

**6.EFRC Düsseldorf, Germany**

# Using reciprocating compressors to liquefy NG in a small scale LNG Plant

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Director**



# Contents

1. Introduction – RWE Energy and gas storage facilities
2. LNG Plant – Plant Data and Liquefaction Process
3. Type of compressors installed
4. Liquefaction compressor
5. Problems and considerations to optimize liquefaction
6. Solutions to be discussed
7. Conclusion

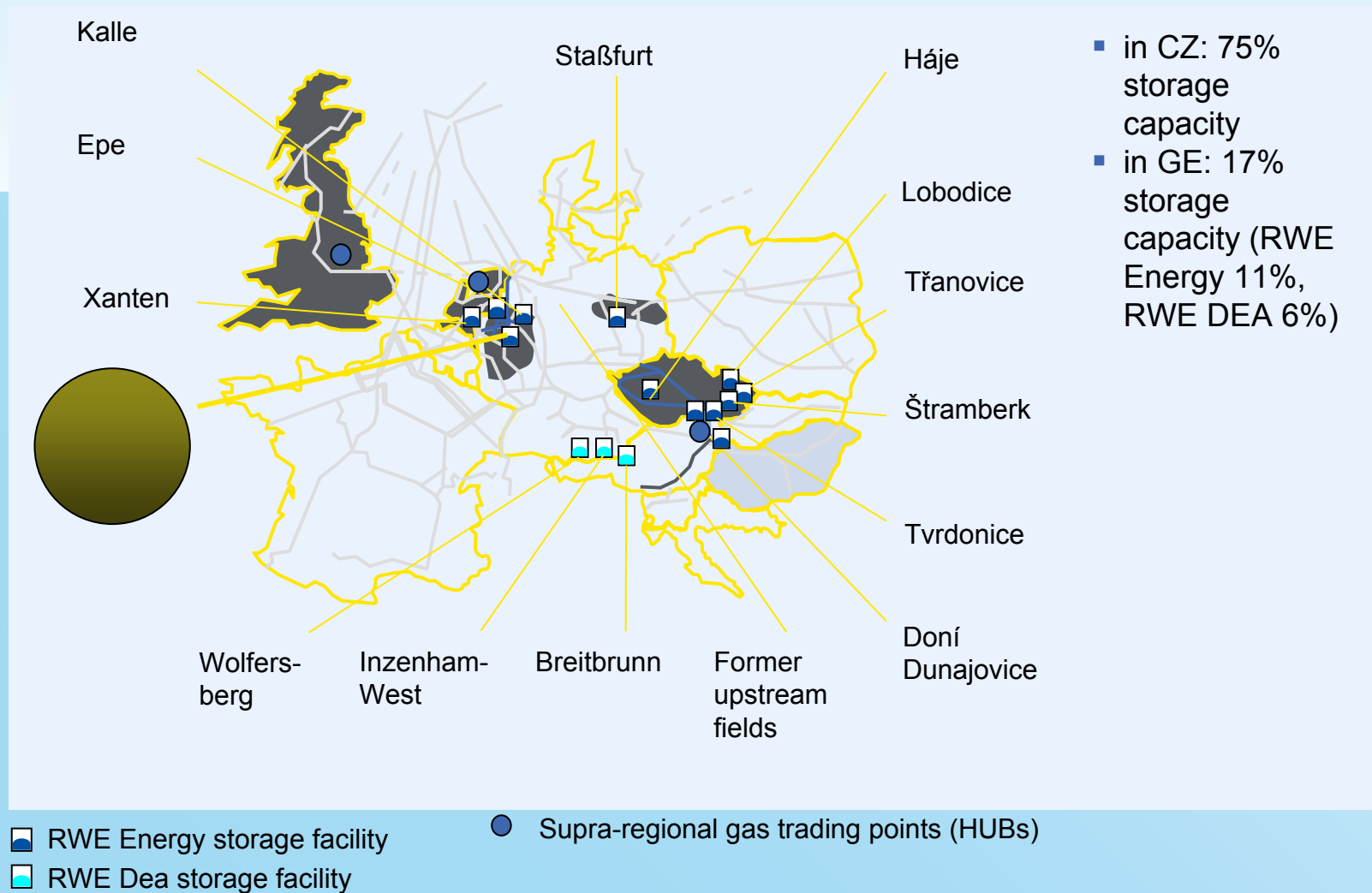
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# RWE Energy

|                                   |                                                    |                                                                     |
|-----------------------------------|----------------------------------------------------|---------------------------------------------------------------------|
| <b>gas sales</b>                  | <b>258 bill</b>                                    | <b>kWh</b>                                                          |
| <b>electricity sales</b>          | <b>168 bill</b>                                    | <b>kWh</b>                                                          |
| <b>gas-storage (underground)</b>  | <b>3.3 bill</b>                                    | <b>Nm<sup>3</sup></b>                                               |
| <b>gas-storage (above-ground)</b> | <b>21,500</b><br><b>14 mio.</b><br><b>140 mio.</b> | <b>m<sup>3</sup> LNG</b><br><b>Nm<sup>3</sup> gas</b><br><b>kWh</b> |

