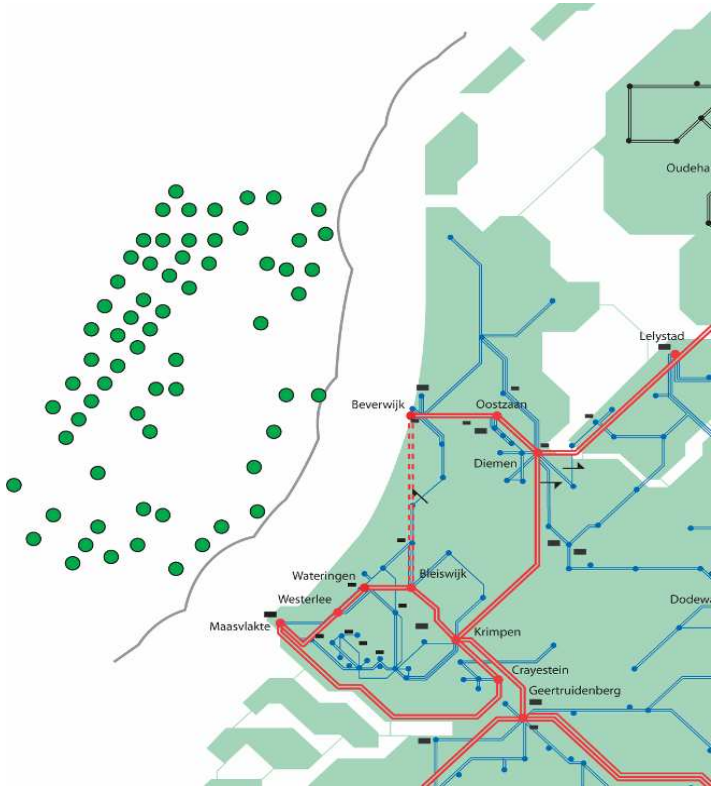
– Strong growth in recent years due to favorable subsidy schemes
– 1 offshore wind farm in operation, 1 under construction

