Process Simulation and Consulting in
sugar and chemical technologies

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# Process optimization and reduction of production costs in modern beet sugar manufacturing

## MASTER PLAN

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**LONG BEACH, 27.2.2025**

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# PRESENTATION OVERVIEW

1. Tailored solution for process development, depending on the technology of treated factory - introduction
2. Master-plan therefore, based on deep process understanding and complex balances of the technology
3. Optimization examples, sorted according to investment and complexity
4. Conclusions, closing remarks


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# MOTTO

- ✓ how to **reduce the production costs/fossil energy** requirement of the processing
- ✓ concurrently to **identify the right technologies** to enable the significant **improvement** tailored to the customer needs
- ✓ all in a **financially viable** manner

## Fossil fuel consumption in EU

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# INTRODUCTION - MASTER-PLAN

**Reduction of production costs → development projects**

Technology analysis →process data → process model → optimization

**Production costs decrease**

- **Technology development**
- **Improved product quality**
- **Commodity diversification (raw sugar refining)**

**Engineering approach**

- **Mass & enthalpy balances, modelling**
- **Optimization, process scenarios, feasibility studies**
- **Basic and detailed engineering**


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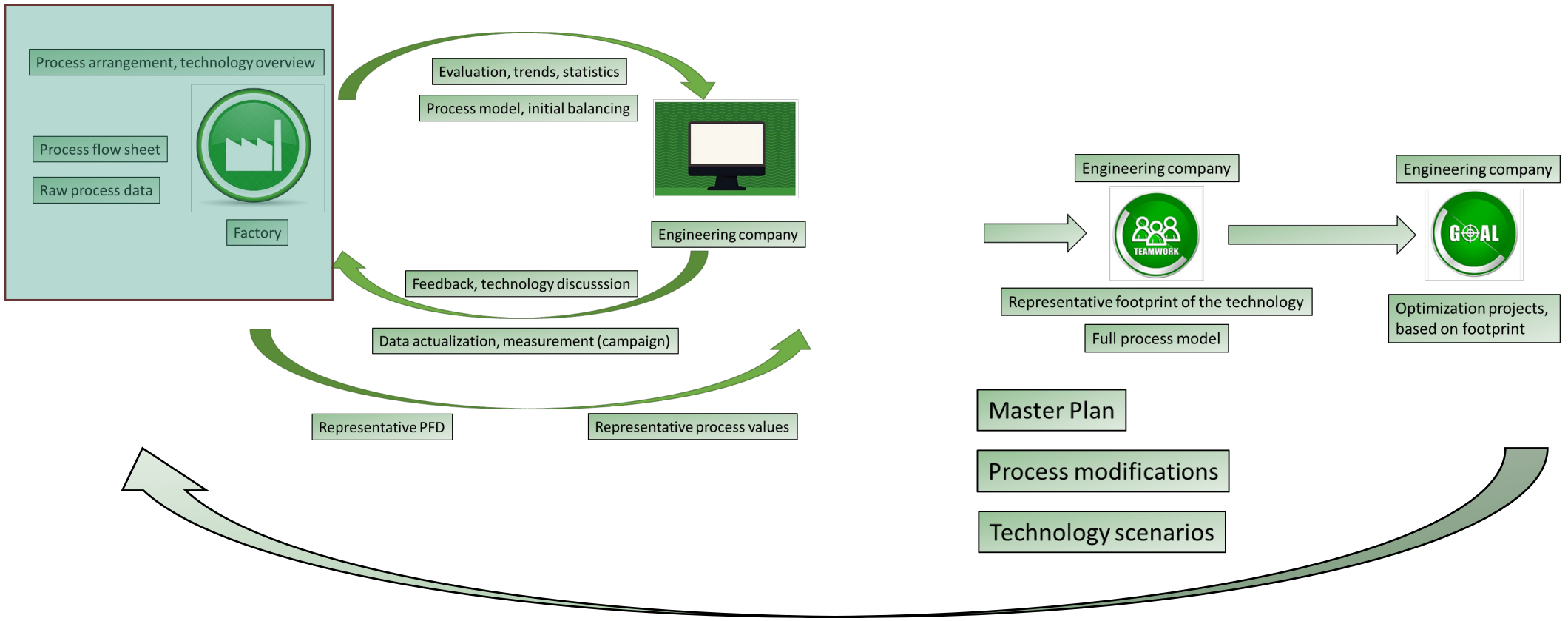
# INTRODUCTION - MASTER-PLAN



