EUR24_15 - Advanced automation scheme for a multistrand and multi-mode plant

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Introduction

This tutorial will explain to you what we developed some years ago to fulfill a high and flexible demand on automation for a process plant

I will present:

- Complex but flexible structuring of automation functions
- Programming to process plant's operational demand
- Advanced control configuration according to "good craftmanship praxis"
- Use "Proven in use" equipment and function modules
- Use of standardized Software packages

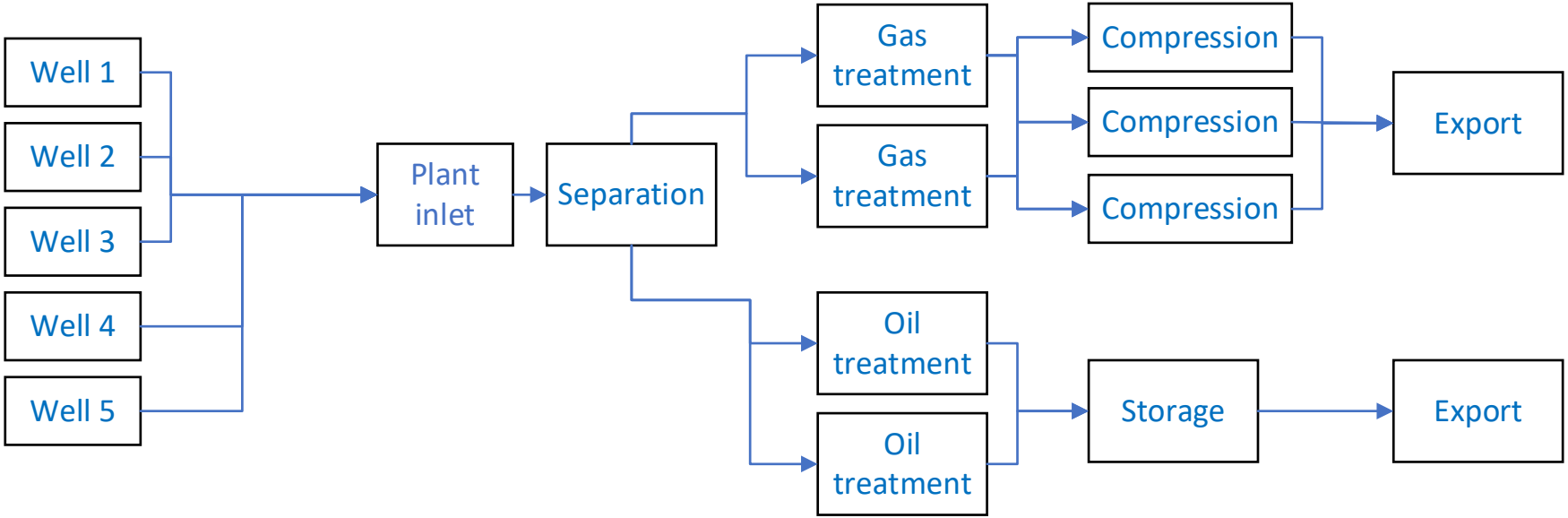
Agenda: Advanced automation scheme for a multistrand and multi-mode plant

- Introduction
- Typical layout of oil & gas process plants
- Typical layout of batch plants
- Typical gas storages
- Schematic of a gas storage plant
- The way in between
  - Different operation modes
  - Structure of process plant
  - Advanced operator interface for operation modes
  - Control strategies, load share
  - Running a product delivery schedule

Examples are from German plants, therefore some terms are in German

Typical layout of petrochemical plants

Petrochemical plant are usually single or multistrand, but in a fixed sequence with fixed duties



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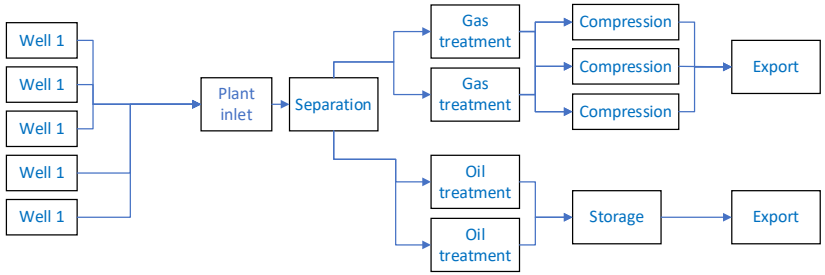
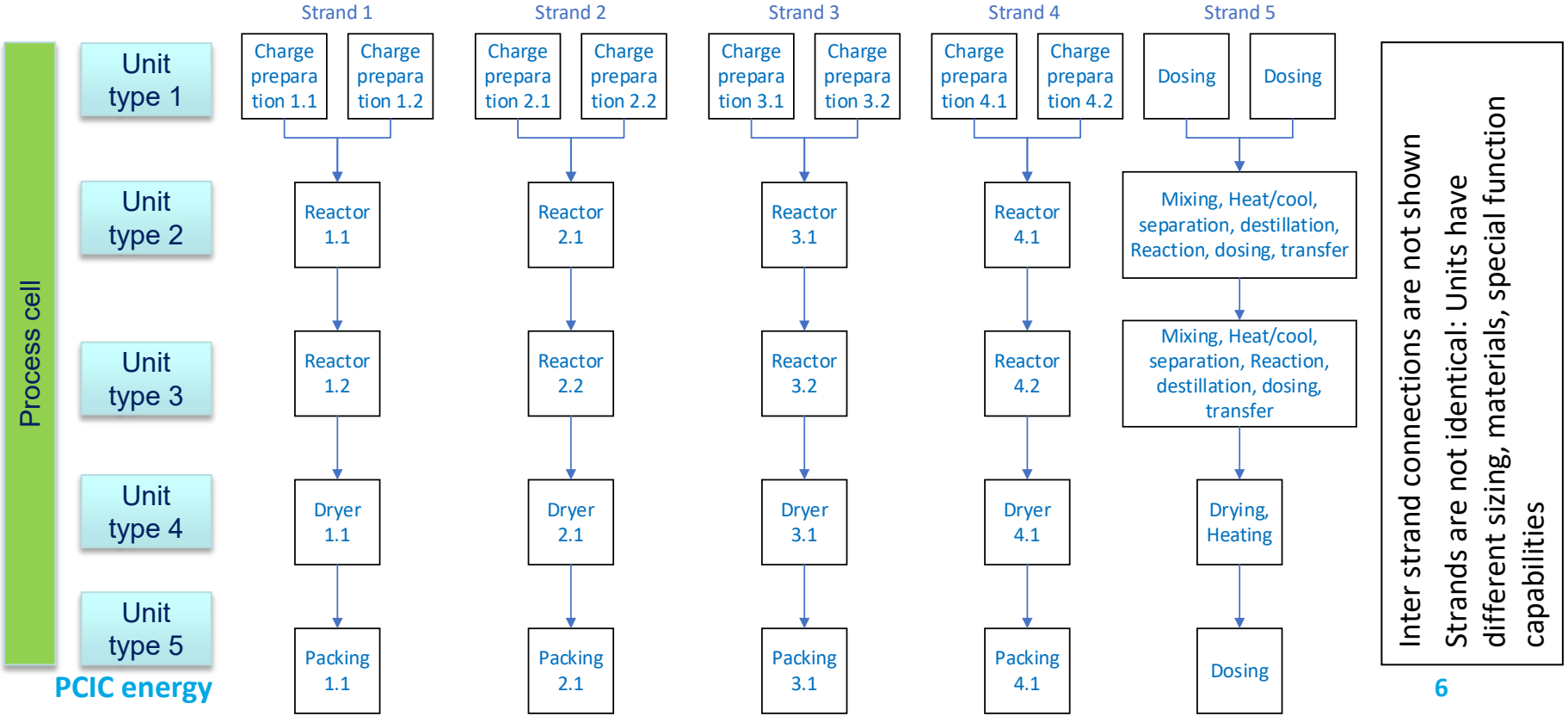


- One dedicated duty per unit.
- Fixed connection of units and fixed direction of flow.
- Single or multi strand configuration. Strands have equal duties and properties.
- Continuous operation. All sections are operating.
- Rare starts and stops (1 to 5 years continuous operation).

Typical layout of pharmaceutical or batch plants

Batch plants are multistrand, multipurpose with variable connections



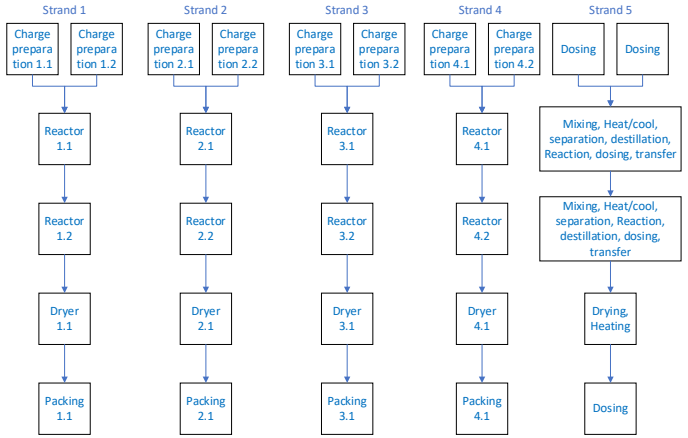
Inter strand connections are not shown

Strands are not identical: Units have different sizing, materials, special function capabilities

Typical layout of pharmaceutical or batch plants

Batch plants are multistrand, multipurpose with variable connections

- several duties per unit (reactor: mixing, heating, reaction, separation, distilling, dosing, etc.)
- Fixed direction of flow. Batch runs from unit to unit. Not all units are running.
- Non continuous operation
- variable and changing connections

