# Variation of Natural Gas Composition

# Challenges for Power Generation

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# Introduction of Gas Composition

- Chemical composition of Natural Gas defined as gas quality in the DVGW-Arbeitsblatt G 260
- Natural gas is mainly methane with a fraction of alkanes or hydrogen with a max. fraction of 12%, L and H gas acc. to G 260
- Fractions can also be higher more than 20% in future
- Pipeline gas is mixed from different gas fields with a certain range of variation in compositions
- Globalisation of pipeline network and sourcing of energy like LNG and increase of  shale gas within the supply chain will increase the variation of compositions
- Sustainability direction will increase the biogas and hydrogen fraction



# LNG supply channels for Europa

## Flüssigerdgas (LNG) für Europa

Mrd. m³/a

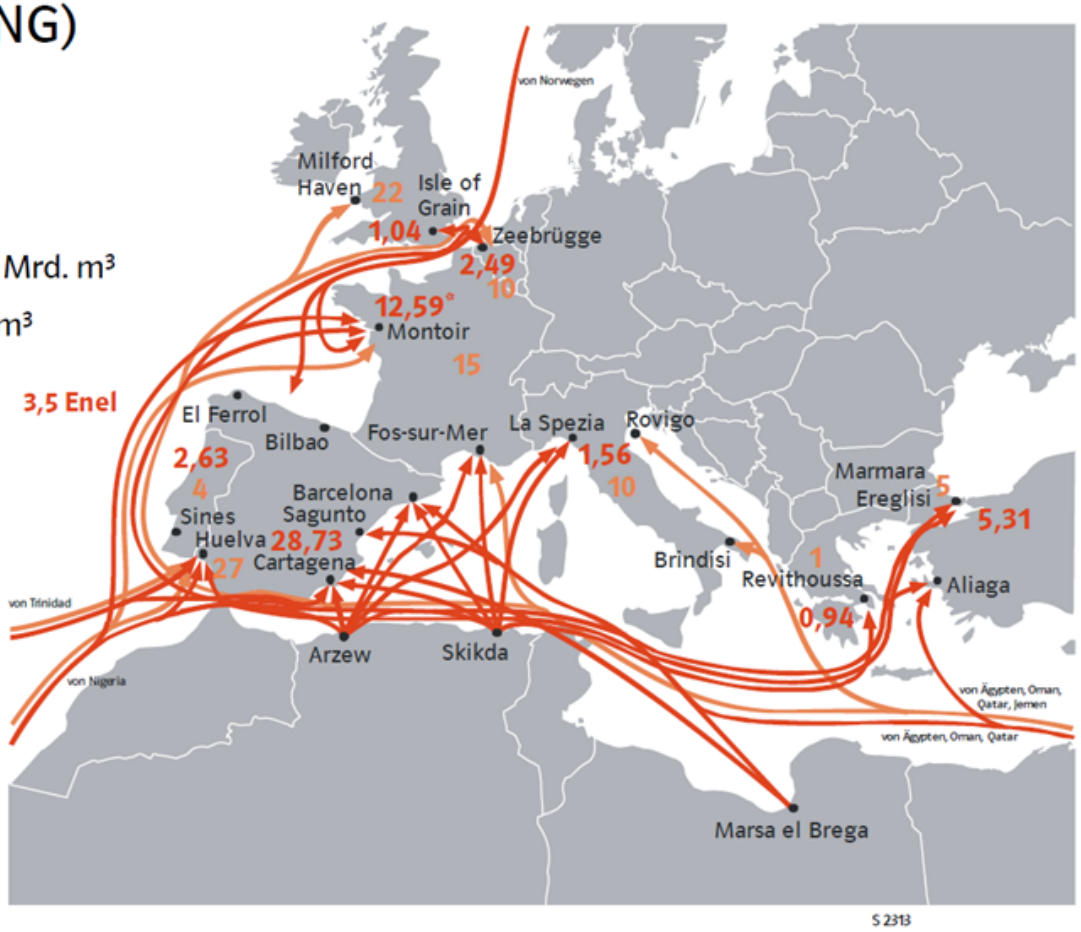
— Lieferungen 2008 : 55,3 Mrd. m³

— Importe 2010 : 94 Mrd. m³

| davon | |
|---|---|
| Algerien | 19,38 |
| Ägypten | 6,37 |
| Qatar | 7,89 |
| Oman | 0,17 |
| Trinidad & Tobago | 5,03 |
| Libyen | 0,53 |
| Nigeria | 14,63 |
| Norwegen | 1,38 |
| Äquat. Guinea | 0,08 |

