TATA STEEL

Universiteit Utrecht

TATA

Techno-Economic Demand Response Potentials of the Integrated Steelmaking Site of Tata Steel in IJmuiden

Arzu Feta[1], Machteld van den Broek[2], Wina Crijns-Graus[3], Gerard Jägers[4]

[1,4] Tata Steel IJmuiden

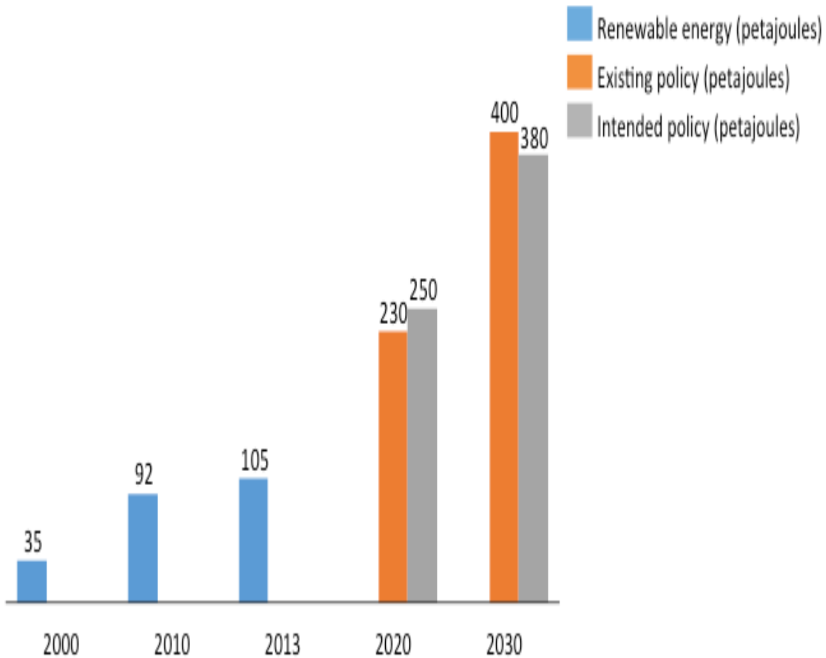
[2,3] Copernicus Institute of Sustainable Development, Utrecht University

14-09-2016

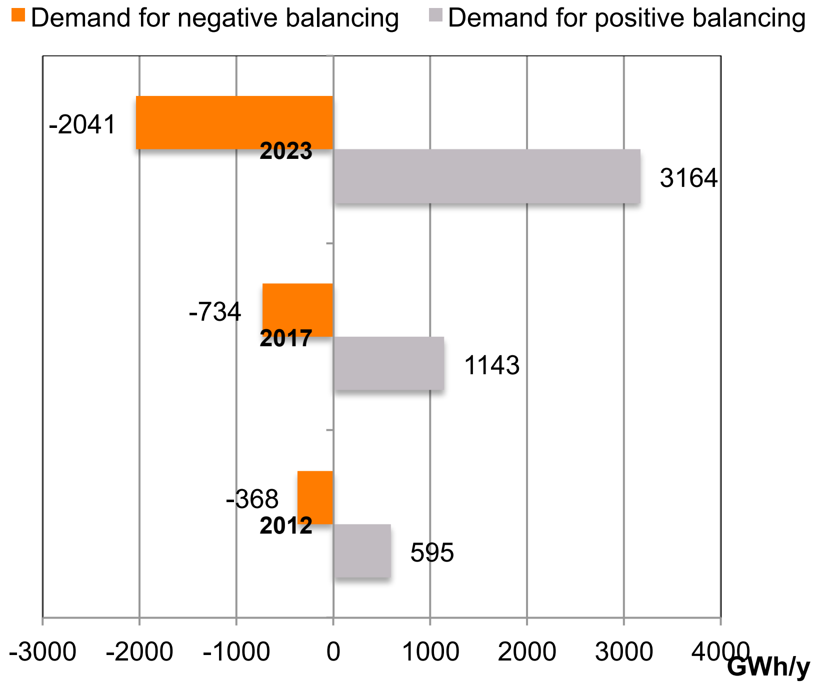
ECEEE

Outline

Increase in energy generation from renewable energy sources leads to a growing demand for balancing capacity



Renewable energy in NL by 2030.
Source: Energy Research Center of the Netherlands. (2015). National Energy Outlook 2015.



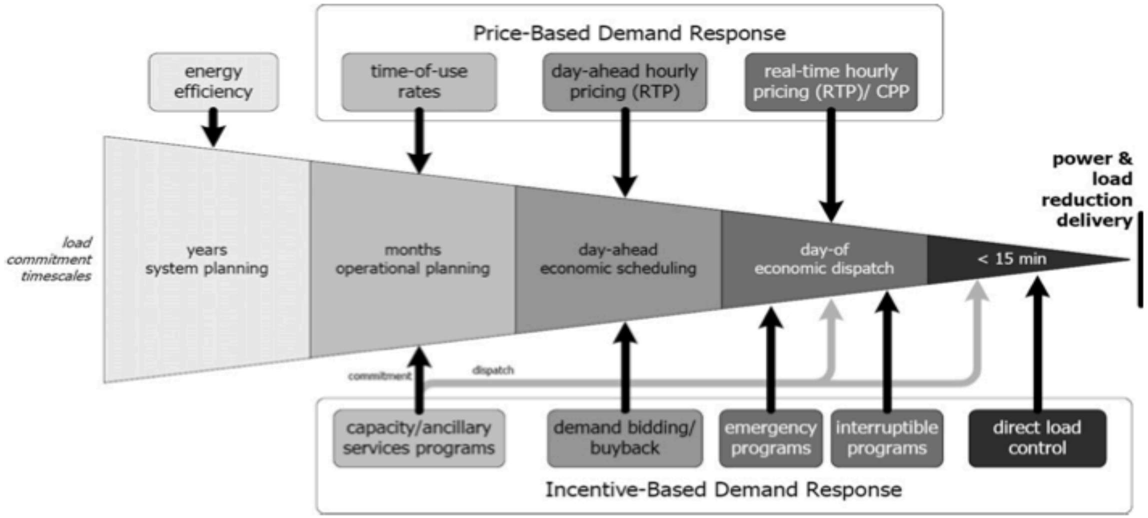
Demand for tertiary balancing capacity by 2023 in the Netherlands Source: Verdonk et al. (2012). *Referentieraming energie en emissies: actualisatie*.