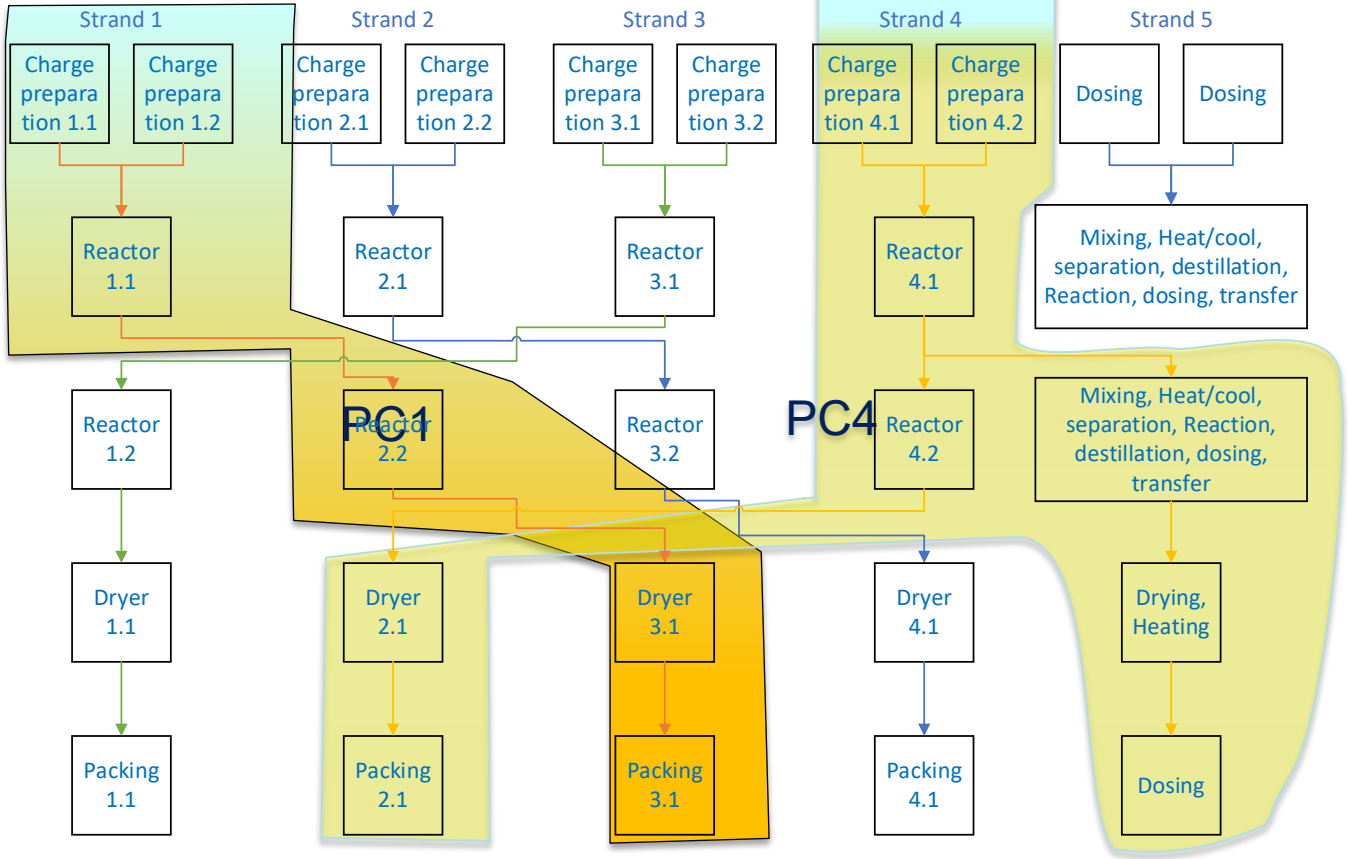


- Single or multi strand for one product. Several products at same time
- To setup the equipment requirement for a product, units will be connected to a **process cell**. Generic, variable assemblage of process cells
- Frequent starts stops (daily or by shift or weekly, depending on process and production needs)

Typical layout of pharmaceutical or batch plants

Next day, new products, new setup, new process cells

Strands are not identical:
Units have different sizing, materials, special function capabilities

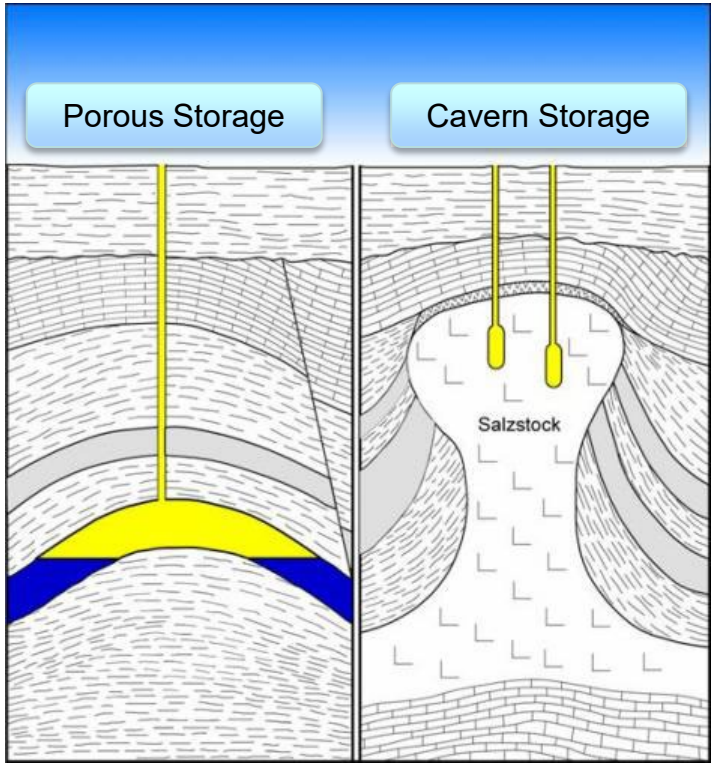


There is something in between: Gas storage plant

Types of underground gas storage

- Porous storage
  These are former gas field. They have proven to be tight by rock layers since millions of years (Rehden, Haidach are former gas fields).
- Cavern storage
  These are large caves created by salination. The size is around 80m diameter and 400m height. (Jemgum, Etzel, Epe are Kavern Storages)
- Aquifer storage
  The gas will displace water in deep ground layers. The proof of tightness is difficult.

All require facilities to connect to a pipeline grid



There is something in between: Gas storage plant facilities

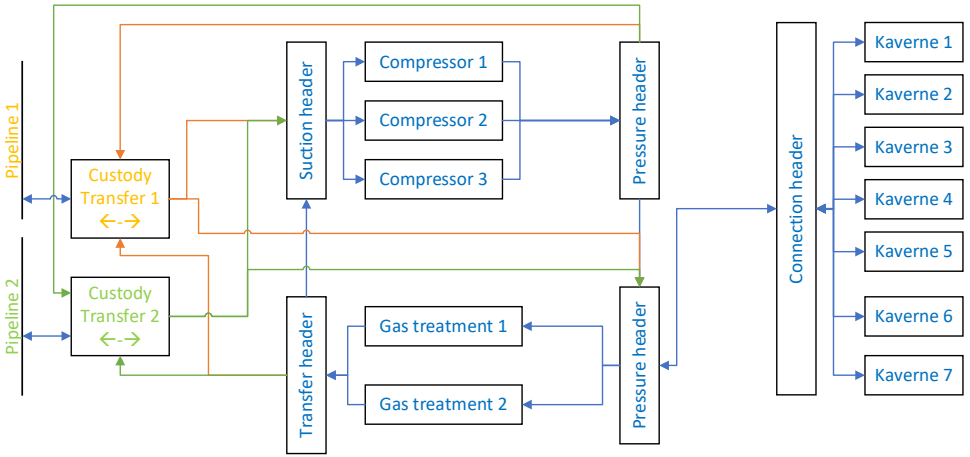
Standard Operation modes:

↓ Injection w/o Compression (In w/o C)

↓ Injection with Compression (In w C)

↑ Withdrawal w/o Compression (Wd w/o C)

↑ Withdrawal with Compression (Wd w C)

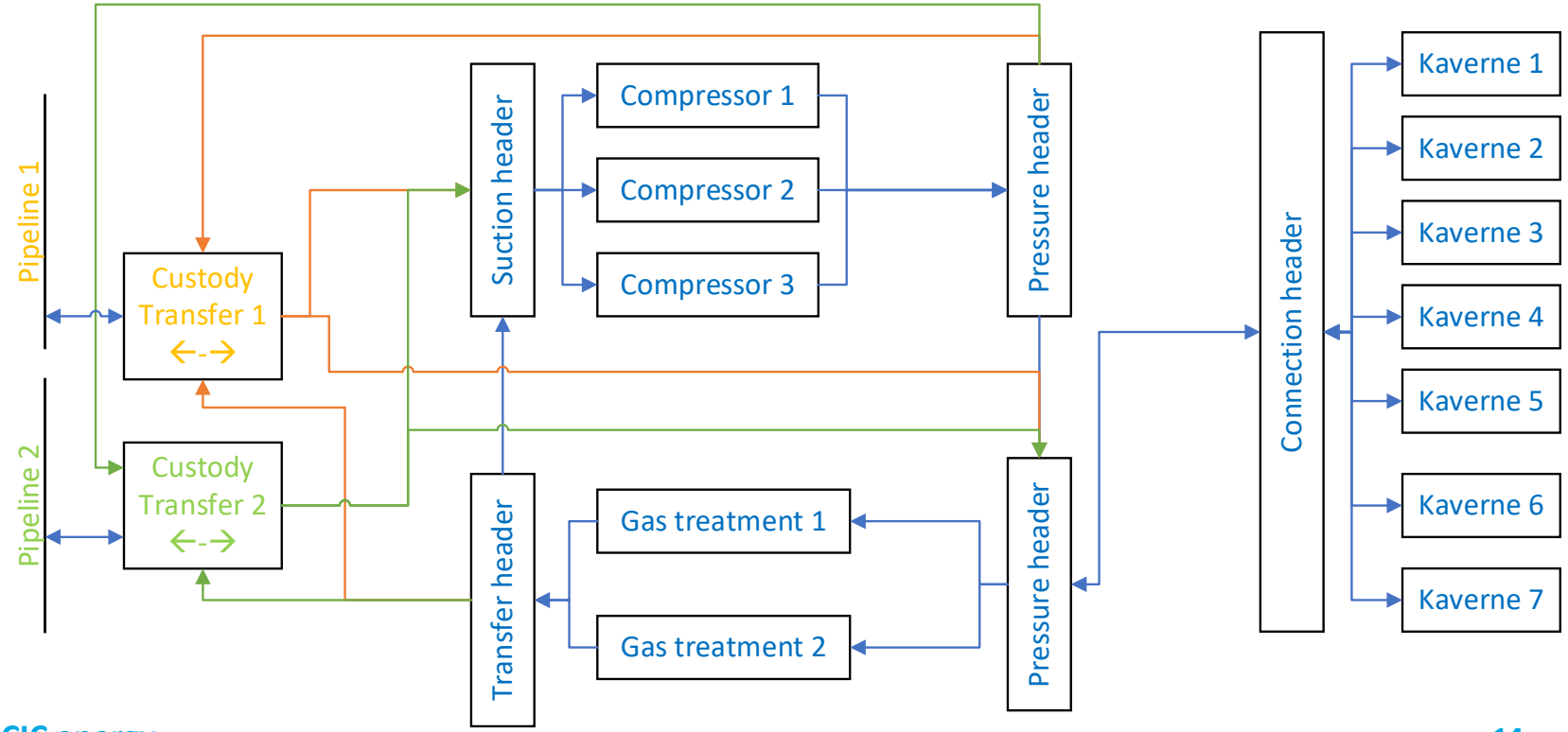


Special operation modes:

- Swap w/o Compression (Sw w/o C)
- Swap with Compression (Sw w C)

There is something in between: Gas Storage Plant facilities

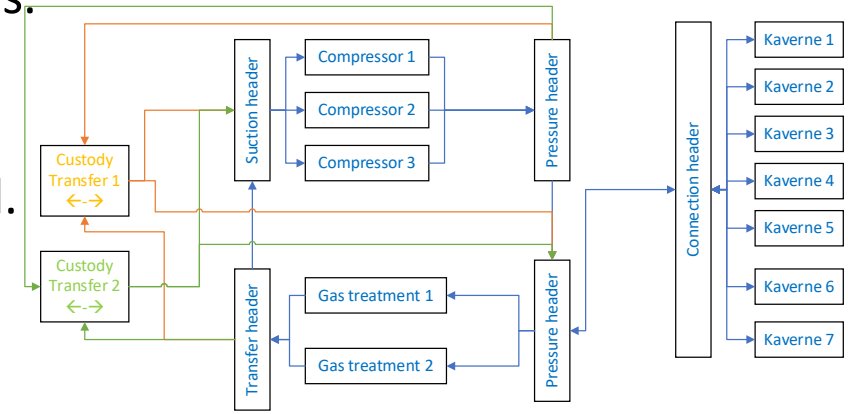
Schematic of an Underground GasStorage: Variable connections, bi-directional



Note: Doubled headers are not shown

Gas storage typical units

Units of gas storages plants and their duties.

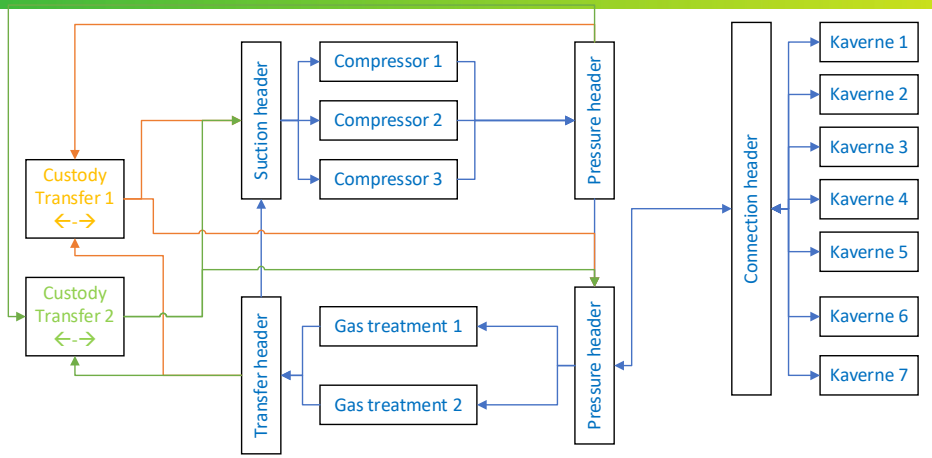


- **Custody transfer** measures the gas flow to and from the storage to a pipeline grid.
- **Compression** lifts the gas pressure from pipeline level (50-80 bar) to storage pressure (60-200bar) or return.
- **Gas treatment**: when the gas comes out of the ground it is too wet to feed into the pipeline grid. Needs to be heated, dewatered, pressure control.
- **Kaverne, wells**: The storage containment (recipient).
- **Header system** connects the units. Usually double or more headers.
- **Utilities**: hot water, glycol regeneration, glycol injection, flare, gas recovery.

Gas storage operation modes

Gas storages have:

- **Bi-directional** flow represented by **operation modes**,
- Single **duties** per unit,
- Single or **multi** strand for one operation mode.



- Variable and changing connections using a header system, high number of possible combinations,
- **Defined** origination of **process cells**. This is at a dedicated unit (transfer point). Assembling the units to a process cell will be to the demand of operation mode.
- Continuous operation until the demand changes.
- **Often** starts stops (up to 100 per year, depending on demand)

Gas storage operation example

In order to perform an **operation mode**, the variable connections need to be utilized for setting up a **process cell** which is suitable for the task.

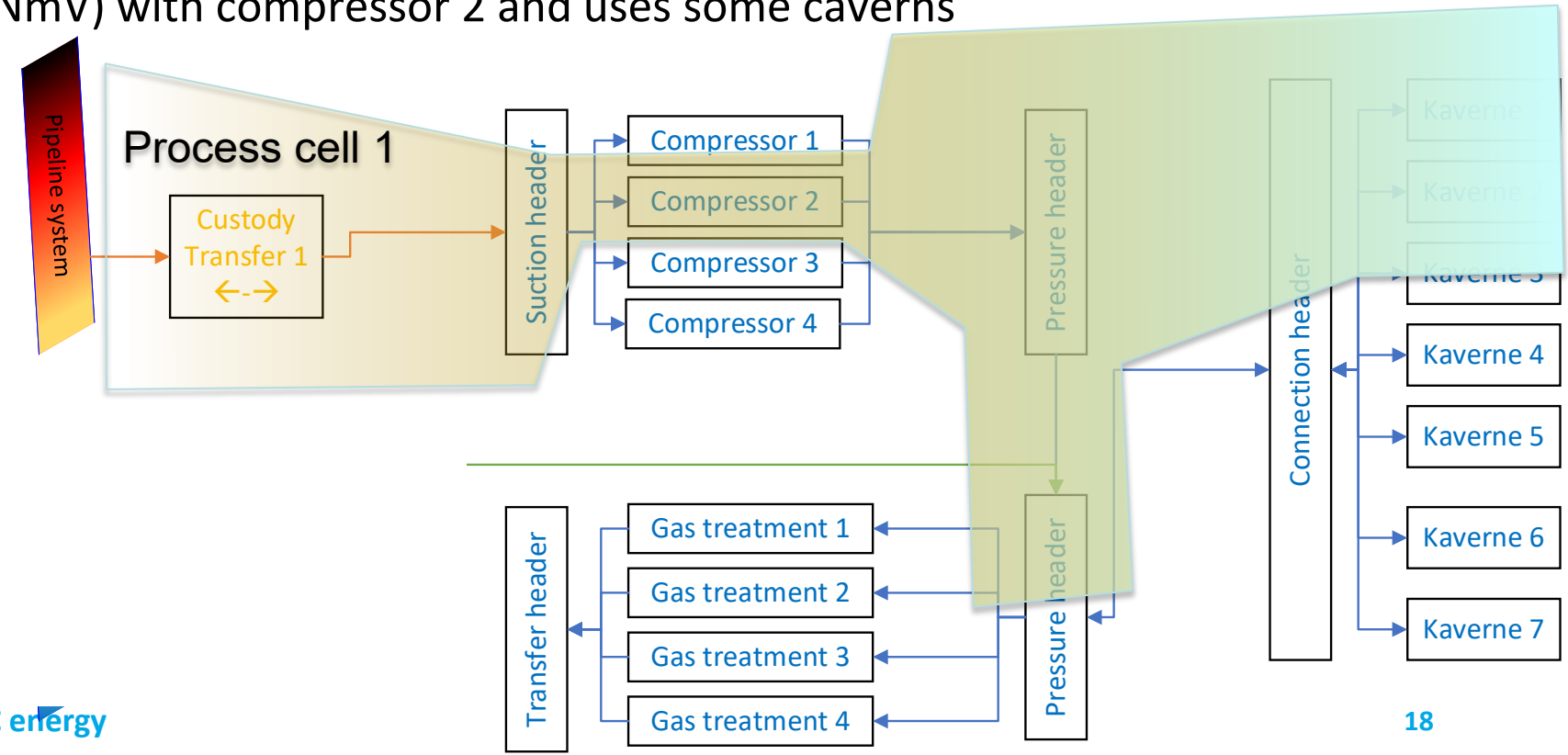
Defined origination of **process cells** is at a dedicated unit (transfer point). Assembling the units to a process cell will be as to the demand

- Demand1: extract from Pipeline grid via custody transfer 1 an amount of gas into the storage.