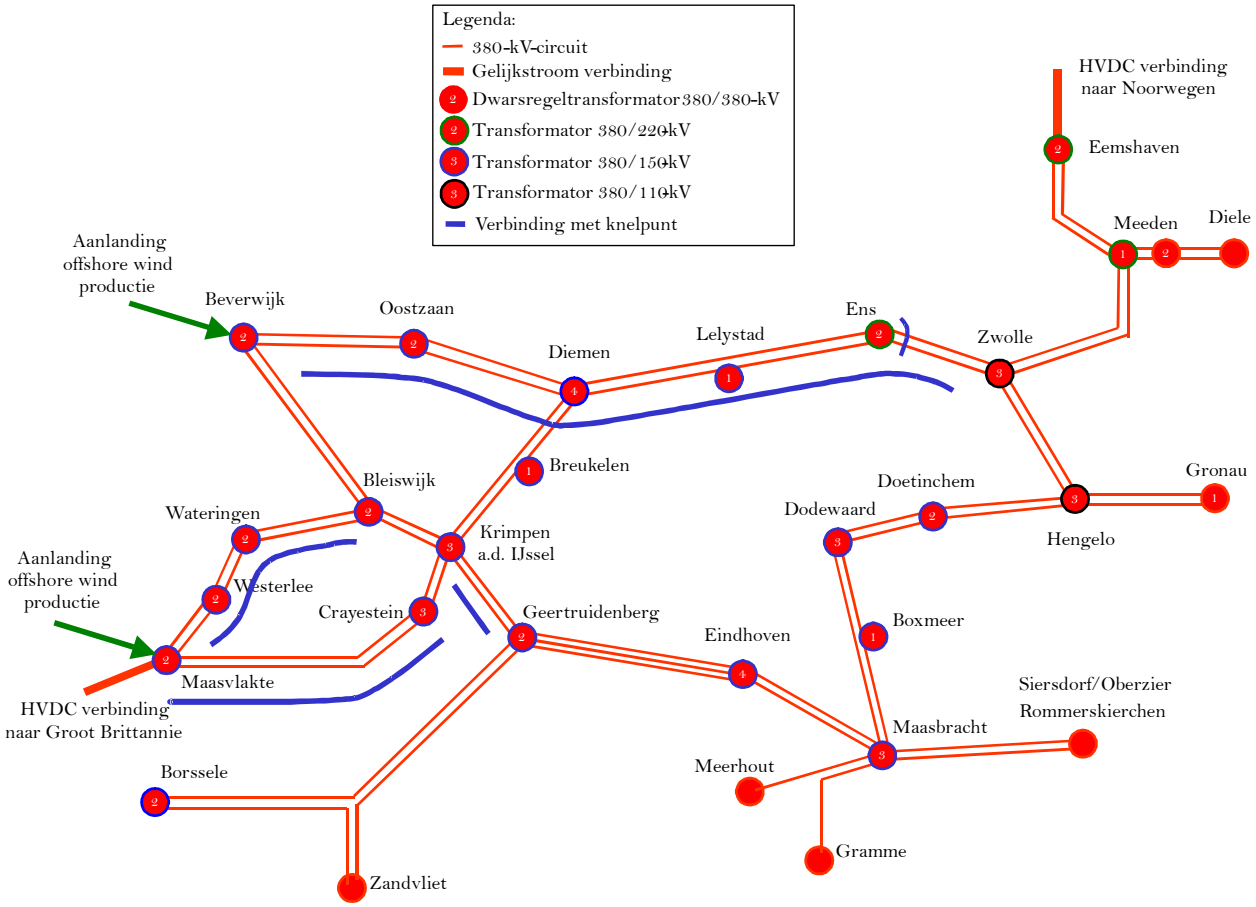


Wind Power in the Netherlands
Future Developments

- 2010 target recently reformulated
  - 1500 MW onshore
  - 700 MW offshore

- 3 – 4 GW on land and 6 – 10 GW at sea may become a reality





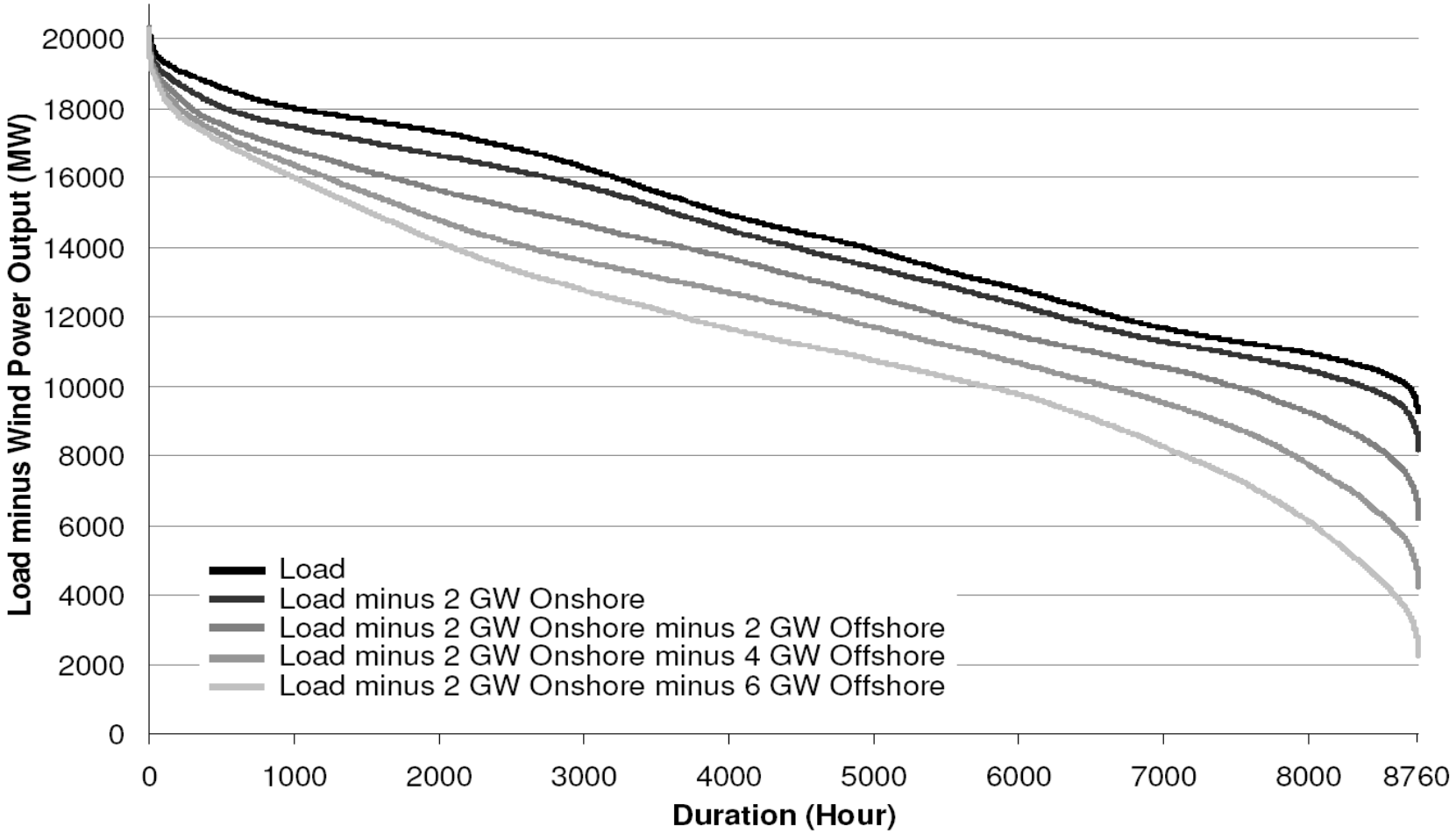
Power flow constraints for large scale offshore wind power in the Netherlands