- Expected changed in balancing capacity demand:
  - Positive balancing capacity or downward adjustment –activated in case of shortage of electricity on the grid
  - Negative balancing capacity or upward adjustment - activated in case of surplus of electricity on the grid

Increase in electricity generation from renewable energy sources increases the demand for intra-day balancing capacity

Methods to meet the balancing capacity demands:

- Increasing the flexibility electricity generation
- Cross-boarder electricity grid interconnectivity
- Electricity storage
- Demand response



	Regulating capacity	Reserve capacity	Emergency capacity
Type	Secondary	Tertiary	Tertiary
Bid size	≥4 MW	≥4 MW	≥20 MW
Activation method	Automatic	Automatic / Manual	Manual
Deactivation method	N/A	Systematically at the end of 1st full PTU	Manually at end of PTU
Activation ramp rate	≥7 %/min	≥100 %/PTU	≥100 %/PTU
Activation duration	≥4 sec	≤15 min	≤15 min

Emergency demand response programs (additional) requirements*:

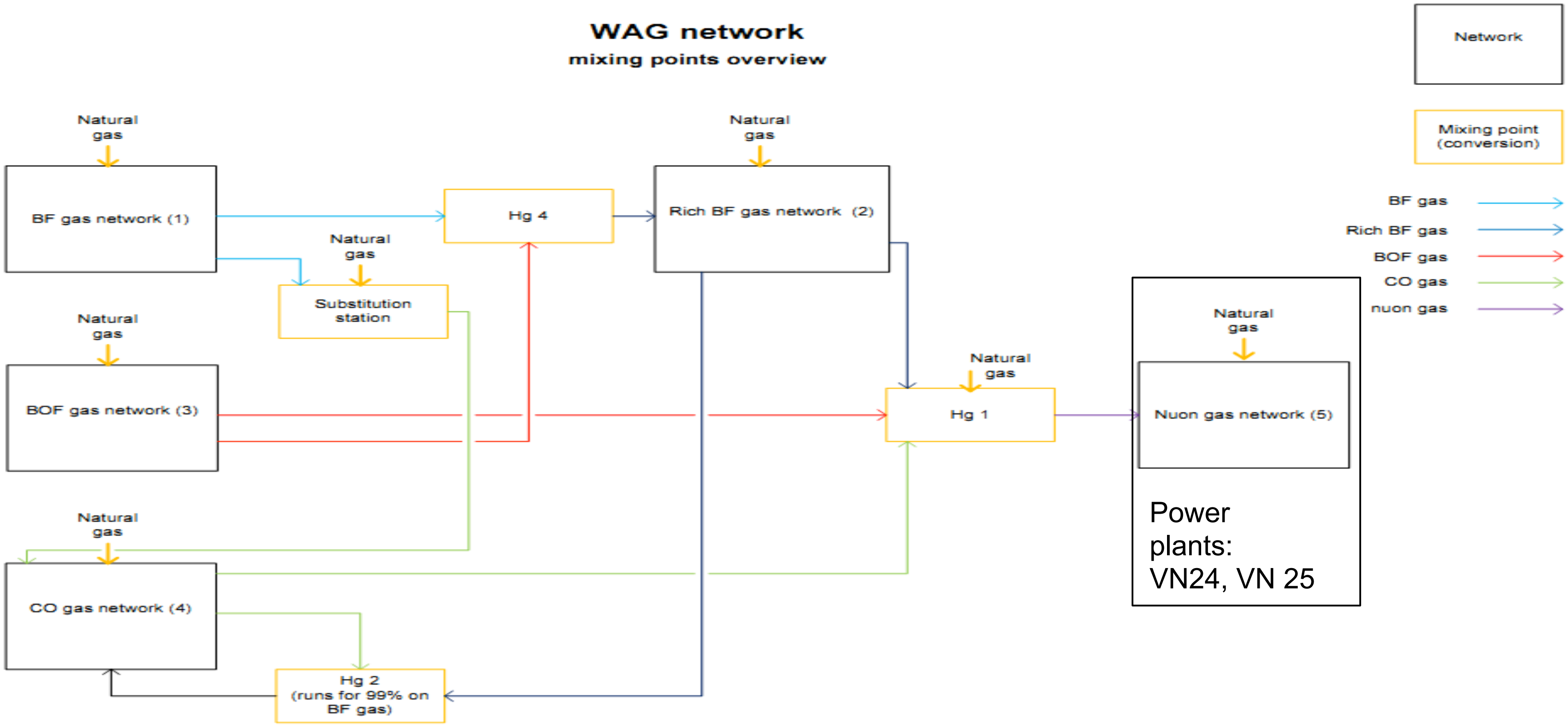
- Supply period: 4 PTUs
- Availability rate: ≥97%

*Different values possible if not enough participants.

Sources: Frunt, 2011; Kundur, 1994; Lampropoulos et al., 2012

Tata Steel in IJmuiden can contribute to meeting the growing balancing capacities demands