# RWE Energy storage facilities



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# LNG Plant Nievenheim - basic data



|                        |         |
|------------------------|---------|
| start of construction: | 1974    |
| start of operation:    | 1976    |
| reinvestment:          | 2003/07 |

## LNG-Tank:

|           |                       |
|-----------|-----------------------|
| height:   | ca. 32 m              |
| diameter: | ca. 37 m              |
| volume:   | 21,500 m <sup>3</sup> |



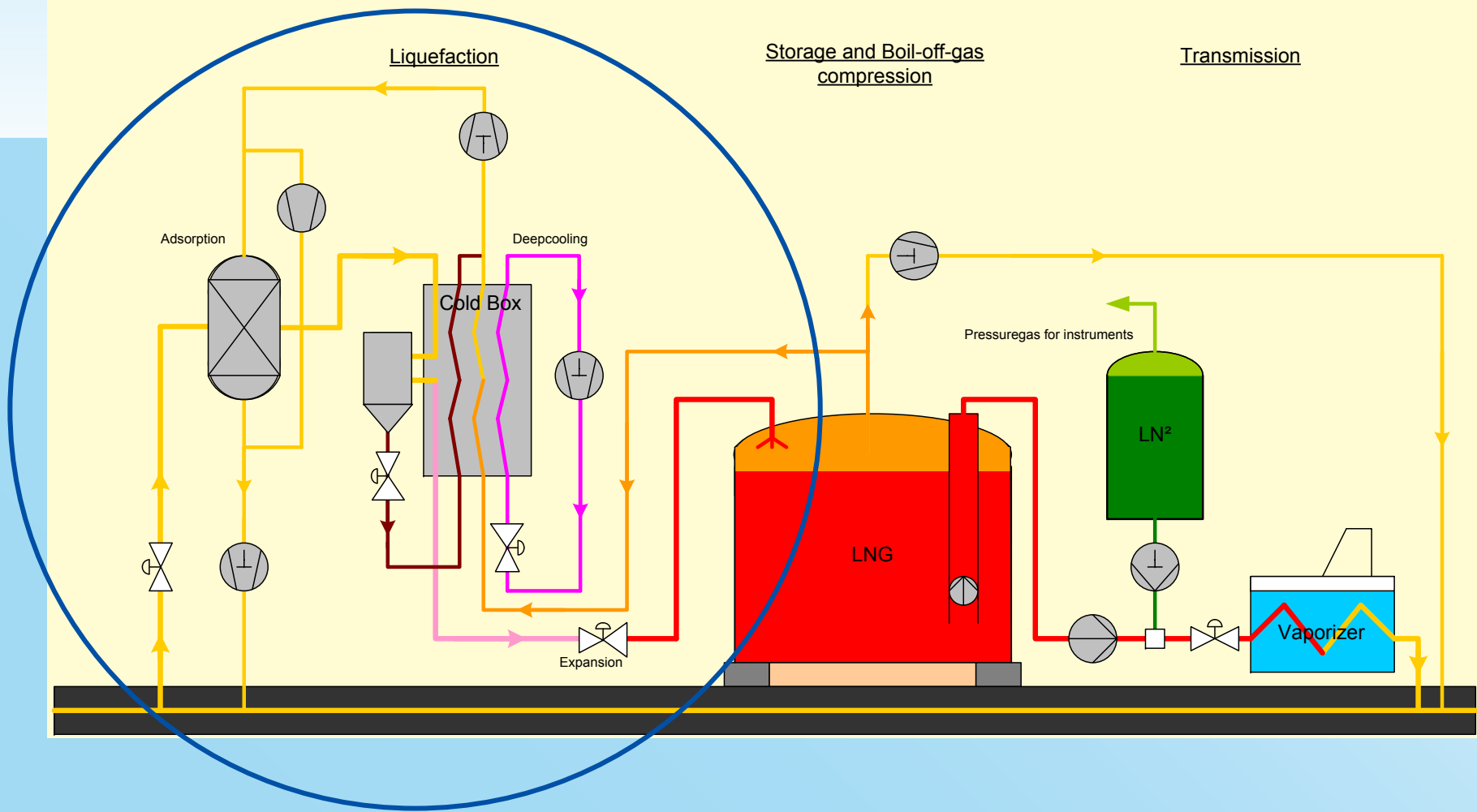
|                        |                            |
|------------------------|----------------------------|
| capacity (L-gas form): | 14 Mio.Nm <sup>3</sup>     |
| liquefaction           | 2,400 Nm <sup>3</sup> /h   |
| regasification         | 100,000 Nm <sup>3</sup> /h |

|               |                            |
|---------------|----------------------------|
| 5 Compressors | (3 reciprocating, 2 turbo) |
|---------------|----------------------------|