➢Example1: Process cell 1 originates in custody transfer 1 and does EINmV with compressor 2 and uses some caverns

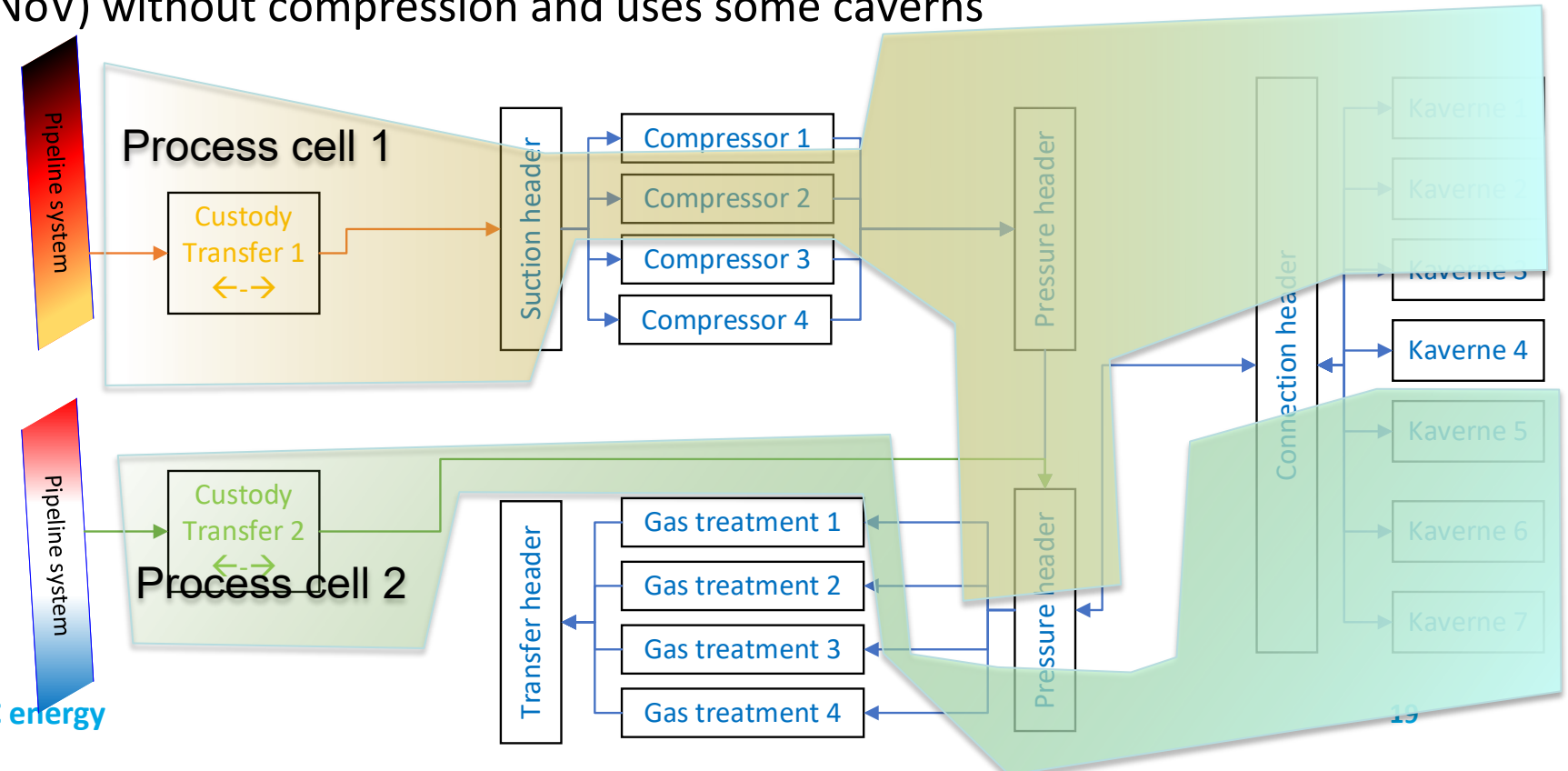
Gas storage operation example

Example1: Process cell 1 originates in custody transfer 1 and does injection (EINmV) with compressor 2 and uses some caverns



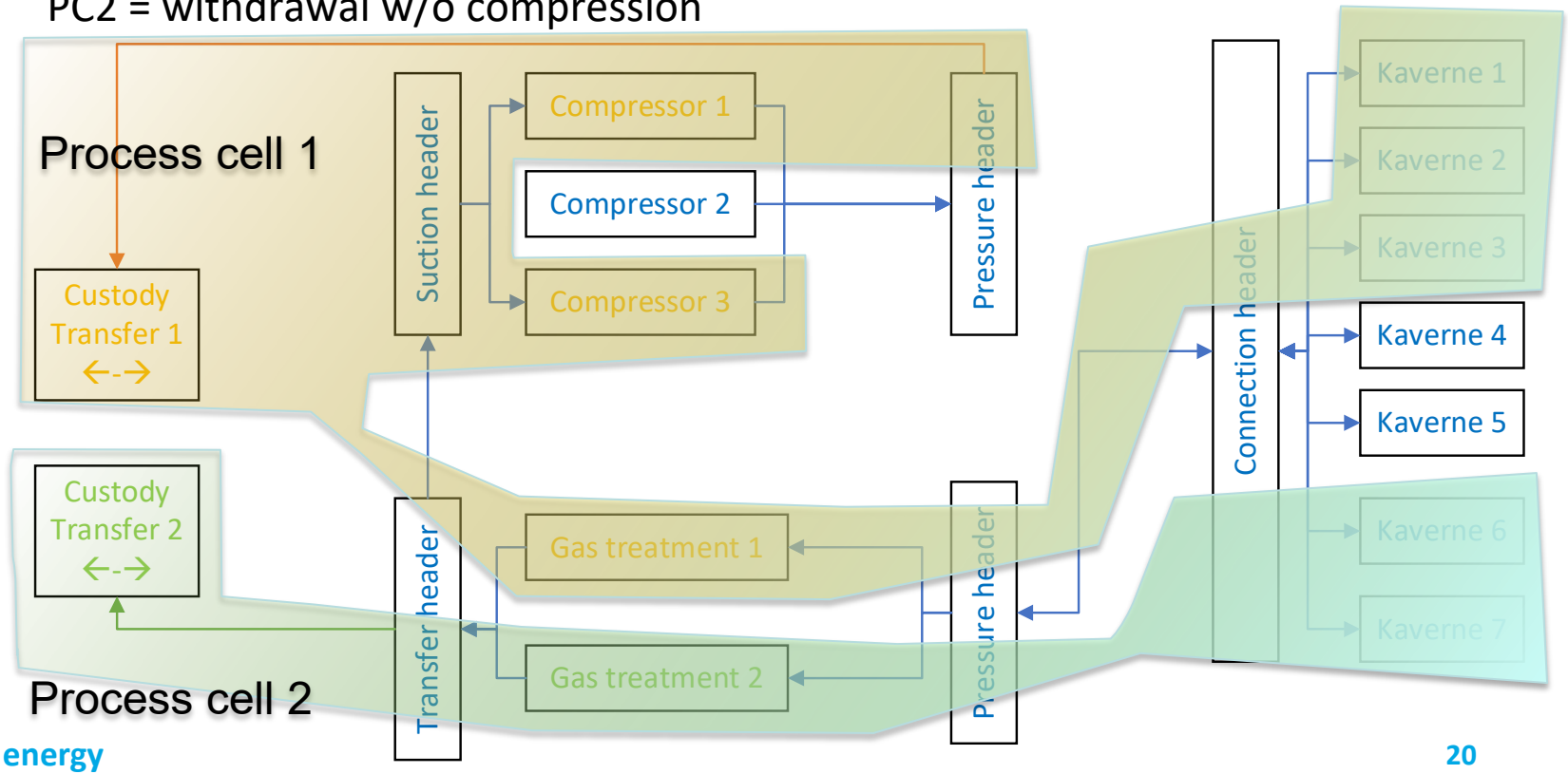
Gas storage operation example

Example2: Process cell **2** originates in custody transfer 2 and does injection (EINoV) without compression and uses some caverns



Gas storage operation modes

Example3: PC1 = Withdrawal with compression
PC2 = withdrawal w/o compression



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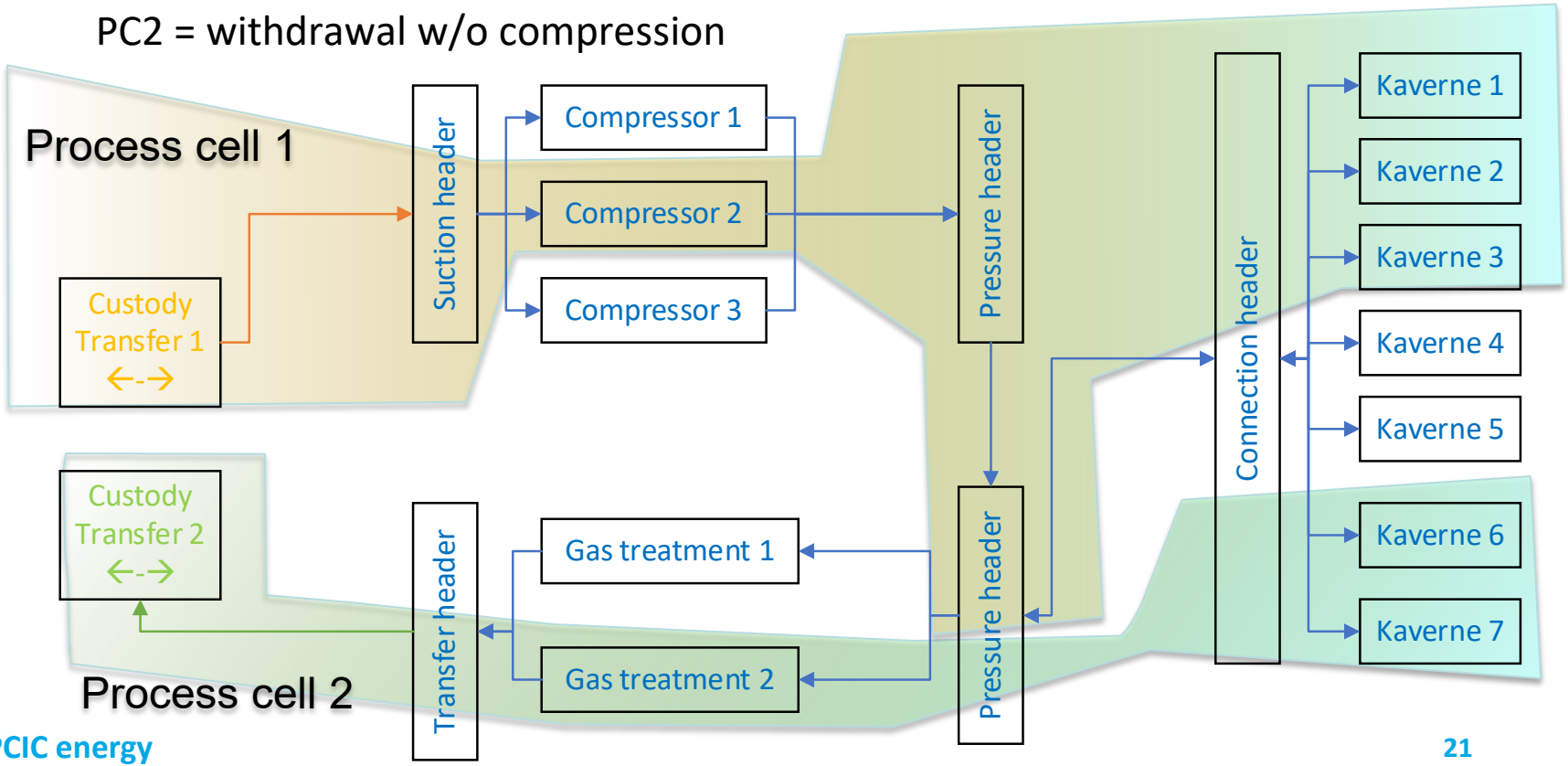
Gas storage operation modes