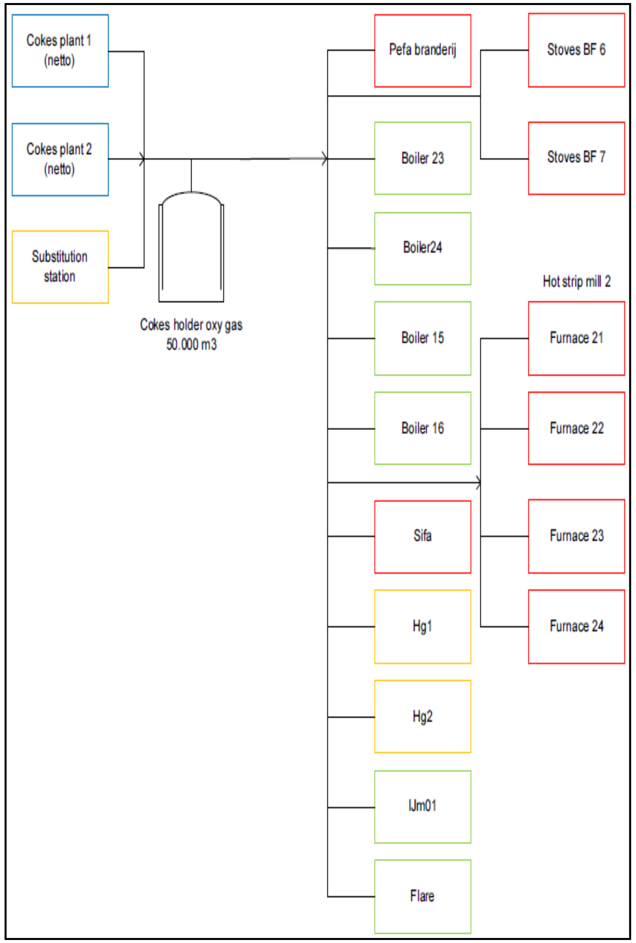
- Integrated steel plant with steel production capacity 7.2 Mton/year
- Electricity consumption: 2740 GWh/year (~3% of the total electricity consumption of the Netherlands); electricity generation: 3500 GWh/year
- Steel sector among the sectors with the highest demand response potential in Europe



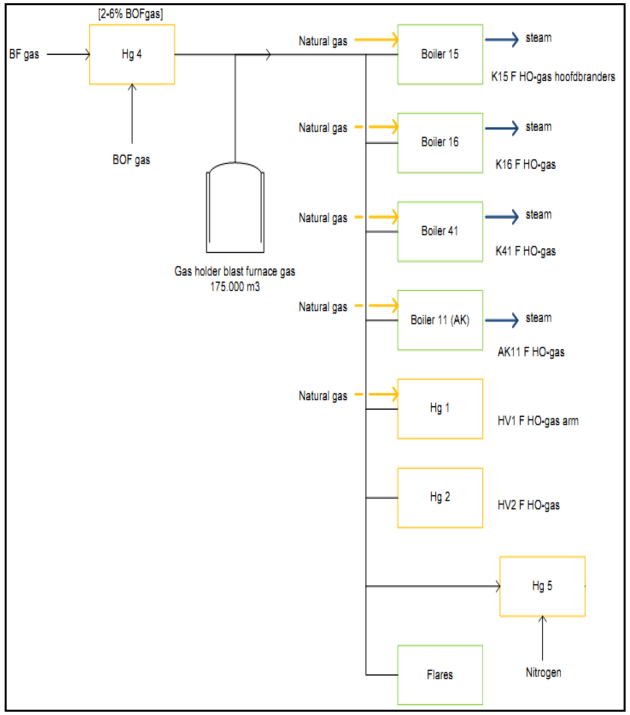
Simplified representation of the works arising gas network of Tata Steel

Works arising gases (WAGs) are used for meeting the energy demand of works units, generating electricity and steam