# Peak Shaving Plant Nievenheim

## Plant scheme

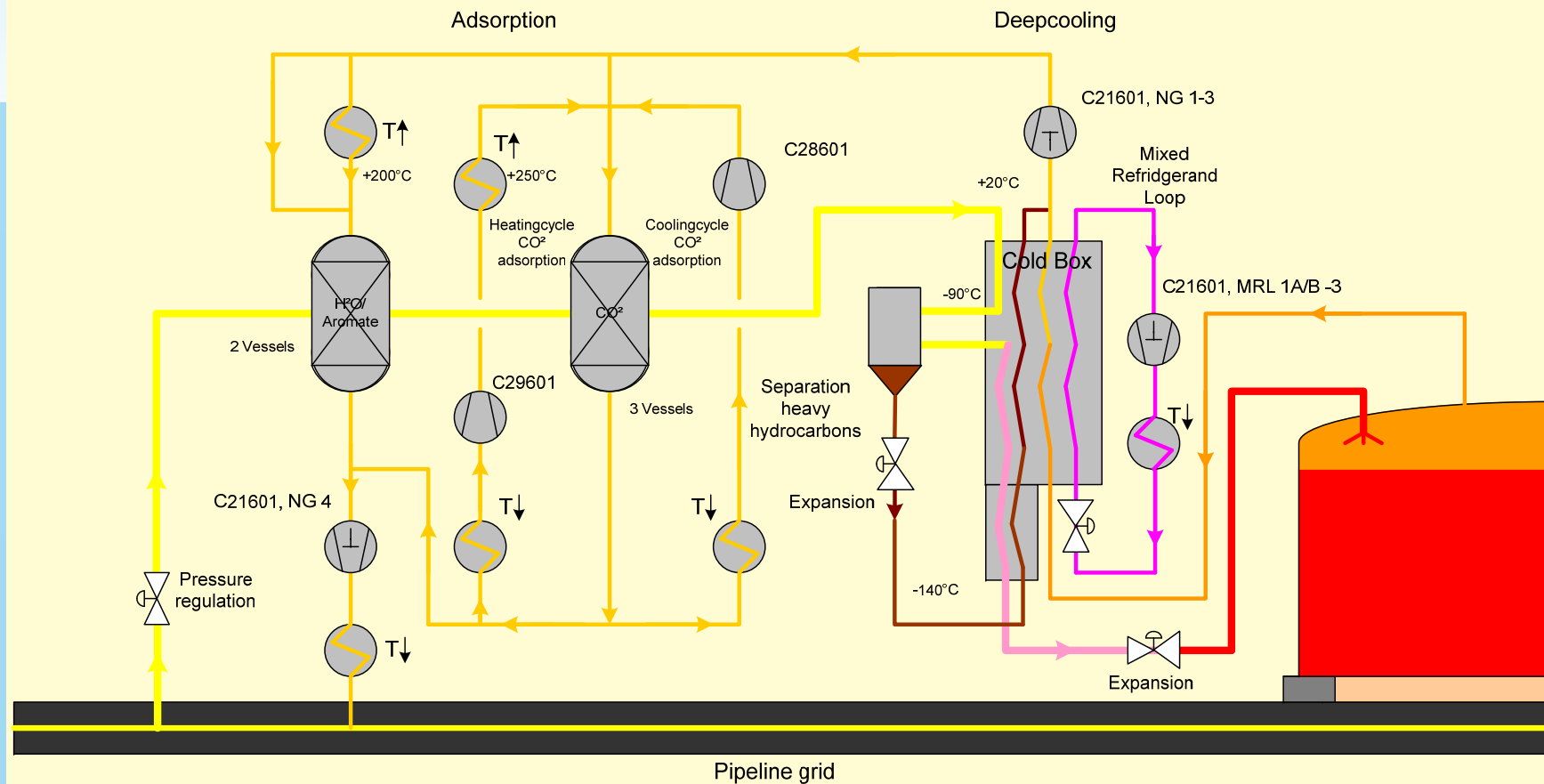
Stand 2008



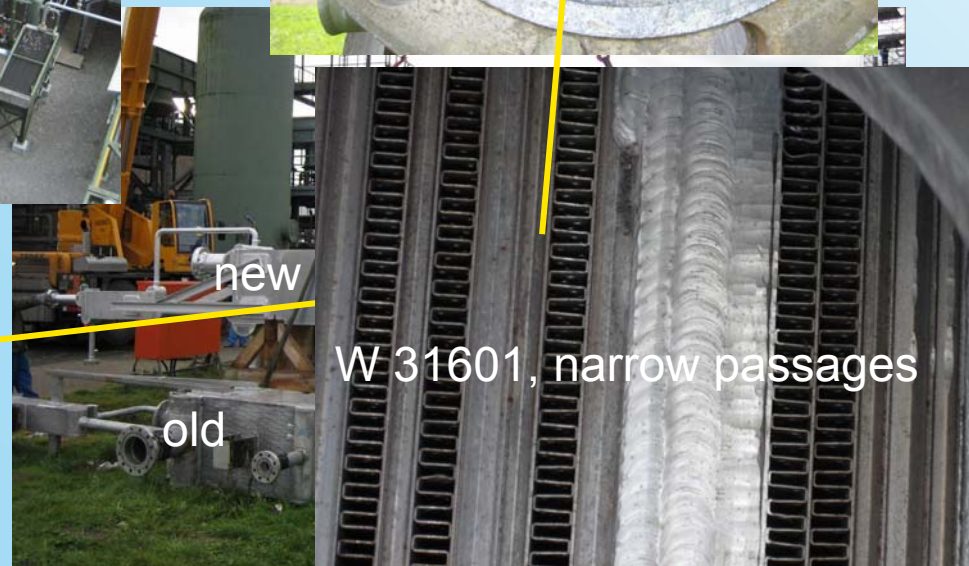
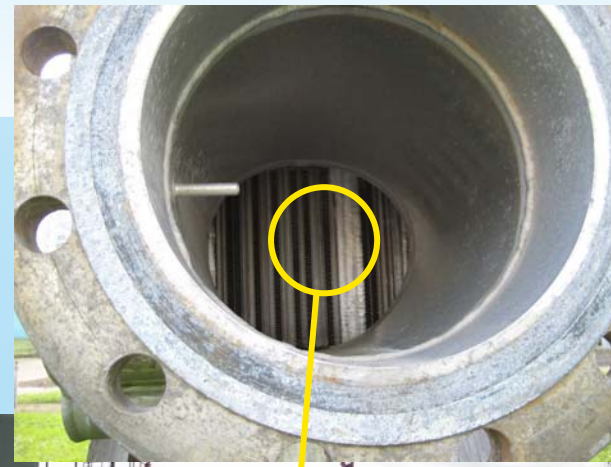
# Peak Shaving Plant Nievenheim

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## Liquefaction - Natural gas flow



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## Stand 2008

The diagram illustrates the process flow of a CO<sub>2</sub> capture plant, divided into two main sections: **Adsorption** and **Deepcooling**.

**Adsorption Section:**

- Feed:** The process starts with a feed from the **Pipeline grid** at the bottom, passing through a **Pressure regulation** valve.
- CO<sub>2</sub> Adsorption:** The feed enters a **CO<sub>2</sub>** adsorption vessel (3 Vessels). The **Coolingcycle CO<sub>2</sub> adsorption** is maintained at **+250°C**. The **Heatingcycle CO<sub>2</sub> adsorption** is maintained at **+200°C**.
- FGD/Aromatics Adsorption:** The feed also passes through a **FGD/Aromatics** adsorption vessel (2 Vessels). The **Coolingcycle Moisture and aromatics adsorption** is maintained at **+200°C**.
- Temperature Control:** Temperature sensors (T) are placed at various points in the flow, showing **T↑** (heating) and **T↓** (cooling).
- Separation:** The process includes a **Separation heavy hydrocarbons** step, followed by an **Expansion** valve.

**Deepcooling Section:**

- Cold Box:** The feed enters a **Cold Box** where the temperature drops to **-90°C**.
- Refrigeration:** A **Mixed Refrigerand Loop** is used for deepcooling, involving a **C21601, MRL 1A/B -3** stream.
- Expansion:** The feed passes through an **Expansion** valve, reaching a temperature of **-140°C**.
- Storage:** The final product is stored in a large tank, with a **C21601, NG 1-3** stream being added.

**Process Flow Summary:**

- The feed from the **Pipeline grid** is regulated and then splits into two parallel adsorption vessels (CO<sub>2</sub> and FGD/Aromatics).
- The adsorption vessels are cooled by a **Coolingcycle** and heated by a **Heatingcycle**.
- The feed then passes through a **Separation heavy hydrocarbons** step and an **Expansion** valve.
- The feed enters a **Cold Box** where it is cooled to **-90°C**.
- The feed then passes through a **Mixed Refrigerand Loop** and another **Expansion** valve, reaching **-140°C**.
- The final product is stored in a large tank, with a **C21601, NG 1-3** stream being added.