System Integration of Wind Power
System-Wide Impacts

– Variability and limited predictability of wind power
– Need for regulating power because of that
– Minimum load consequences for the production
– Operation of other units in the system

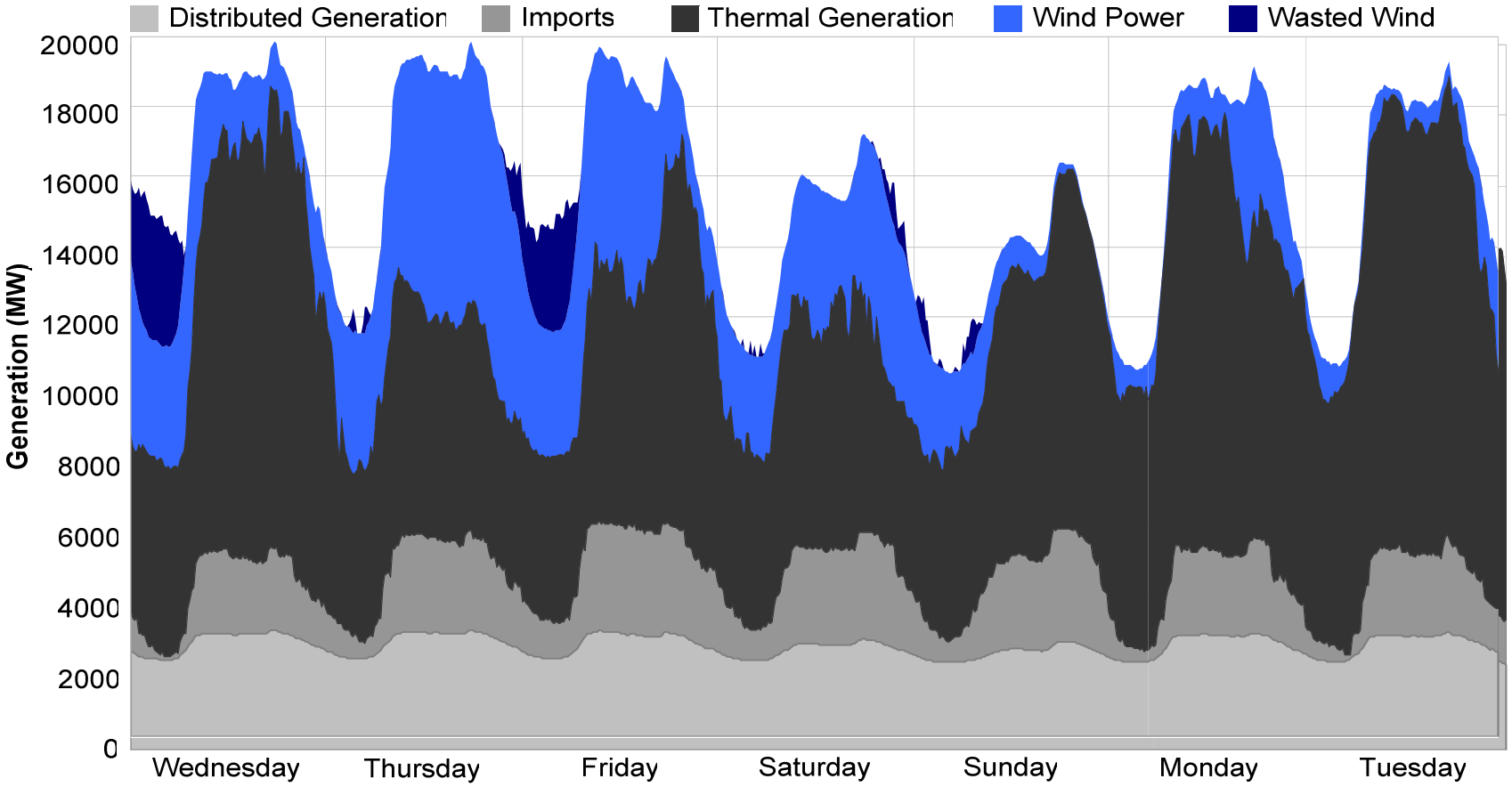
Case study: 0–8 GW in the Netherlands for a given future year