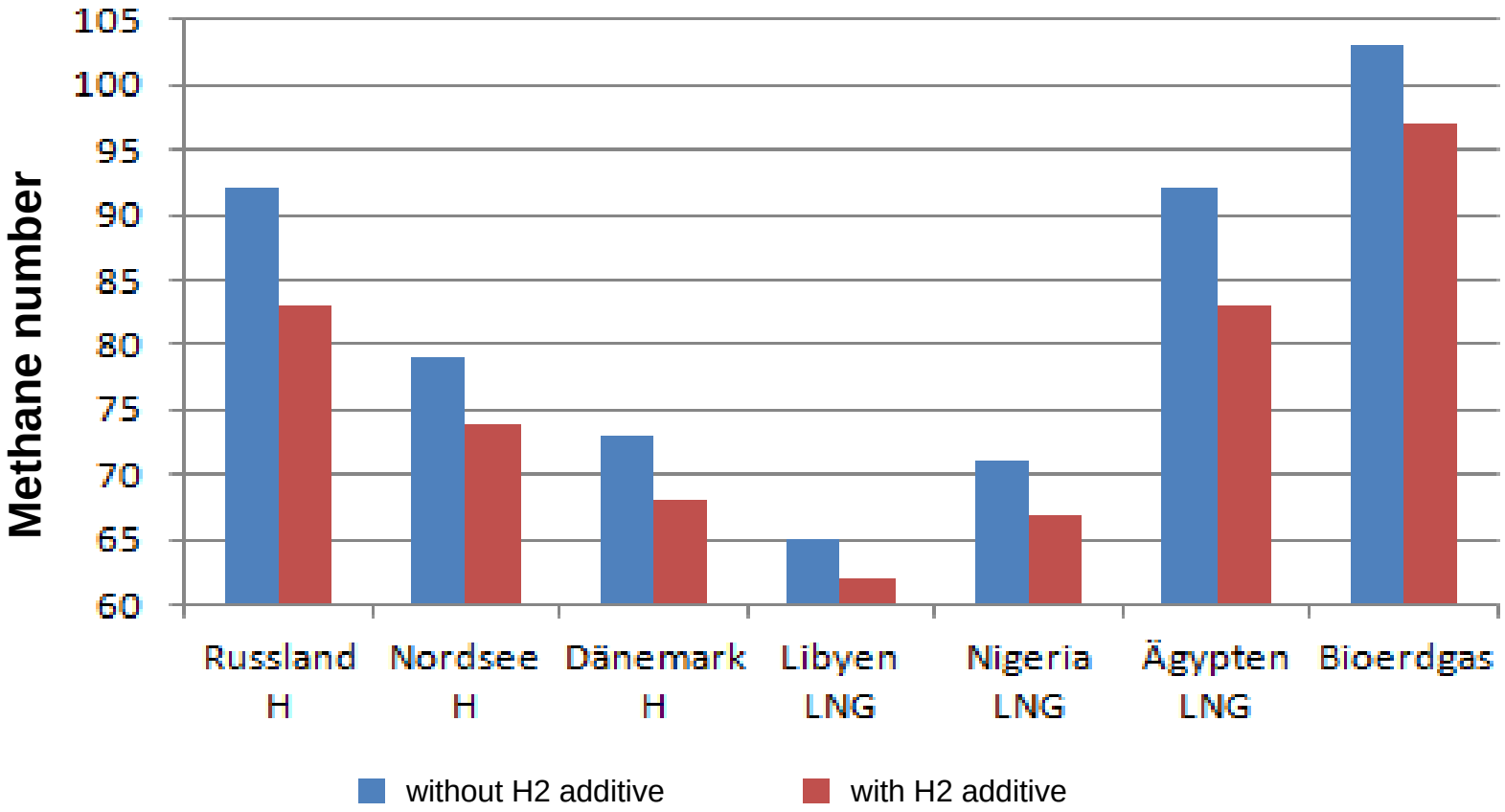
Quelle: Cedigaz

* davon 3,5 Mrd. m³/a aus Nigeria über Montoir für Enel / Italien






# Comparison MN impacted by 10% hydrogen






# Engine Knocking

- Knocking events by self-ignition of unburned Gas-Air-Mixture
- Knocking in the higher load range is a self accelerating process and must be immediately stopped to avoid increase of wear and tear and engine damage
- Knock resistance of NG mixtures depends on fast ignitable long chain hydrocarbons; condensate droplets stored knock initiate compounds which have to be avoided
- Methane Number is the key to define the knock resistance
- Each cylinder has it`s individual knock margin