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Central-heating boiler

Heat exchanger  
(carbon dioxide  
adsorber)

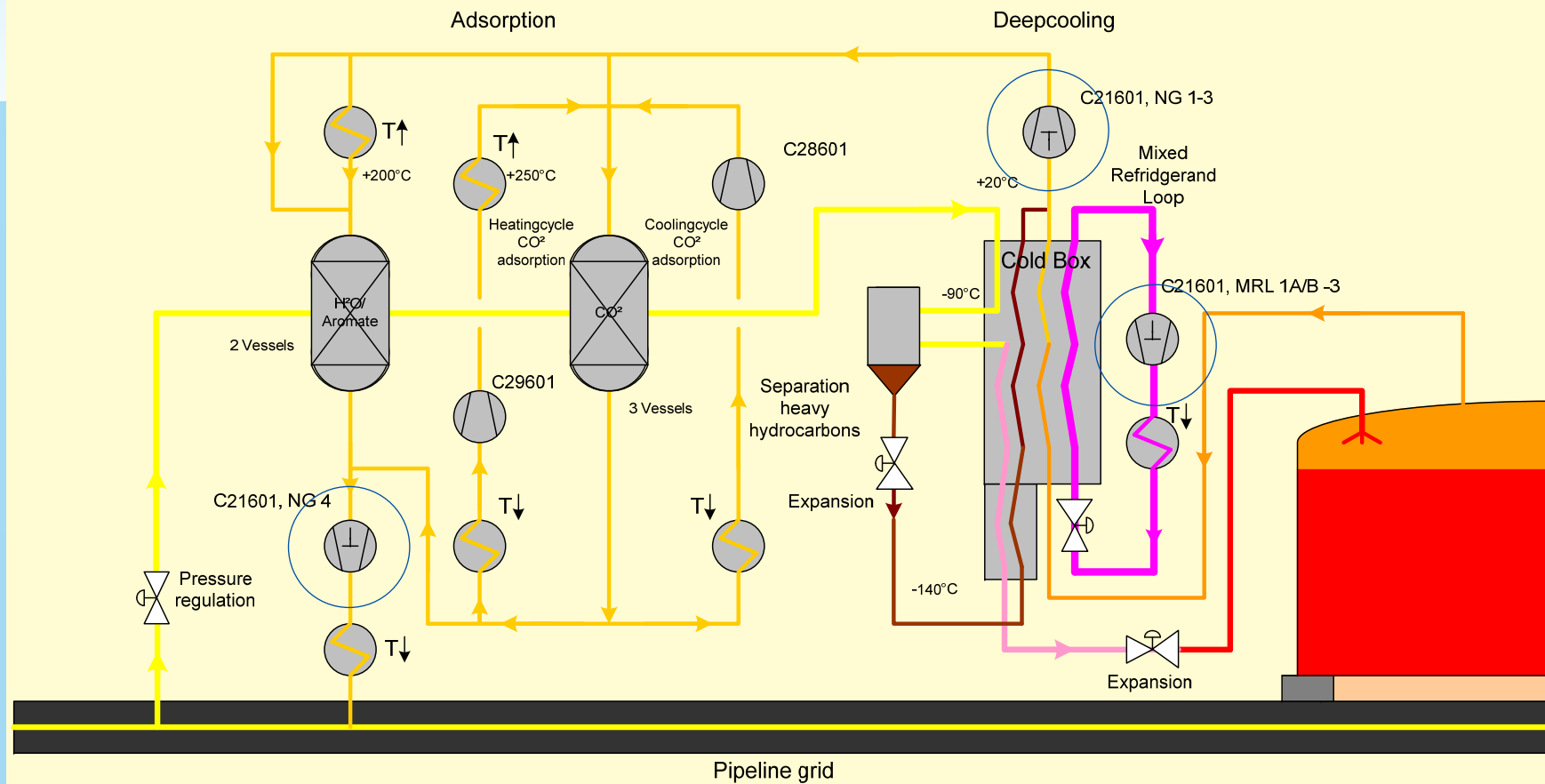


Heat  
exchanger  
(Moisture and  
aromatics  
adsorber)

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## Liquefaction – Coolant circuit



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# Peak Shaving Plant Nievenheim