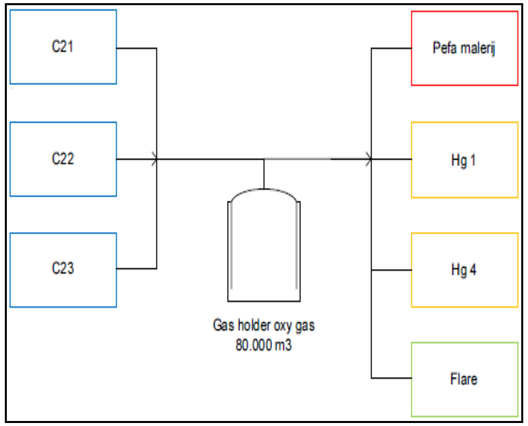
Coke oven gas (COG) system



Rich blast furnace gas (RBFG) system



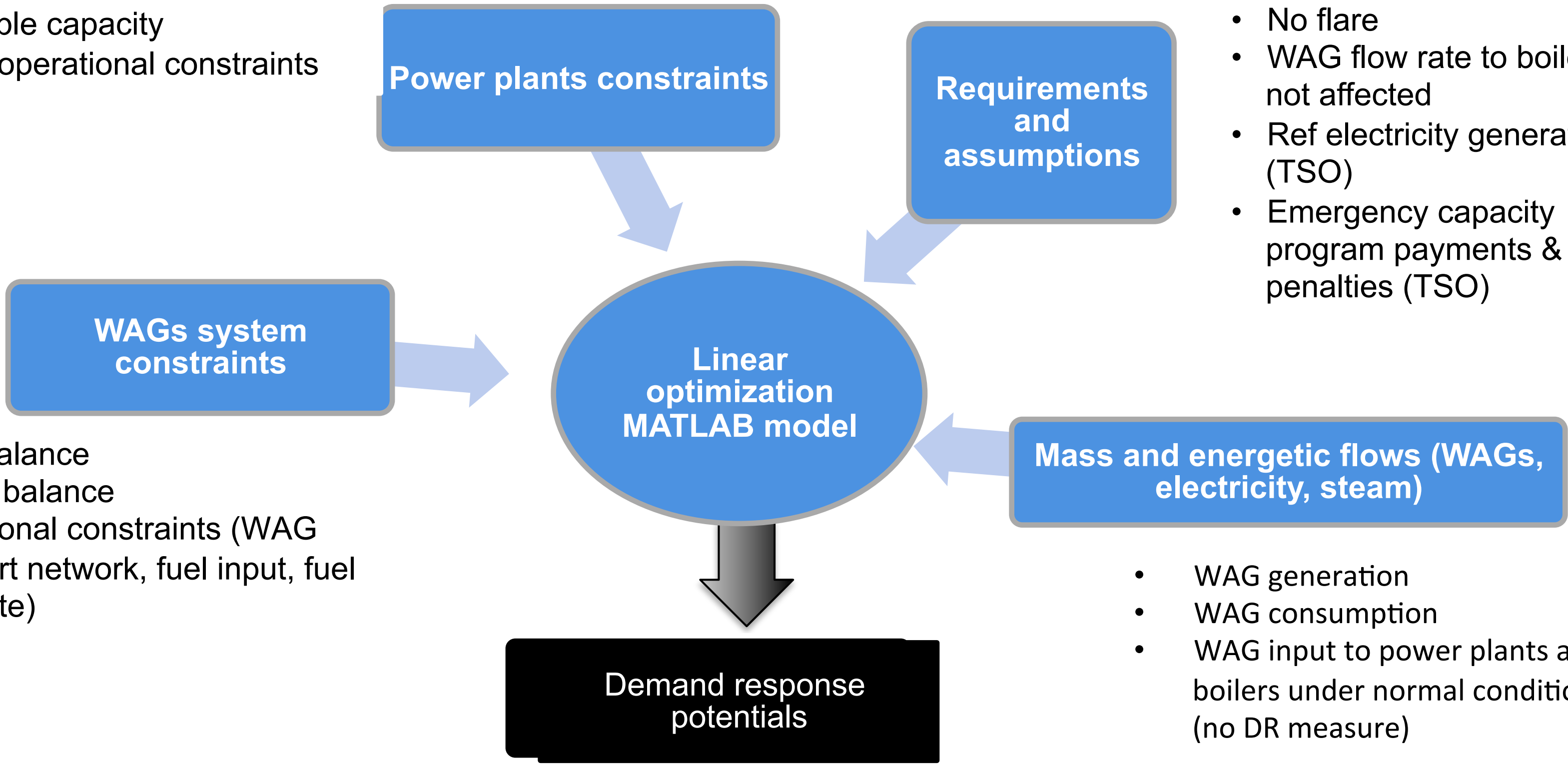
Basic oxygen furnace gas (BOSG) system



A linear optimization model has been developed to calculate the balancing capacity potentials of TSIJ

- Ramp-up rate
- Ramp-down rate
- Available capacity
- Other operational constraints

- Contract details with NUON not considered
- Energy demand met: WAGs to production not affected
- No flare
- WAG flow rate to boilers not affected
- Ref electricity generation (TSO)
- Emergency capacity program payments & penalties (TSO)



- Mass balance
- Energy balance
- Operational constraints (WAG transport network, fuel input, fuel input rate)

- WAG generation
- WAG consumption
- WAG input to power plants and boilers under normal conditions (no DR measure)

- Input: call time, supply period
- The bid size
- Output: The availability rate, activation duration, complexity of the measure

Description of the linear optimization model developed

Linear optimization model

$$\textit{minimize} \quad c^T x$$

$$\text{Subject to} \quad \begin{aligned} a_i'x &\geq b_i, & i &\in M_1, \\ a_i'x &\leq b_i, & i &\in M_2, \\ a_i'x &= b_i, & i &\in M_3, \\ x_j &\geq 0, & j &\in N_1, \\ x_j &\leq 0, & j &\in N_2, \end{aligned}$$

Objective functions

$$MaxDRP_t = \sum_{t=m}^{M} \sum_{k=1}^{K} \sum_{u=1}^{U} \left(\frac{Fup_{u,k,t} * c_{u,k,t}}{3600} \right) * \eta_u$$

$$MaxDRN_t = \sum_{t=m}^{M} \sum_{k=1}^{K} \sum_{u=1}^{U} \left(\frac{Fdown_{u,k,t} * c_{u,k,t}}{3600} \right) * \eta_u$$

Decision variables

- Positive demand response: $Fup_{u,k,t}$
- *Negative demand response:* $Fdown_{u,k,}$

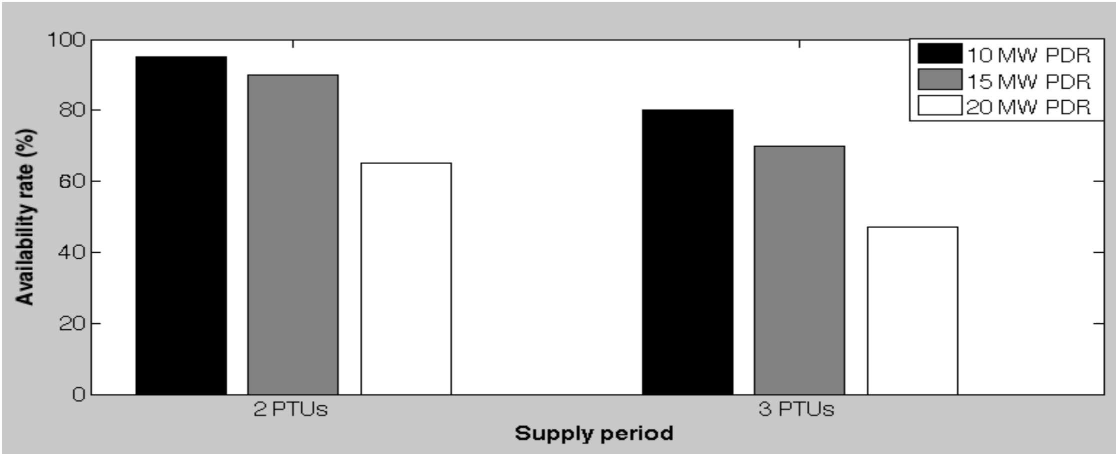
Time unit – 15 minutes (equal to 1 PTU)

Variables
- WAG flows to power plants
- WAG in-flow/out-flow to/from gas buffers

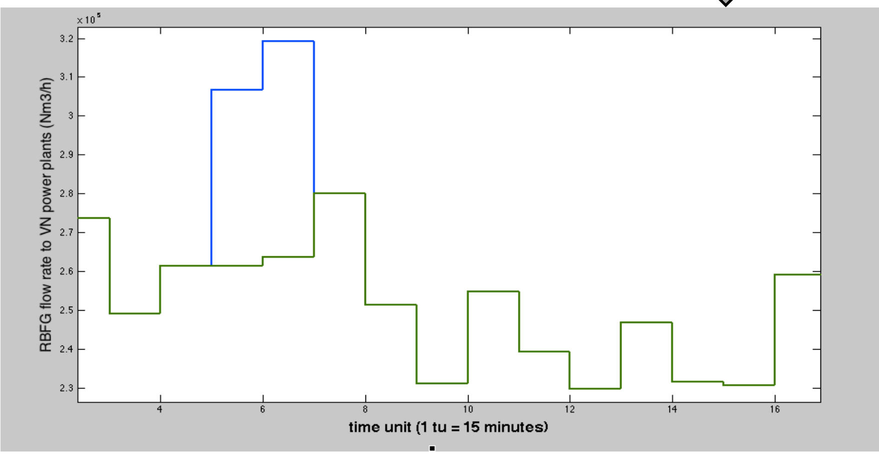
Parameters
- WAG generation rates
- WAG flows rates to on-site plan