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# INDUSTRIAL EXAMPLES IN OVERVIEW

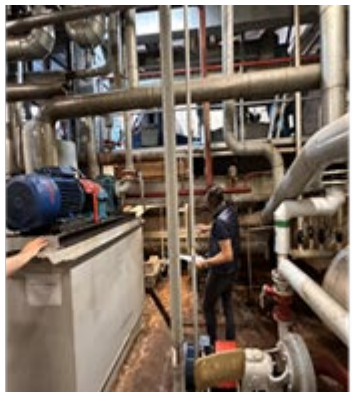
**Master plan: low investment projects, moderate issues and strategical investment**

- **Low investment: Thick juice pre-heating (E1); heating line by pre-limed juice (E2)**
- **Moderate investment: New evaporator bodies (E3); raw sugar refining in beet factories (E4)**
- **Strategic investment:** Bio power station (E5); **low temperature drying (E6)**

**E1**

**E2**

**E3**



**E4**

**E5**

**E6**

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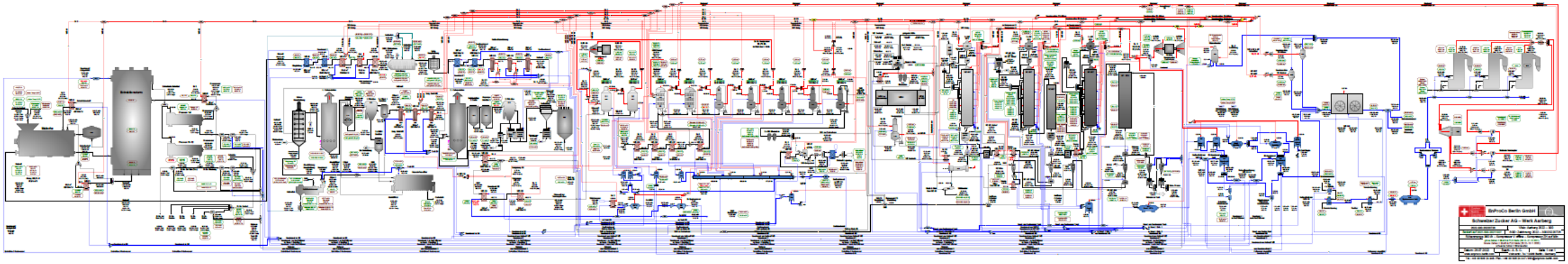
# MASTERPLAN

- Collection and analysis of process data → evaluation and compilation of process model
- Compilation of process model, tailored to the factory processing
- Footprints of the technology, each campaign 2-3 actualizations (good beets, end of campaign, average processing)
- Precision of the model
- **Identification of bottle necks and technology troubles → definition of master plan**