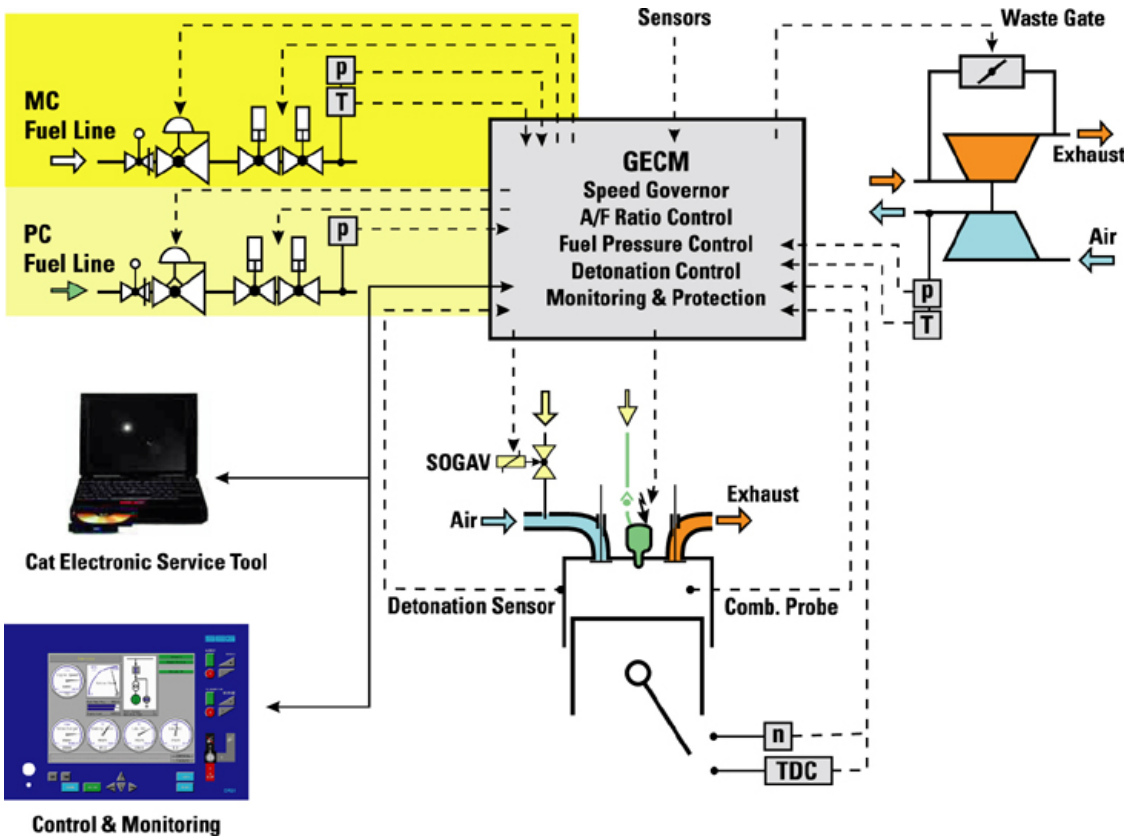


# Main factors impacting the gas engine operation

- Methane Number
- Gas quality, gas composition
- Air to fuel ratio
- Compression ratio
- Charging pressure
- Ignition system
- Ambient conditions (Charge air temperature / de-rating strategy)



# Gas engine control system




- Monitoring & Protection
- A/F-ratio control
- Ignition Timing control
- Knock control per cyl.
- Gas Pressure control
- Speed Governor



# Control strategie for power plant operation

| Examples | Corrective action plant control system |
|---|---|
| • Grid parallel IPP operation | → Power matching |
| • Unstable grid (frequency, voltage) | → Power matching |