PDR main binding constrain: power plant ramp rate and gas availability

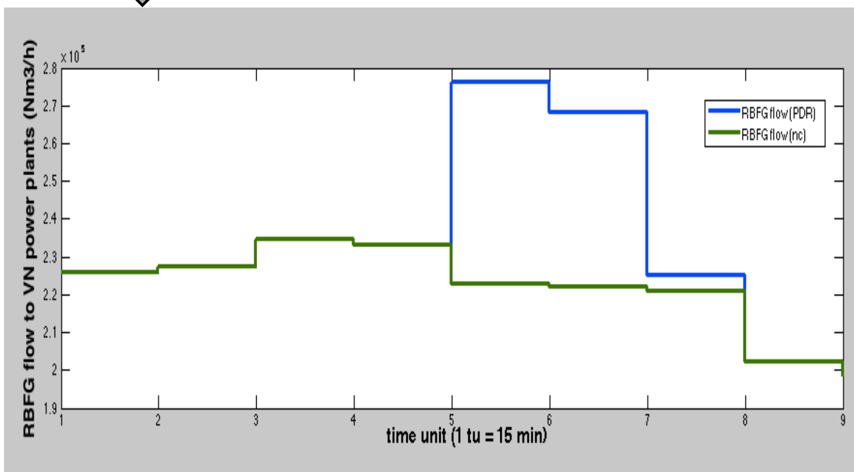
PDR potentials averaged over 100 model run results



Example of a model run result for 2 PTUs

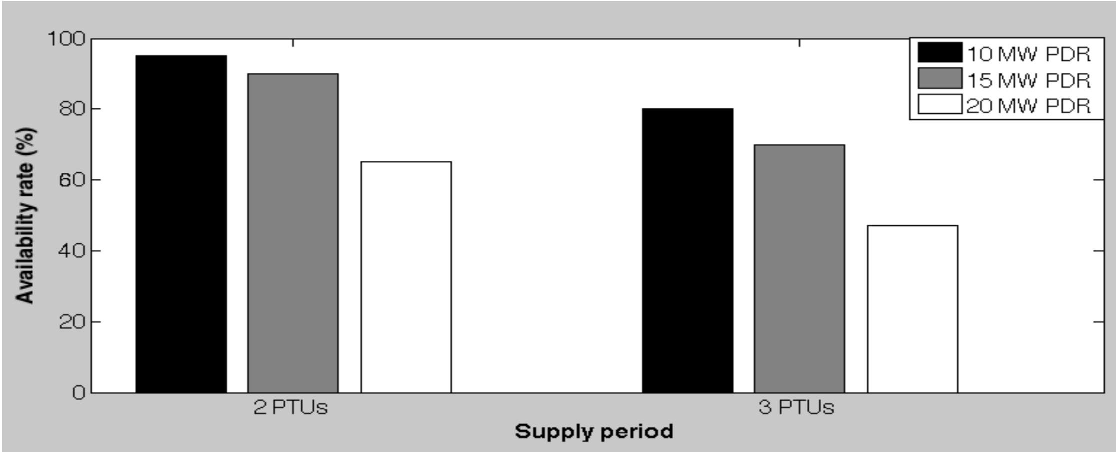


Example of a model run result for 3 PTUs



The PDR potential that TSIJ can provide increases substantially as availability rate requirements reduce

PDR potentials averaged over 100 model run results



Available

Supply period	Bid size	Availability rate
1 PTU	25 MW/PTU	≤ 97%
2 PTUs	10 MW/PTU	≤ 97%
2 PTUs	20 MW/PTU	≤65%
3 PTUs	10 MW/PTU	≤80%