Example4: PC1 = Injection with compression

PC2 = withdrawal w/o compression



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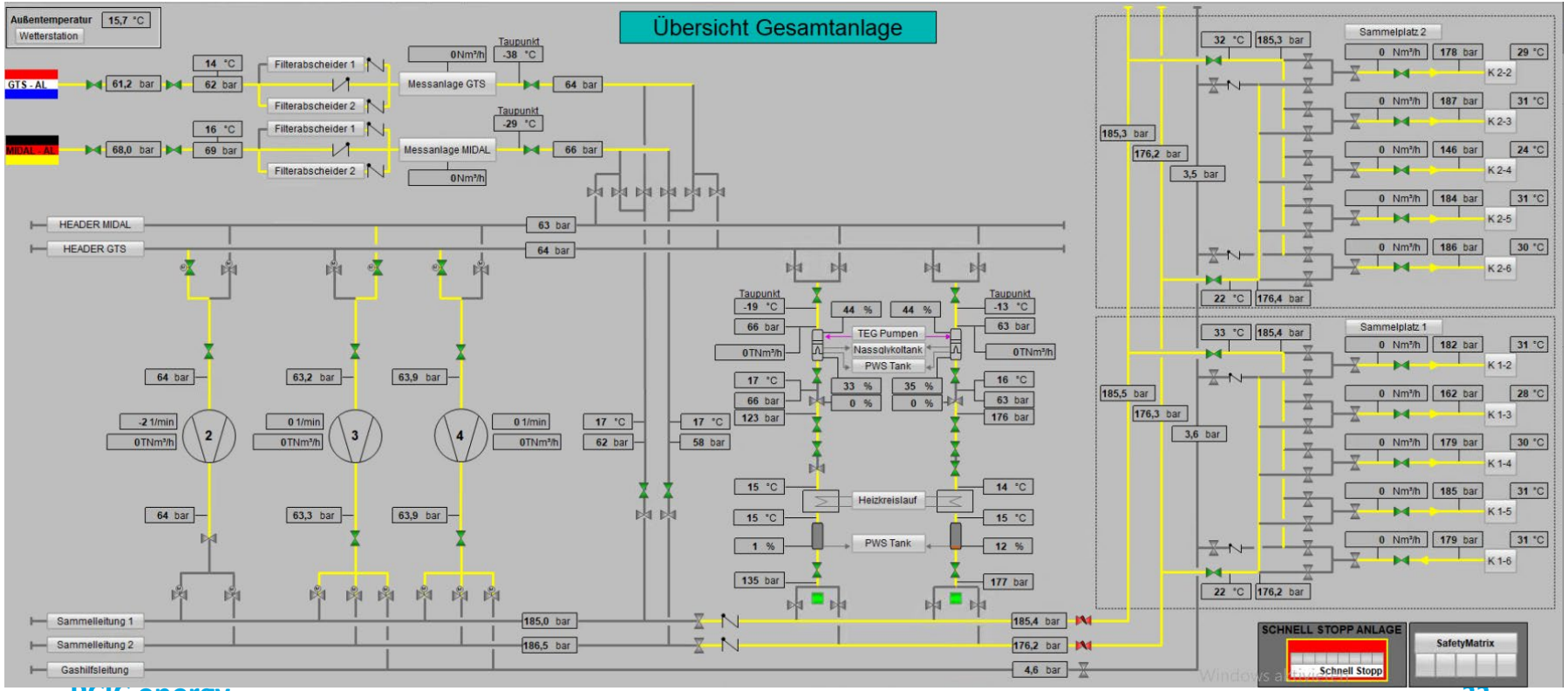
Plant structure Jemgum

130 controls, 1429 indic., 318 O/C valves, 91 contr.valves, 77 motors, 1460 bin. values



Gas storage operation modes, degree of automation

- Many mode and direction changes per year
  - Necessity of short response time for start up and operation mode change
- Operation from a remote-control center
  - High grade of automation
  - support and relief of the operator
  - Automatic start up mode change and adding unit after selection of the structure
  - Consequent control structure which responses to the operation modes and selection of units
- High availability
  - A failure of one unit shall not lead to a complete plant failure
  - Short reaction time and good diagnostics

High level of automation

But still, it is not a generic batch operation

- No need for a batch operation system as per ISA S88, NE 33
- Easy to use HMI pattern is required
- Open to future extension

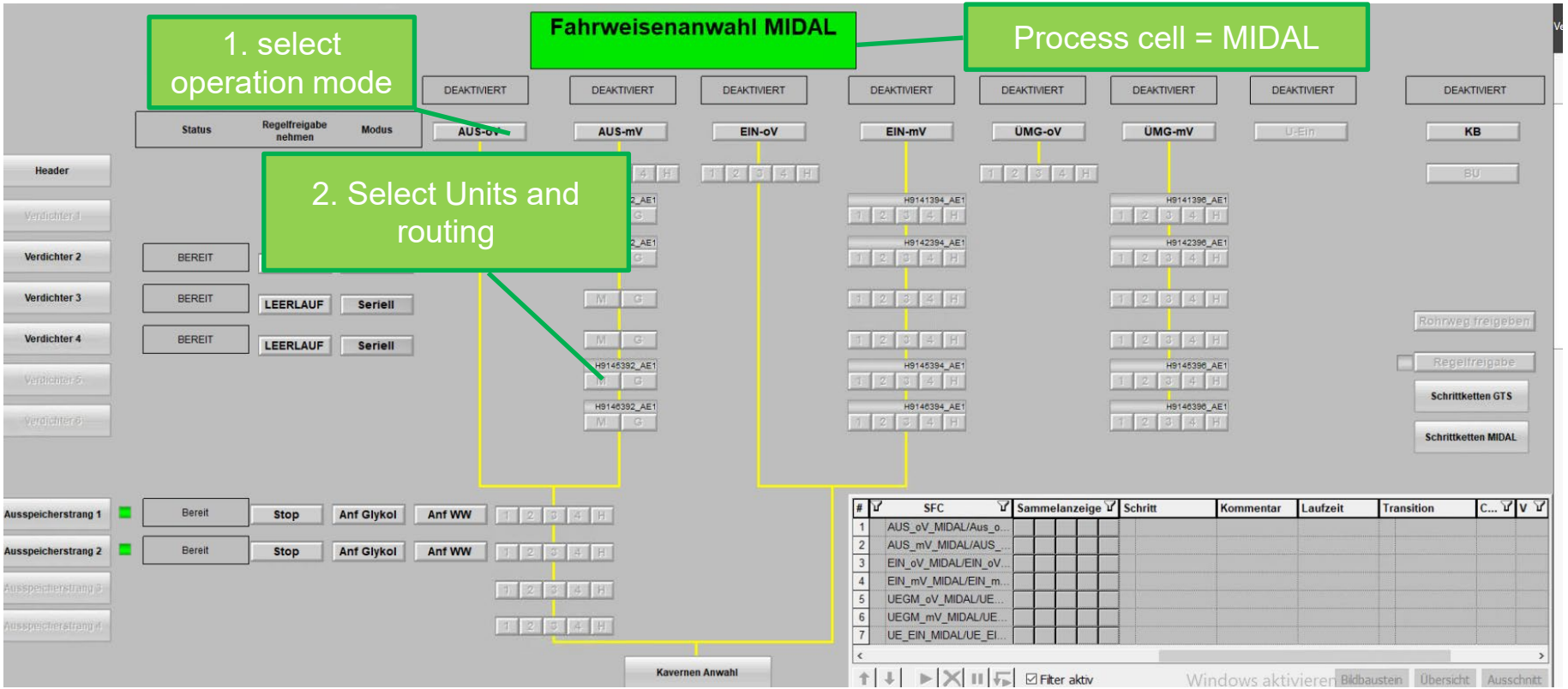
It took us quite some time and brainstorming

- This is the outcome:

➢A structured section and configuration graph

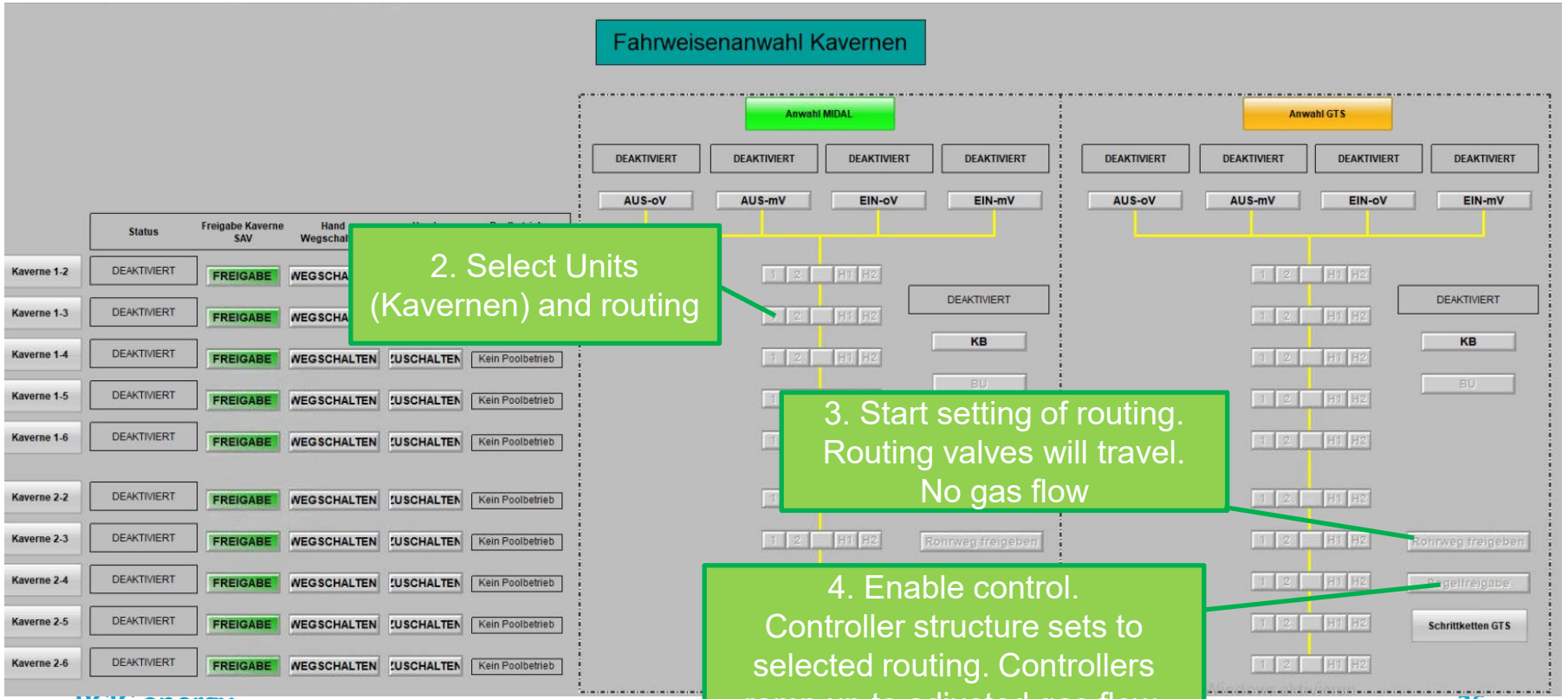
➢Guidance of the operator through the configuration of the plant and start up

Configure a process cell for an operation mode



The sequence of selection does not represent the gas flow direction

Configure a process cell for an operation mode



Degree of automation

As much automatic as required

- **No automatic selection**. The operator must select the units to meet the demand.
- **If a unit fails or trips**, the operator must deselect this and manually select a new unit.
- The **structuring** of the master-slave-follower controllers and load share is done **automatic**ally related to the selection of the units.

Limited number of step functions for the operation modes

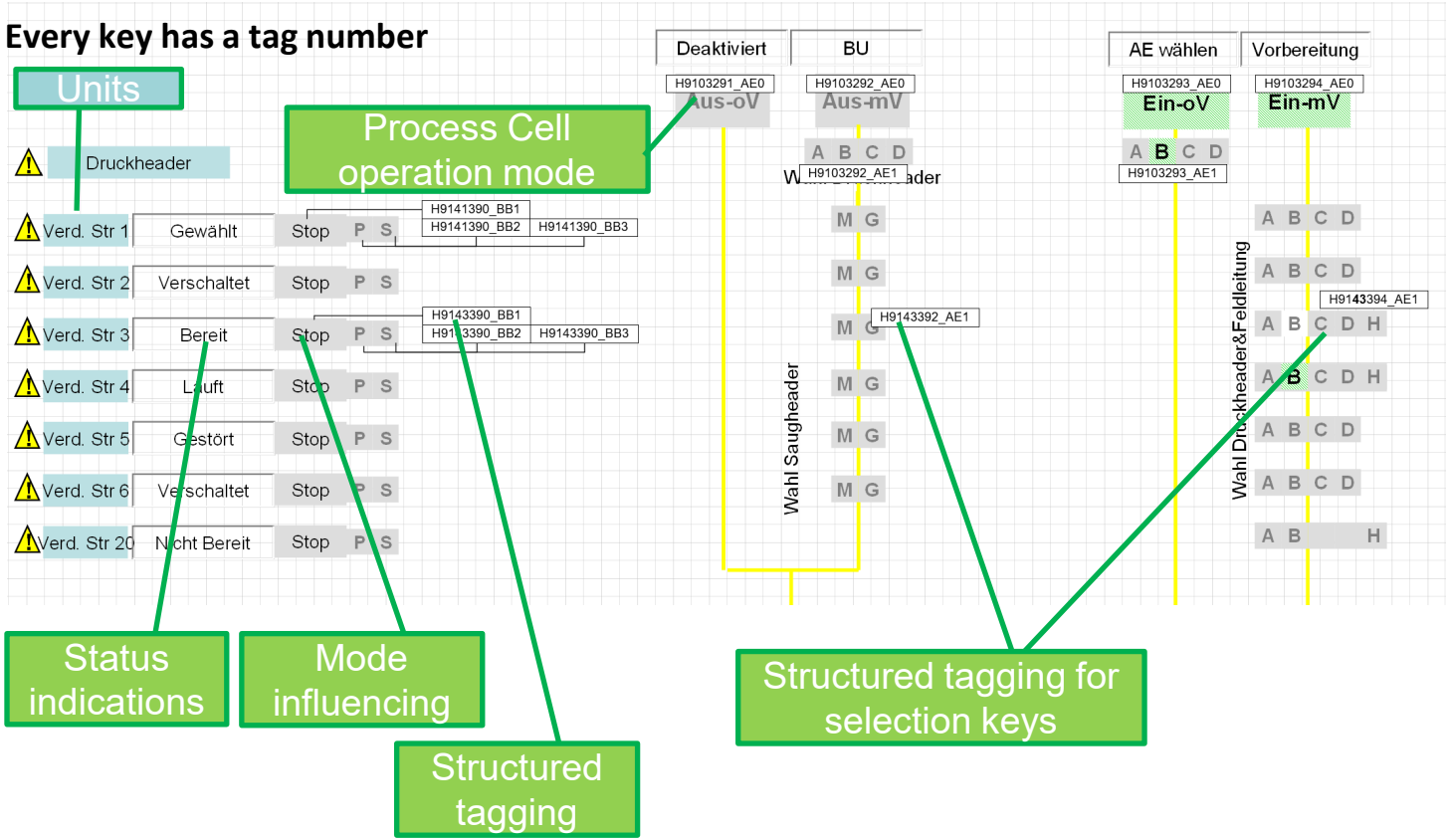
- Only **one** step function per process cell and operation mode
- Commands and transitions will be in relation to the unit and route selection. Hence to the valid selection keys.

Degree of automation

Interlocking of selection

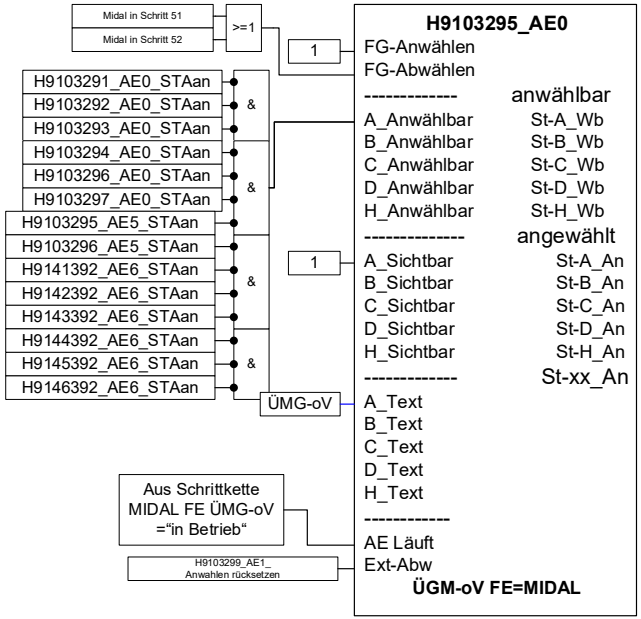
- Once a unit is selected to a process cell, it cannot be selected at the other process cell.
- Once a route (header) is selected, the other parallel units can only select this route.
- On the run deselect and select a unit is possible.
- To deselect a unit, the flow through this units needs to be stopped. Operator must withdraw control permission for this unit.