| • Peak shaving operation grid parallel | → Power matching |
| • Island mode (droop, load shedding, sharing operation) | → Power management |
| • Island mode variation elec. load (e.g. cement industry) | → Power management |
| • Etc. | |



# Reliability

•Continuous knocking can damage engine parts (e.g. piston , see picture)

•Preventing engine knocking

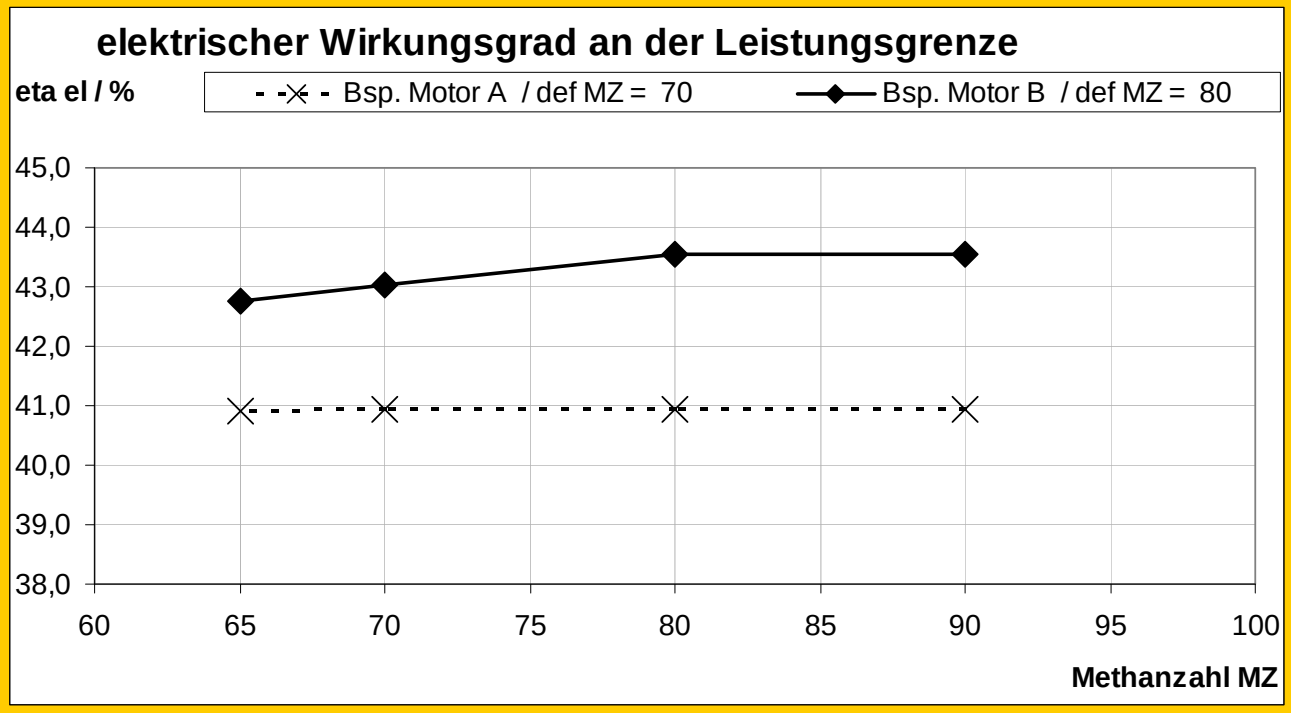
- Drop in methane number reduces knock margin
- MWM TEM anti knock control system per cyl. detects cylinder knocking and acts preventing it
- Knock control system per cyl. optimizes the engine efficiency
- Transient velocity of methane number variation has to be limited. Within this transient time the control is very reliable