REG Gas handling >>> compressor C 28/29 – 601



Turbo compressors for  
Heating up /cooling within  
the REG Gas cycle



# Peak Shaving Plant Nievenheim

BOG handling >>> compressor C 22601

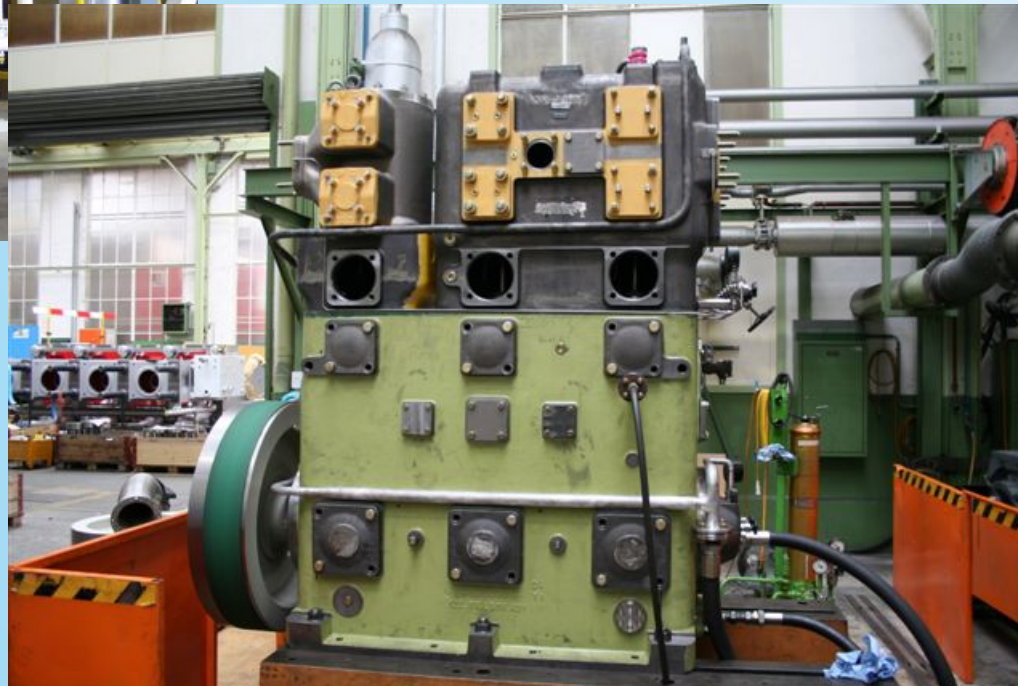


# Peak Shaving Plant Nievenheim

BOG handling >>> compressor C 22601



Mechanical Test run



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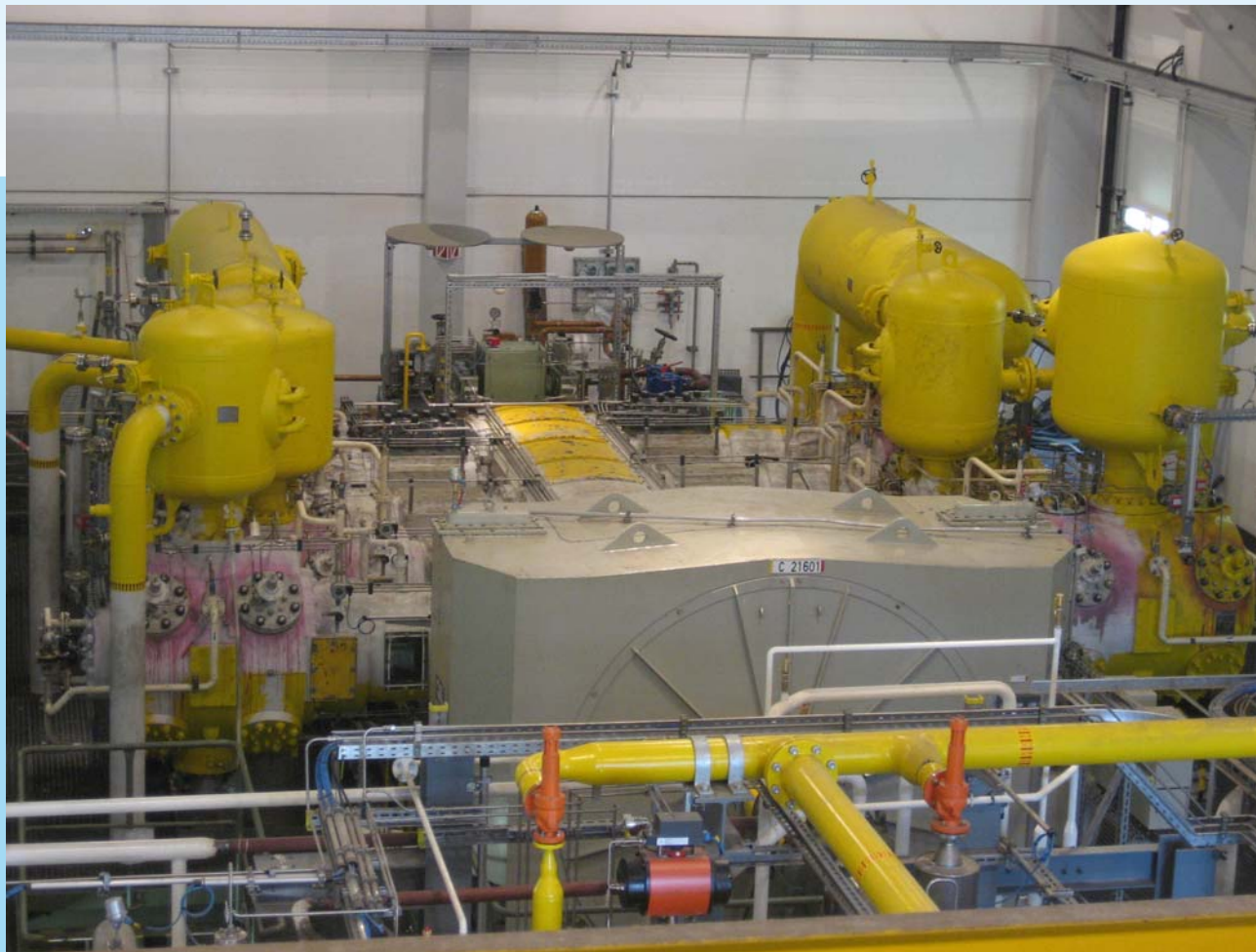