System Integration of Wind Power
Load minus Wind Duration Curve

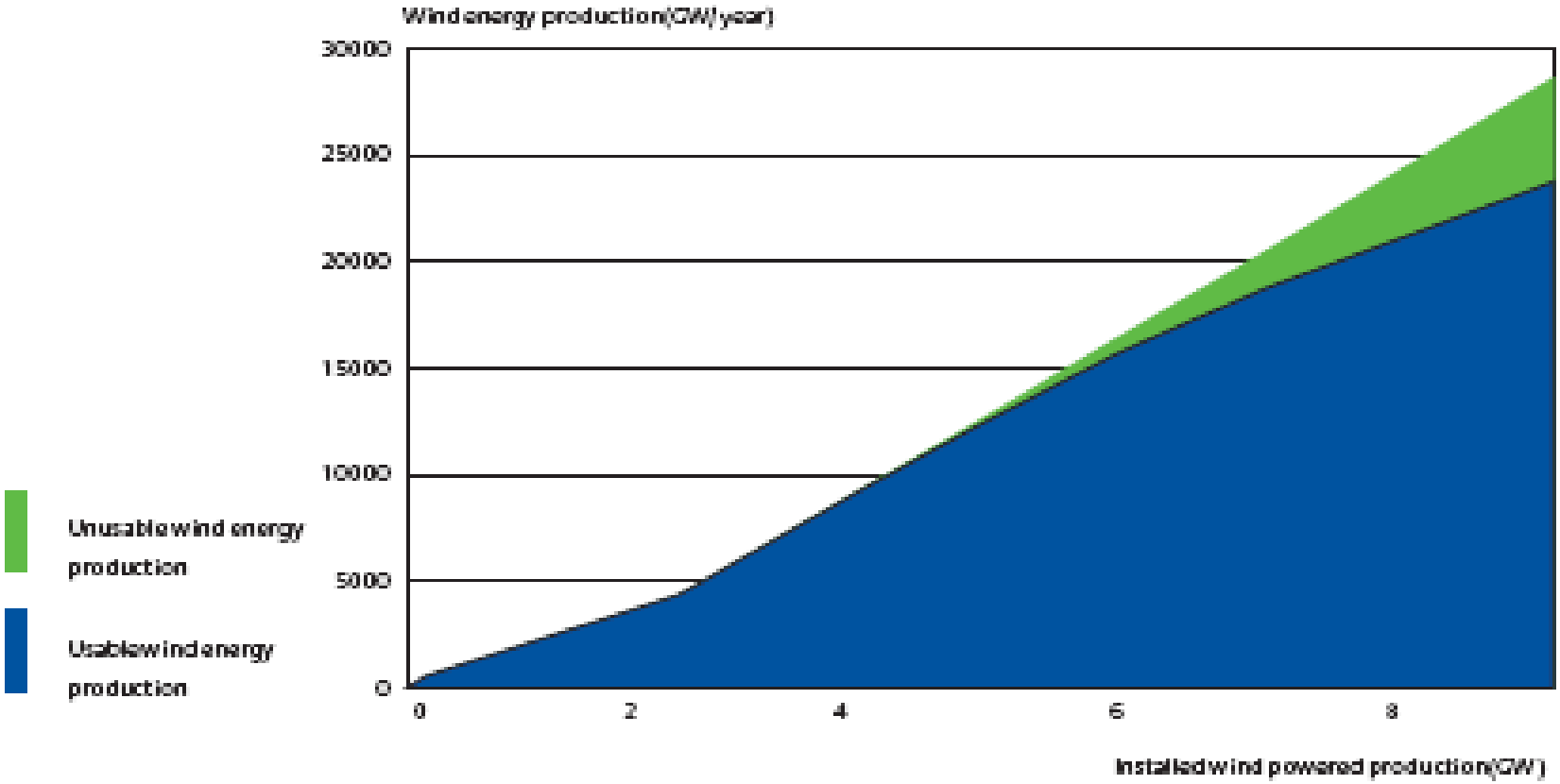


System Integration of Wind Power

Unit Commitment and Dispatch with 8 GW Wind Power



Unusable wind energy production as function of the installed wind power in the future



Concluding remarks

- Long-term decision making for network reinforcements is hampered with uncertainties. Lead-times for investments in network infrastructure is becoming longer than lead-times for generation investments
- Congestion handling with market incentives is promising on an international level (flow based market coupling) and is a must on a national level (runback and demand response)
- Security and stability of interconnected systems should be guaranteed (enough redundancy in generation and transmission)
- Information exchange and communication with authorities, politics and customers is crucial

Thank you for your kind attention.

TenneT