•Older field gas engines are not equipped with this technology.



# Engine efficiency versus methane number

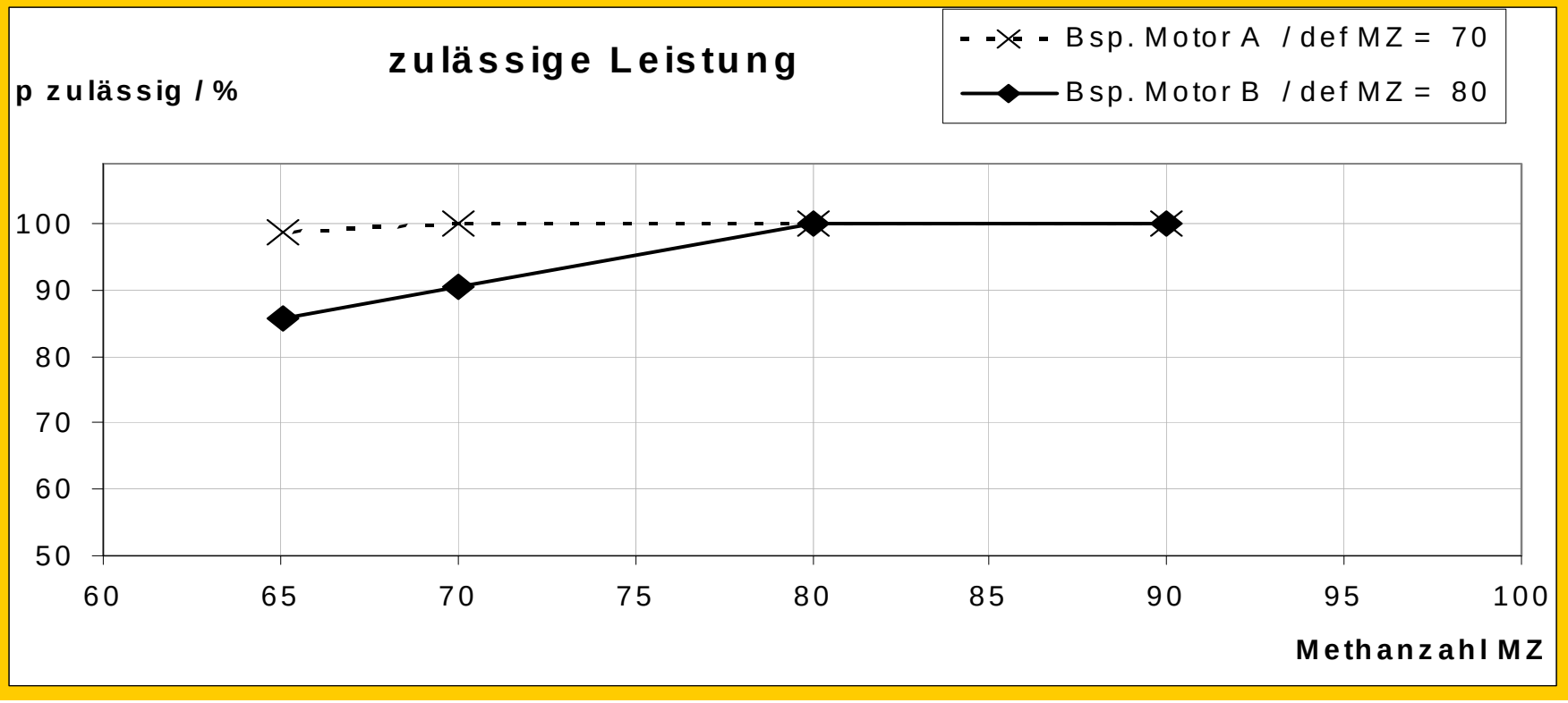
- Reduced methane number resulting in change of efficiency
  - Lower methane number leads to higher flame velocity
  - Engine control increase air ratio to adjust combustion and NOx
  - Both measures have a converse impact to the engine efficiency
  - Due to lower rating effected by the lower methane number a drop in efficiency has to be considered