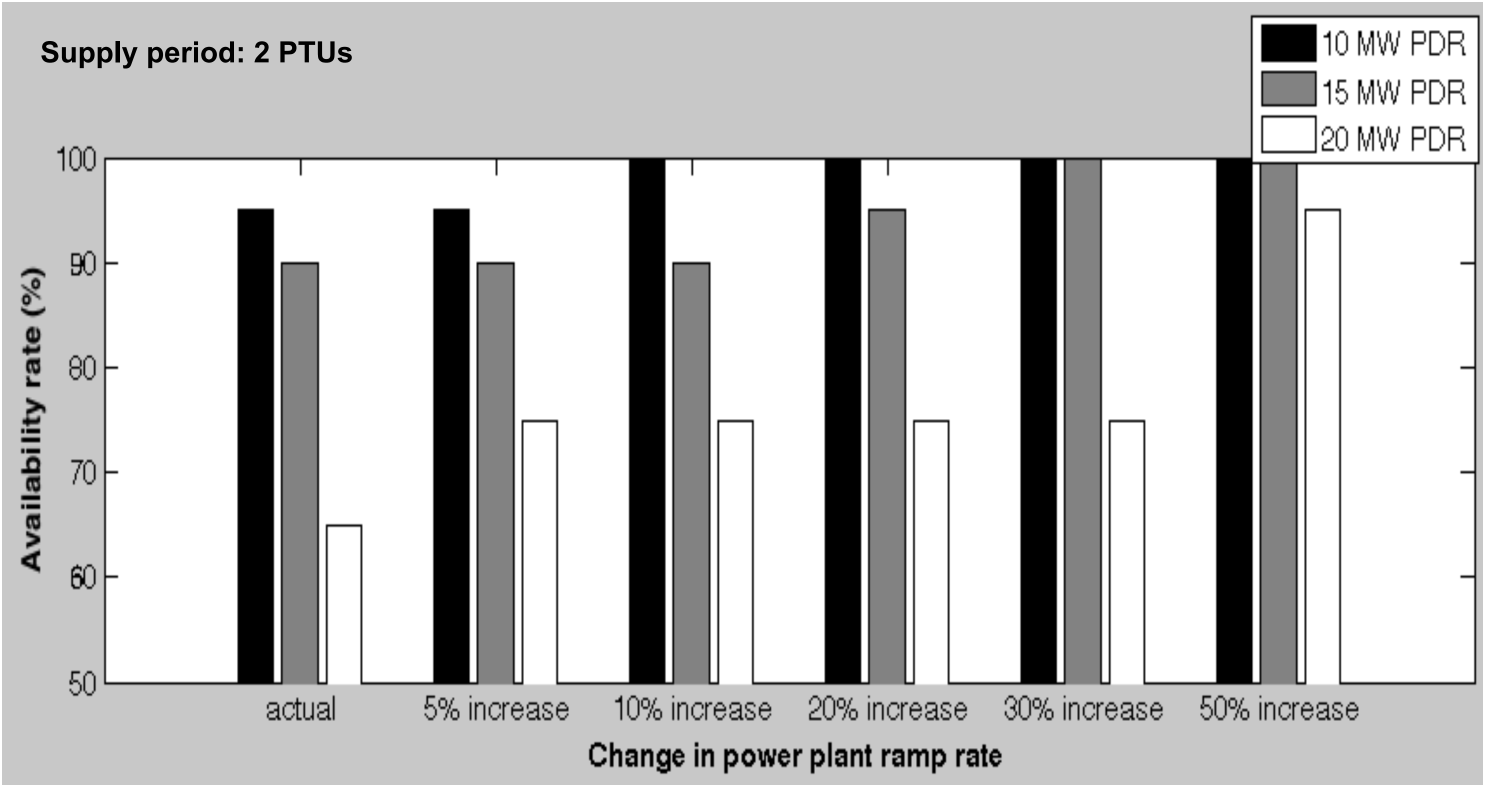
Required*

Type	Tertiary
Bid size	≥20 MW
Supply period	4 PTUs (?) (data: 2 PTUs)
Availability rate	≥97%

*Different values possible if not enough participants.

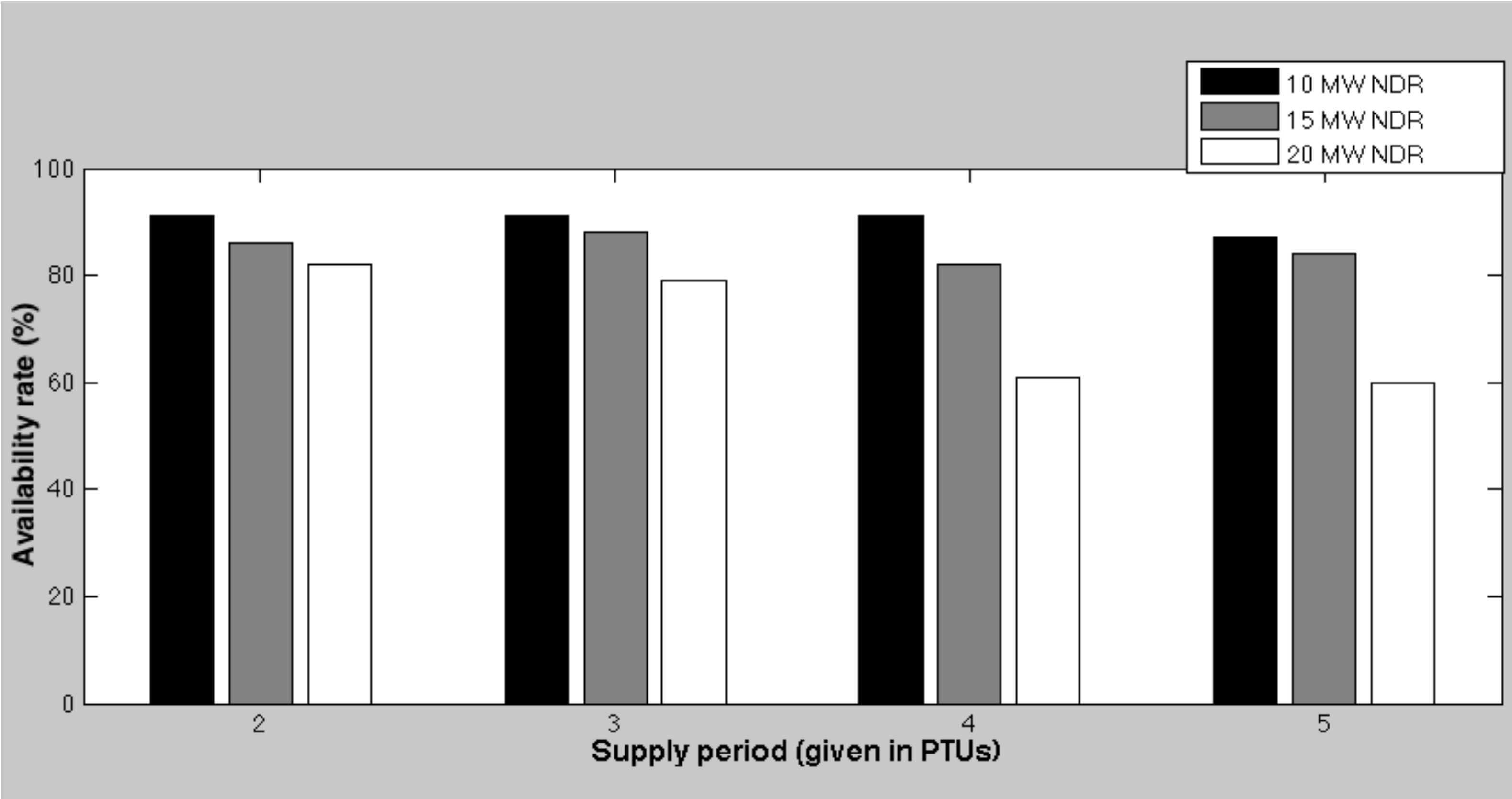
Increasing power plant flexibility can make PDR a viable option for Tata Steel in IJmuiden