Typical compressor in Cavern storage plants

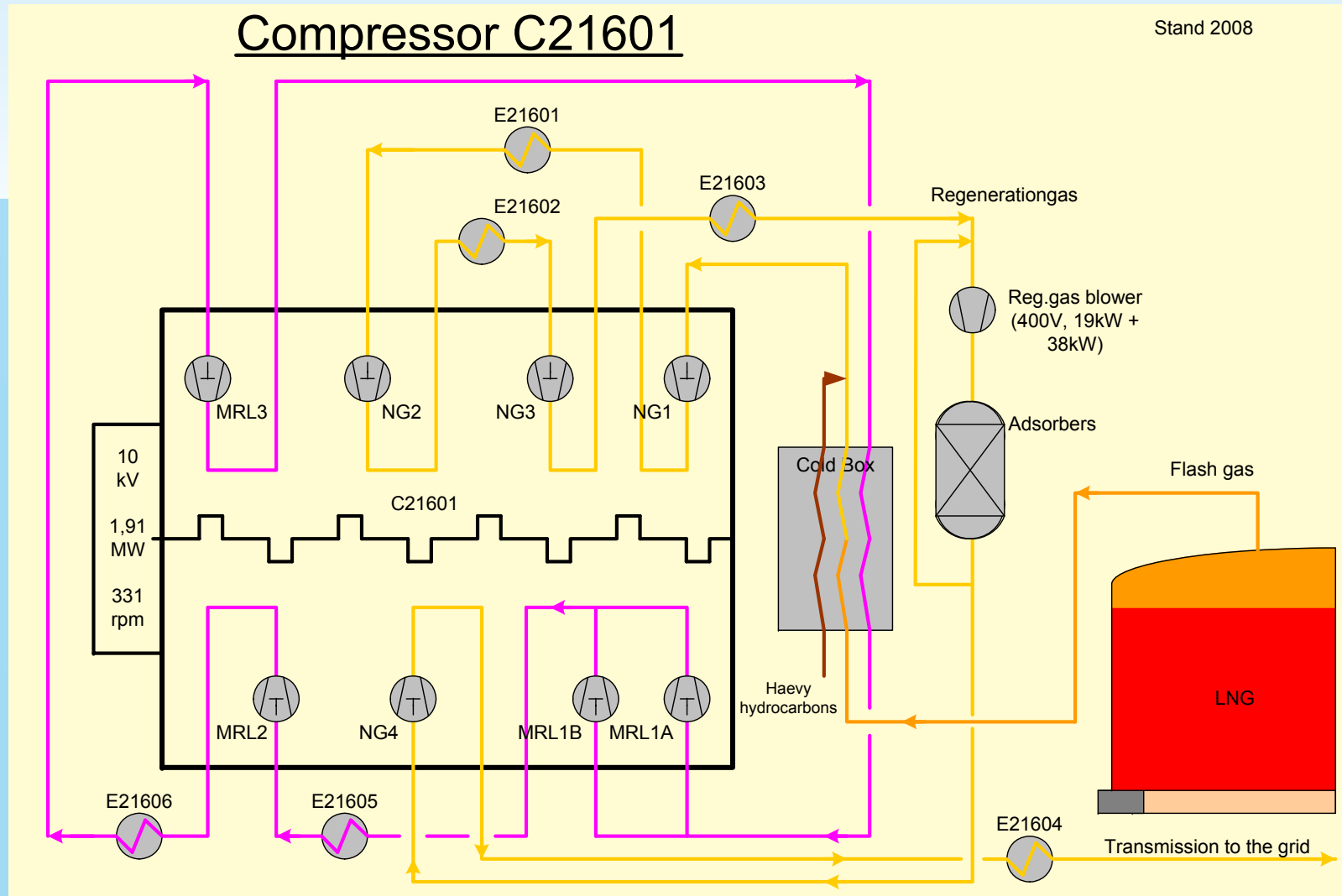


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## Compressor C21601



# Peak Shaving Plant Nievenheim



# Peak Shaving Plant Nievenheim

## Compressor C 21601



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## Compressor C 21601

### Some operation problems and limitations

- ▶ Control of process
- ▶ Startup conditions
- ▶ Trip function/ control of compressor safety features
- ▶ Control of process at partial load conditions
- ▶ High risk to damage the compressor