# Engine rating versus methane number

- Engine rating is impacted by lowering the methane number
  - Knock limit could impact engine rating ( de- rating with lower MN)
  - Knock margin is different from engine to engine
  - Engine reacting  on parameters changes in next working circle






# Measures to operate with changing methane numbers

- Limitation of methane number transient velocity for state of the art gas engines with knock control
- Older field engines without knock control requested in time information from gas supplier about impacting methane number for preventive de- rating
- In time information that temporary supply with low methane number gas is terminated, operator can switch back to previous load profile with improved engine efficiency



# Sulphur content in natural gas supply

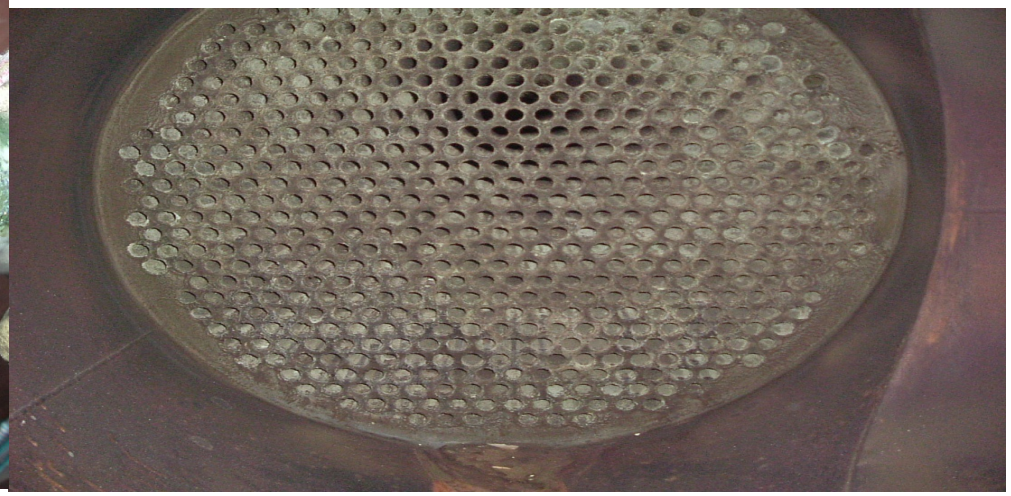
- Natural gas in the network contains contaminants from the different sources.
- Sulphur content is limited acc. to DVGW G260 (max. 30 $mg/m^3_n$ )
  - Sulphur is transported over long distances acc. to pressure and velocity in the pipeline to the consumer
  - Sulphur is converted during the combustion process to $SO_2$
- Especially oxidation catalysts convert SO2 with additional oxidation towards $SO_3$ and generate together with the water vapour sulphur acid $H_2SO_4$
- Increased risk due to sulphur acid corrosion in the exhaust gas system



# Example corrosive attack by sulphur acid

Gas engine operated with natural gas

- The condensate contained sulphur acid with a ph of 0,3 was extreme acid dissolving chromium and nickel in the condensate
- Source for the sulphur origin couldn`t be identified afterwards





# Thank You For Your Attention!