PDR potentials averaged over 100 model runs



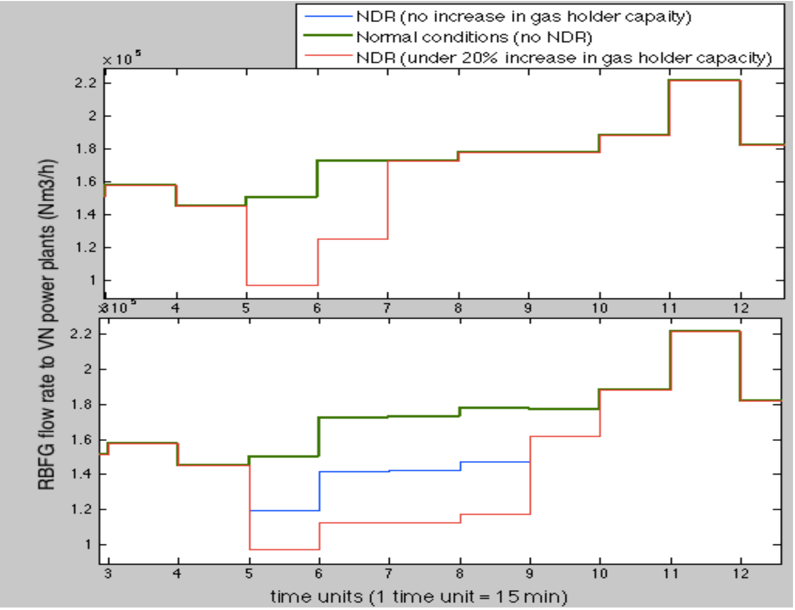
Gas-holder capacity among the main binding constraints for NDR

NDR potentials averaged over 100 model runs

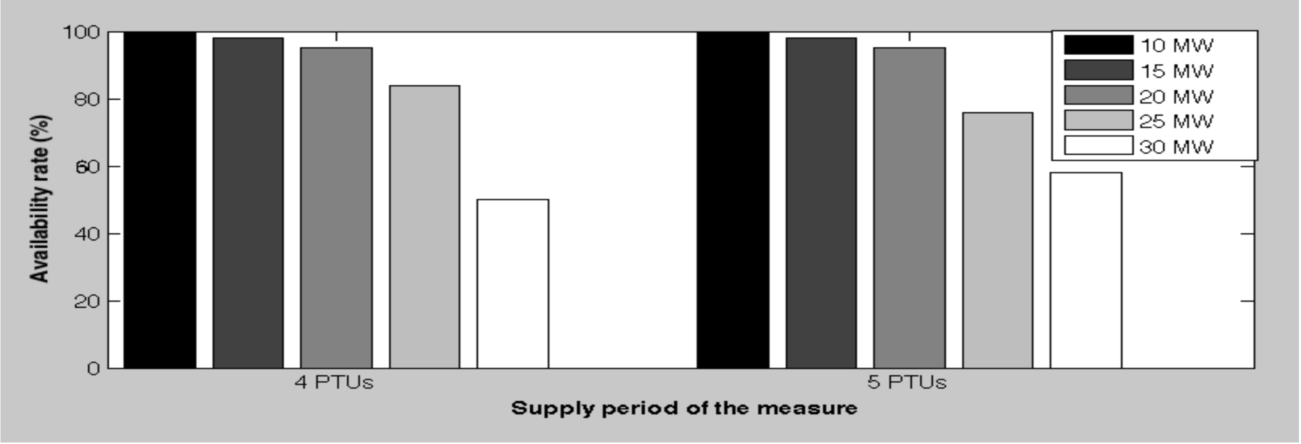


Gas-holder capacity among the main binding constraints for NDR

- NDR emergency capacity under development in the Netherlands



Effect of 50% increase in gas holder capacity.



Discussions and conclusions – Positive balancing capacity

- 10 MW/PTU of PDR capacity with availability rate of 97% for a supply period of 30 minutes.
- 20 MW/PTU of PDR capacity with availability rate of 65% for a supply period of 30 minutes .
- TSIJ's PDR capacities, achieved by controlling the on-site electricity generation, are not enough for participating in current emergency capacity programs in the Netherlands.
- Reduction in availability rate requirements will increase the participation in emergency capacity programs.
- PDR capacities substantial when compared to other sectors: 53 MW/PTU capacity provided by households in Germany by 2020 (DENA, 2010).

Next steps

- Investigating pooling options:
  - Pools with companies we cooperate: Nuon, Linde etc…
  - Pools with other parties

Discussions and conclusions – Negative balancing capacity

- 20 MW/PTU of NDR measure with a supply period of 3 PTUs and 80% availability.
- Main constrain is the gas storage availability for negative balancing capacity.

Next steps

- Negative balancing capacity programs still under development in the Netherlands. Analysis to be updated as NDR requirements are set.
- Increasing the gas storage capacity – high CAPEX.
- Tata Steel is investigating alternative ways to utilize WAGs (i.e hydrogen generation). Investigate the possibilities how balancing capacity can be used in combination with the new WAG utilization techniques.

TATA STEEL

TATA

Questions?