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## Solutions/next steps

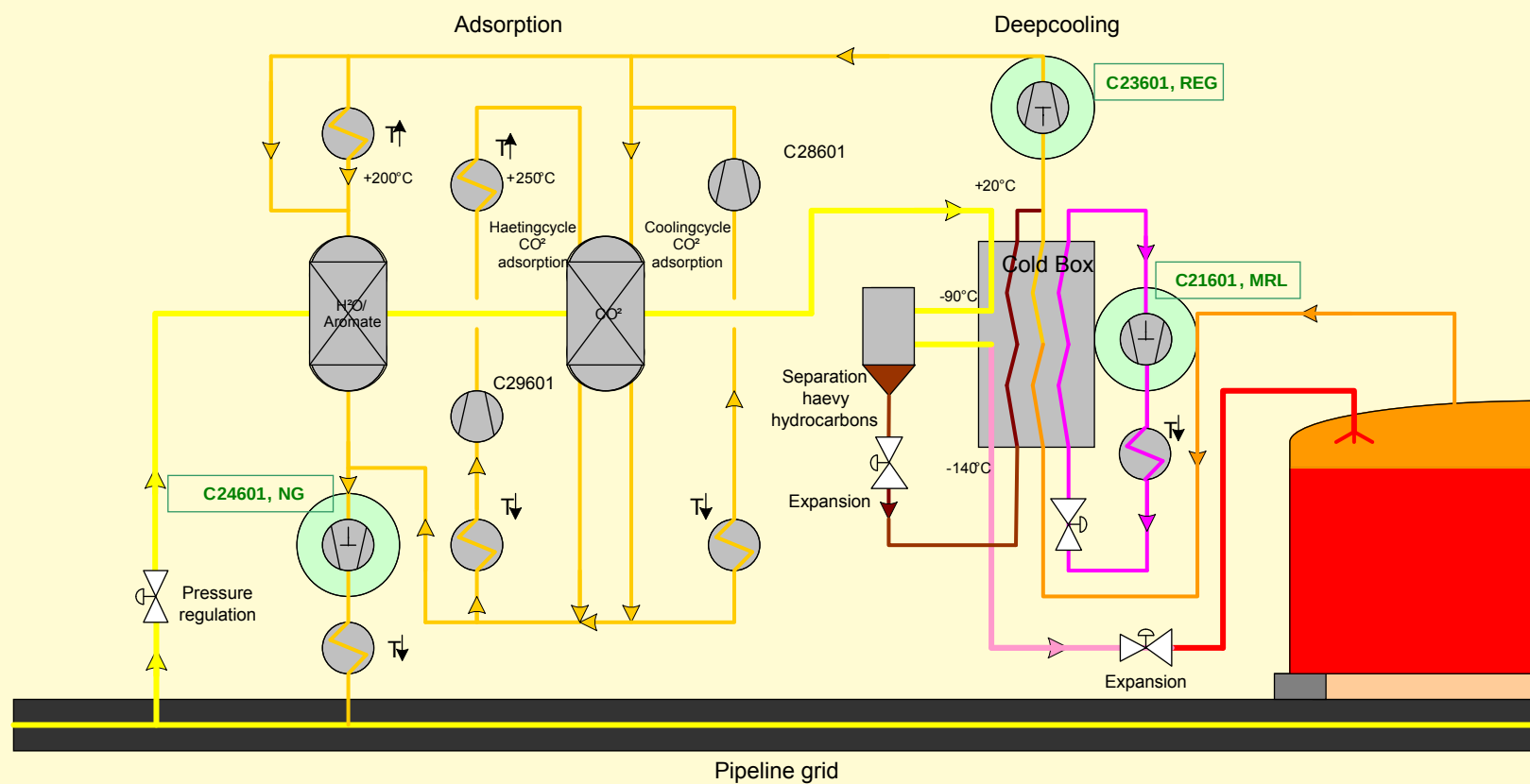
### Solutions to be discussed

- ▶ New liquefaction process
- ▶ Optimized existing plant arrangement ( modify MRL)
- ▶ New compressor arrangement

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## Liquefaction process-new-

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## Conclusions

- ▶ Existing compressor arrangement is complex but it works
- ▶ Still possibilities to optimized the existing process
- ▶ Discuss new compressor arrangements
- ▶ **Next Step:** Conduct feasibility study to compare CAPEX/OPEX of the alternatives

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**Thank you  
for your attention !**

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