Interlocking of 88 selection keys and units



Interlocking of 88 keys and units

Function module for a selection key



Enable select the group

Enable deselect the group

Interlocking of the 5 sub-keys

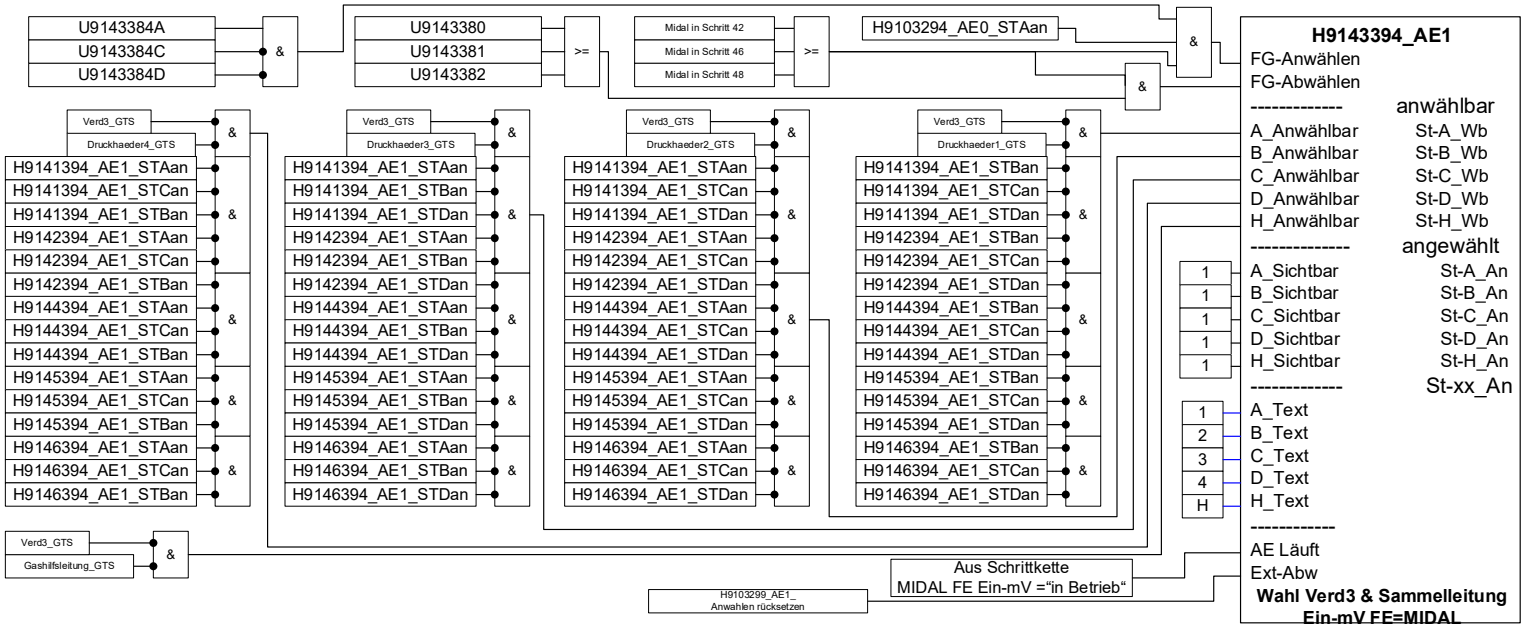
show the 5 sub-keys

text of the sub-key

Indicate status

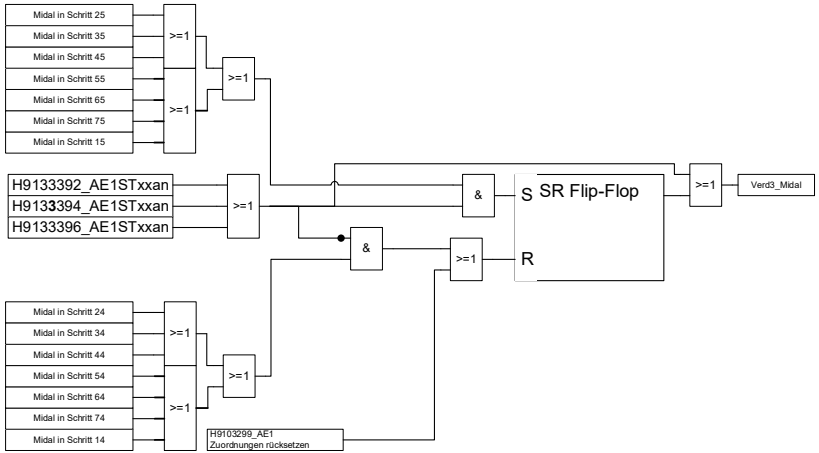
Interlocking of 88 keys and units

Function module for display and enabling more interlocks



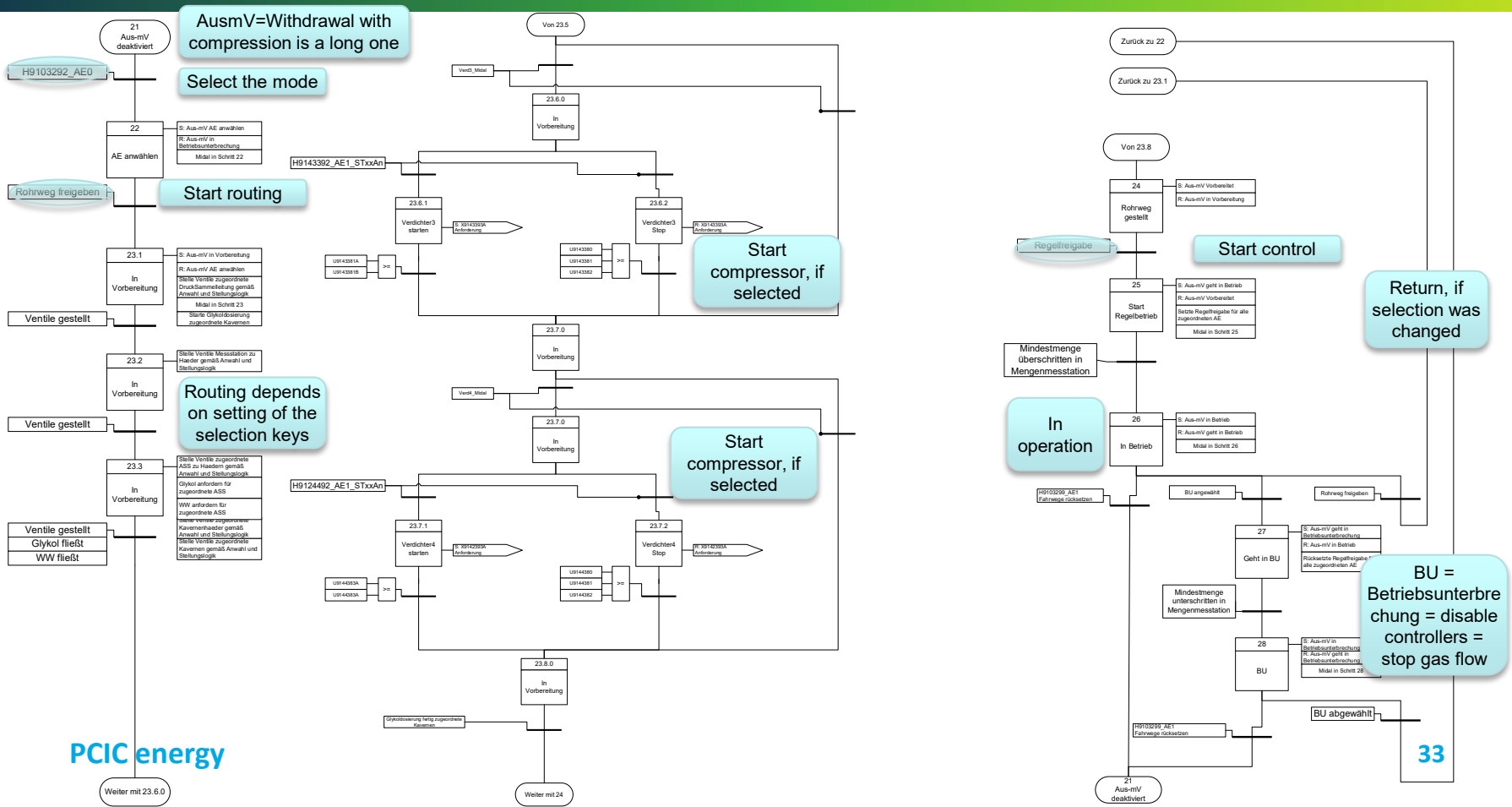
Interlocking of 88 keys and 23 units

Assigning 23 units to 2 process cells



Step function

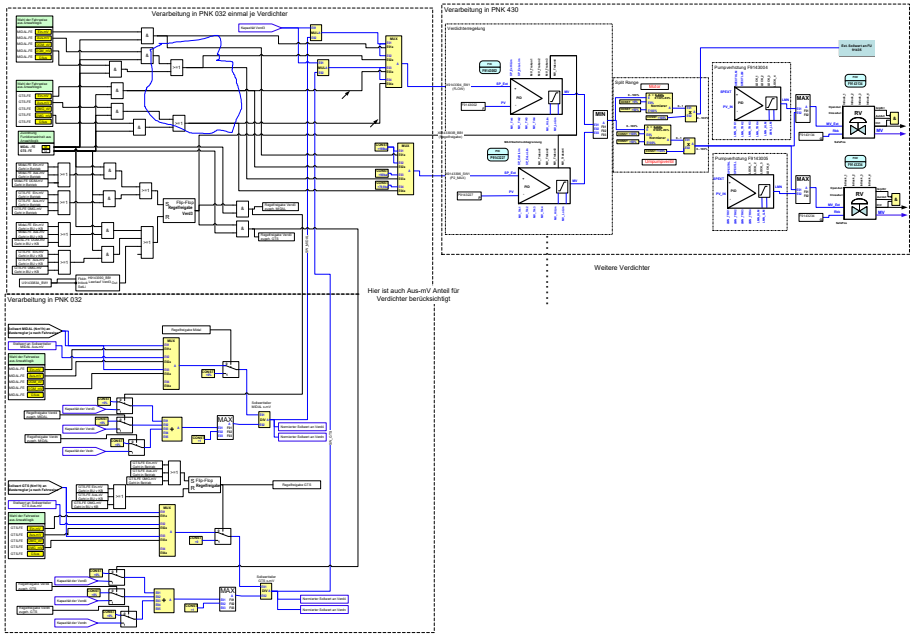
One step function per operation mode per process cell = 8 + 2