Friday, 26 August, 2016

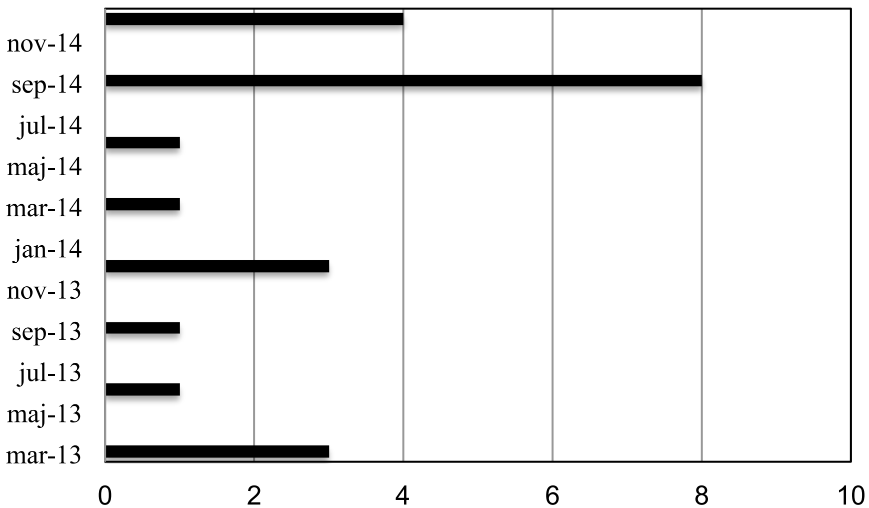
Together we make the difference

Back-up

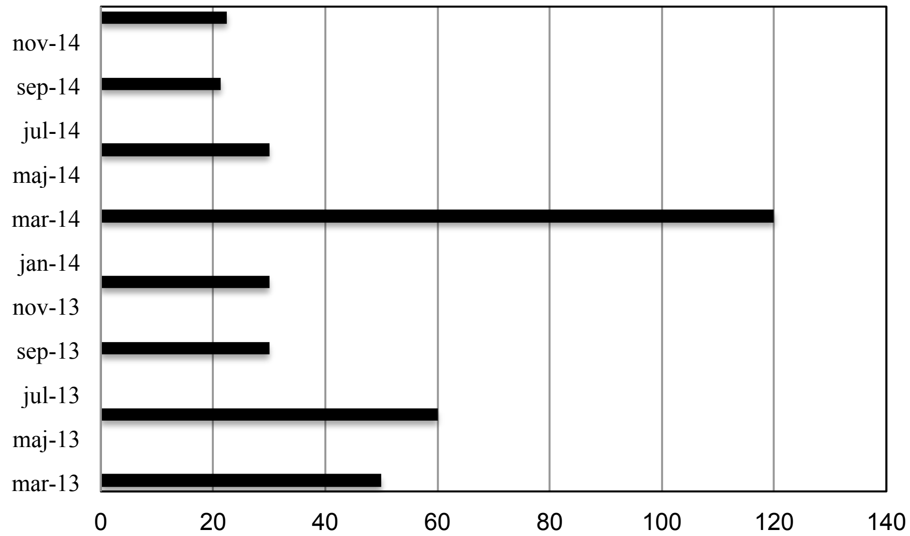
Calls for emergency capacity

- The bid size
- The availability rate
- The supply period
- Activation duration
- Complexity of the measure

Type	Tertiary
Bid size	≥20 MW
Activation method	Manual
Deactivation method	Manual
Supply period	4 PTUs (data: 2 PTUs)
Availability rate	≥97%

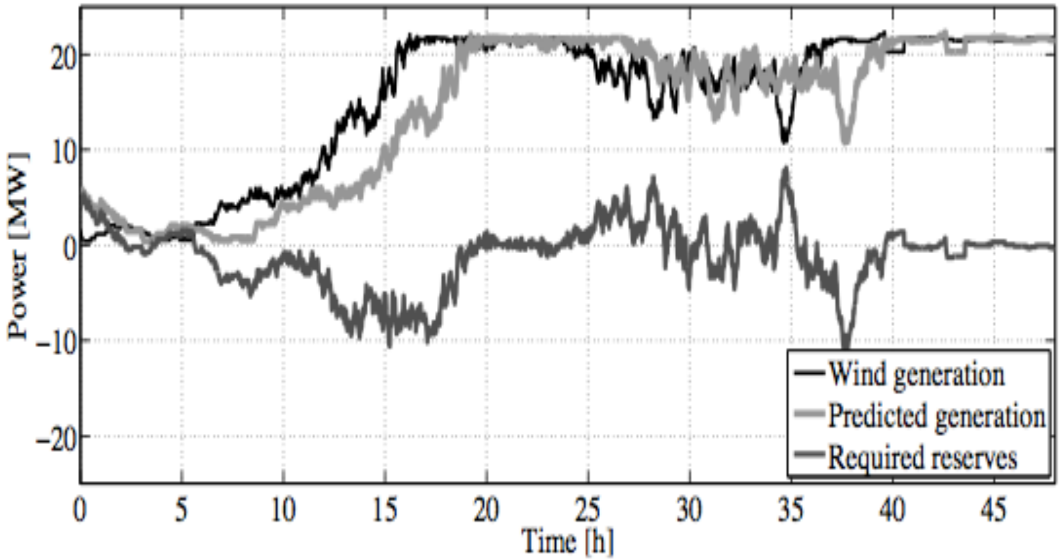


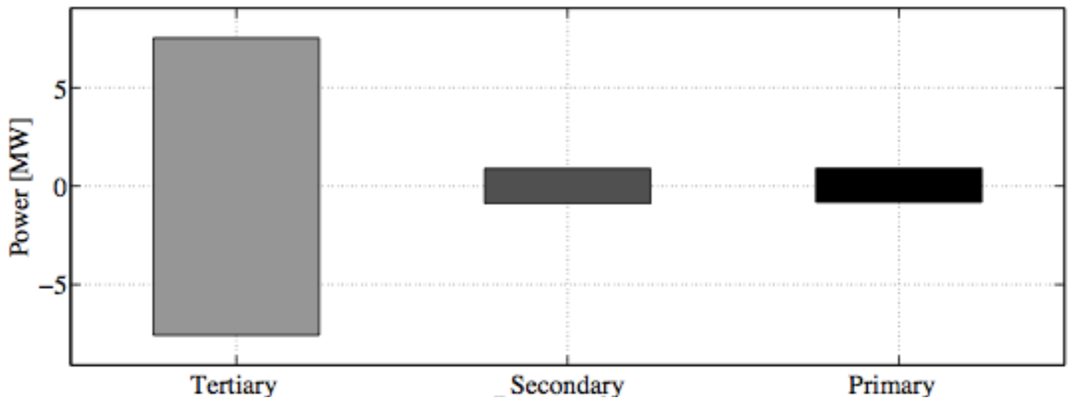
Number of emergency capacity calls per month



Duration of the emergency measure (min)

- Balancing capacity demand for a 25.5 MW wind farm





Source: Frunt, 2011

Assessment of PDR results

- Theoretical PDR potentials of German industry:
  - Cement industry – 314 MW
  - Aluminum industry – 277 MW
  - Steel (electric arc furnaces) industry – 1098 MW
  - Paper industry – 311 MW

- PDR capacity of household in Germany by 2020 is expected to be 53 MW.

Demand response definition

DR is defined as “a change in the electricity consumption pattern of end-use consumers in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized” (U.S. Department of Energy, 2006).