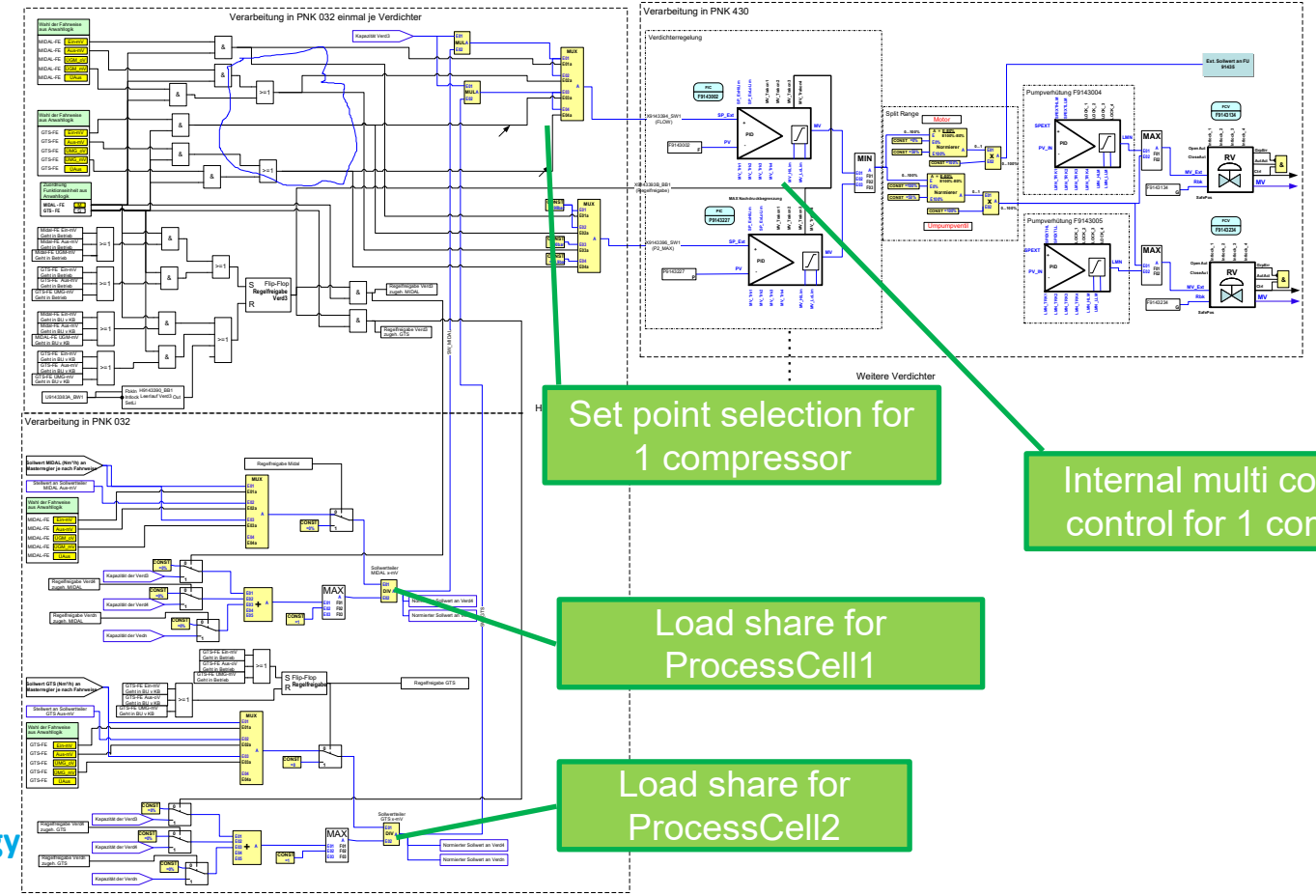
PCIC energy

Structure of closed loop control

- The structuring of the master-slave-follower controllers and load share is done automatically related to the selection of the units.
- This result in a quite comprehensive logic



Control diagram for 1 operation mode



Conclusions

- There is no black and white between continuous and batch plants.
  - There is something in between.
- There is no need for advanced or fuzzy control or AI.
  - Good craftmanship is sufficient.
- Do not over automize.
  - Leave the last decision to the operator.
- A systematic structure helps for future extensions
  - only small number of step functions with variable commands and transitions depending on selection
  - intelligent selection keys

Impressions

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Impressions

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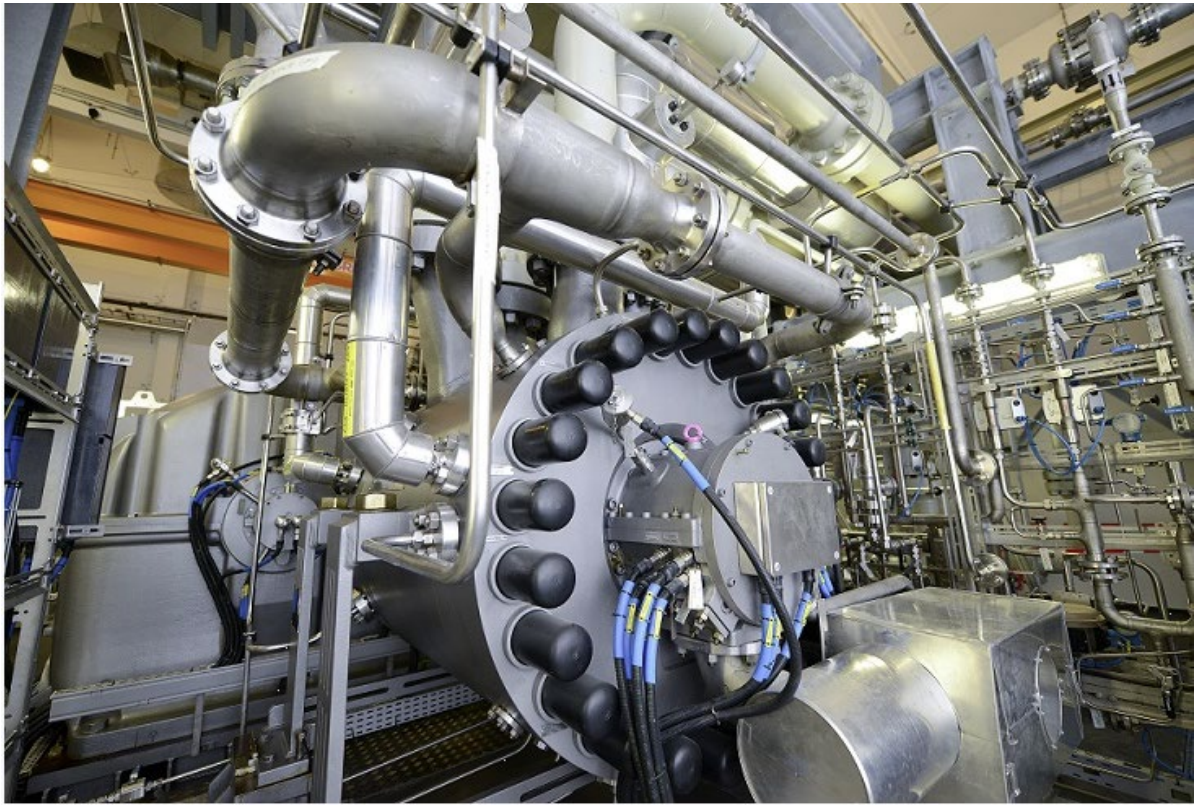
Impressions



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Impressions

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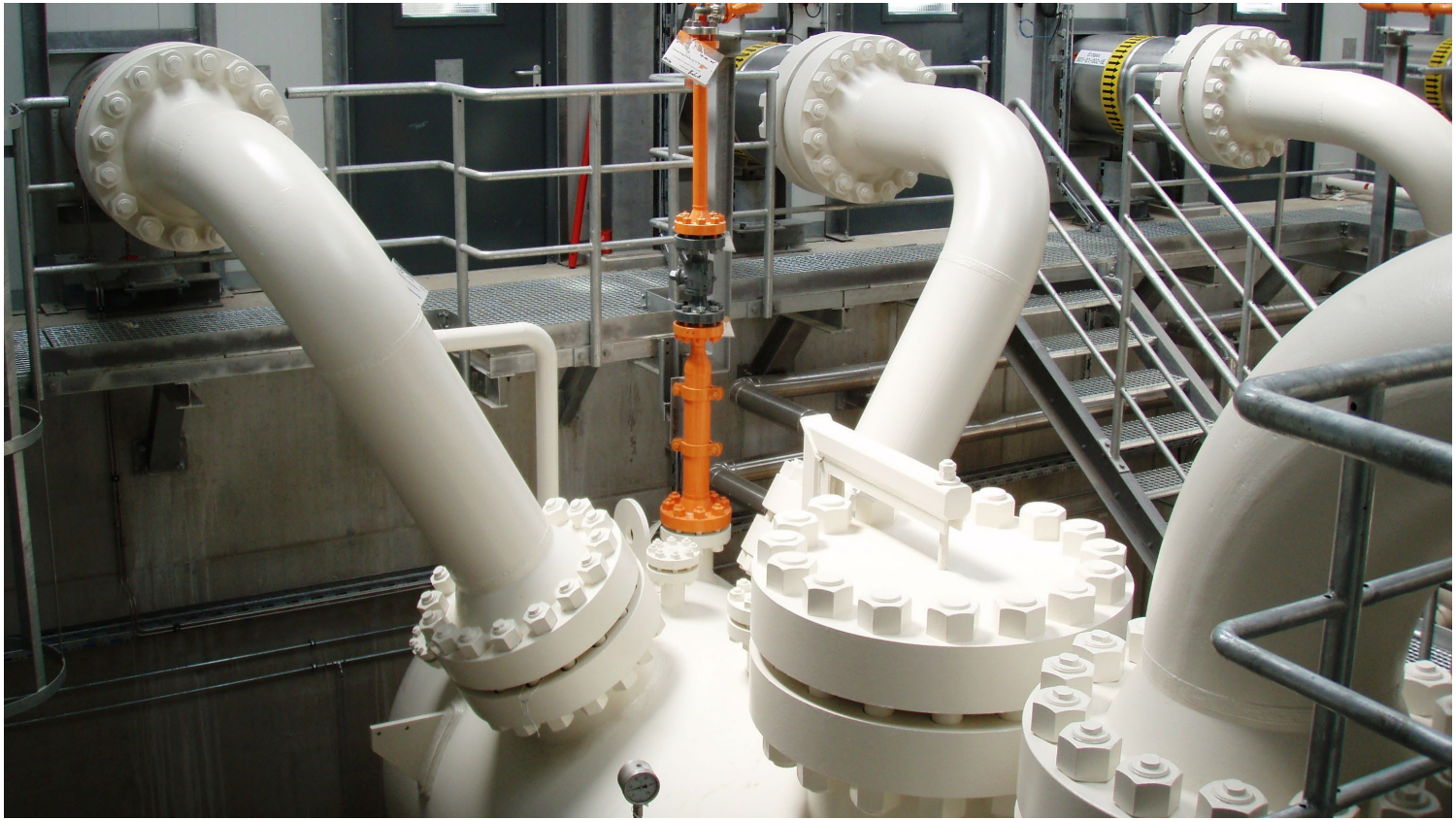

Thanks for your attention!

Time for Question and Answers

Backup running a delivery schedule

Gas storages usually are obliged to deliver a contractual hourly amount of gas energy.

This hourly amount shall be met irrespectively of disturbances, run up effects.

A table of 24 demands will be given by the start of the day

- The transfer station measures and controls the gas flow
- We installed a calculation block which compares the current hour’s demand with the flow already delivered. The flow setpoint results in the difference of demand and delivered divided by the remaining time.

Challenges:

Backup running a delivery schedule

Challenges:

- What to do if the schedule changes on short notice (telephone call)?
- How to react on disturbances at short remain time?
- Summertime to wintertime change (one extra hour)
- Install an allowed control band to minimize disturbances

Backup running a delivery schedule