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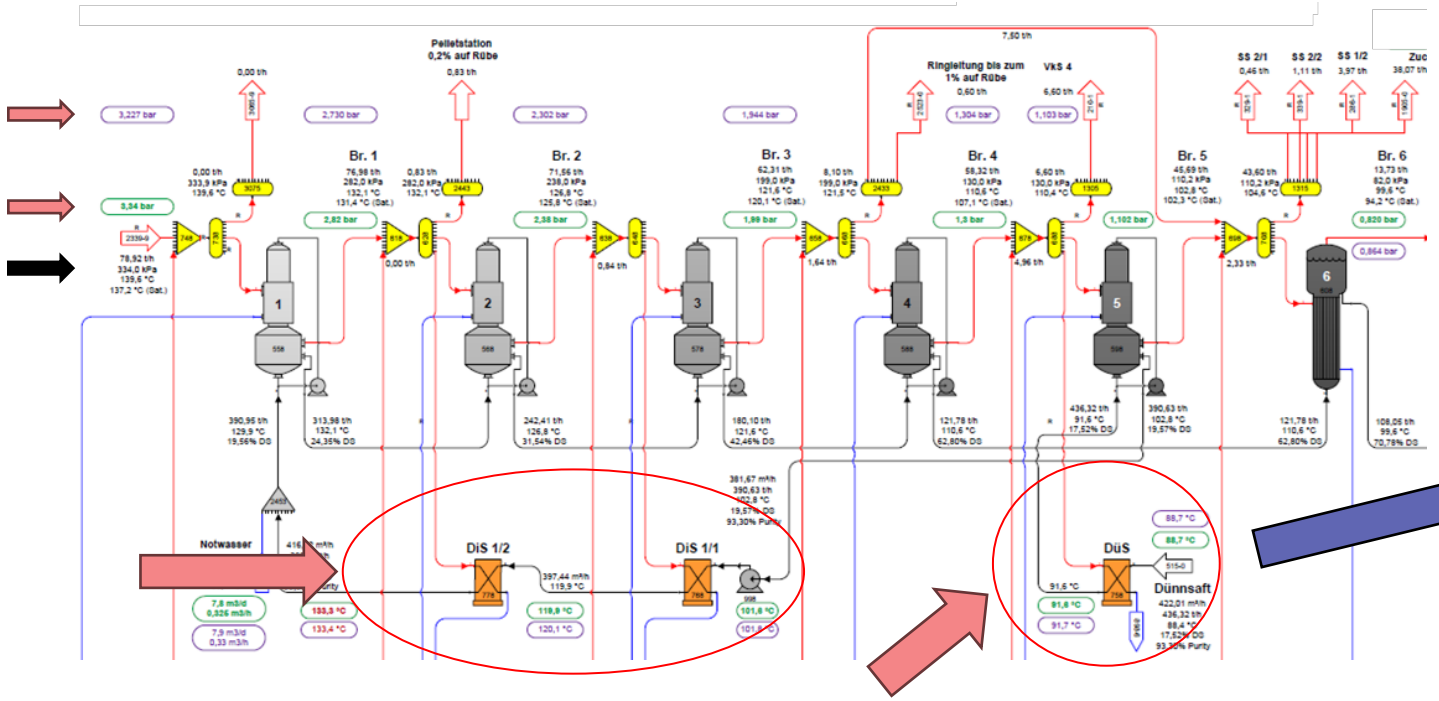
# MASTERPLAN

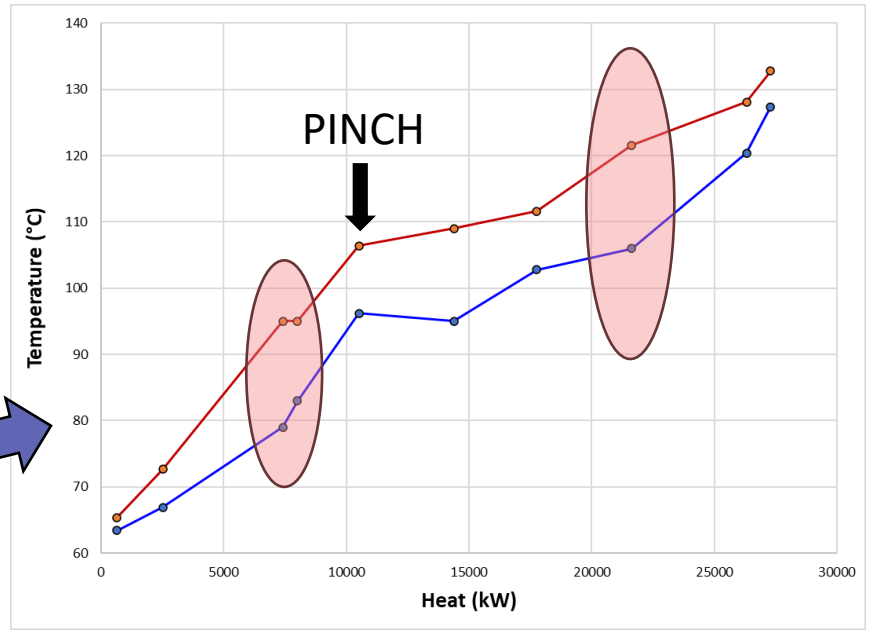
- **Evaluation of process data**
- **Identification of bottle necks and technology troubles → pinch analysis**

**Fossil energy consumption**

State 2019 1.100 kWh/$t_{WS}$

3.4MM BTU/ $st_{WS}$

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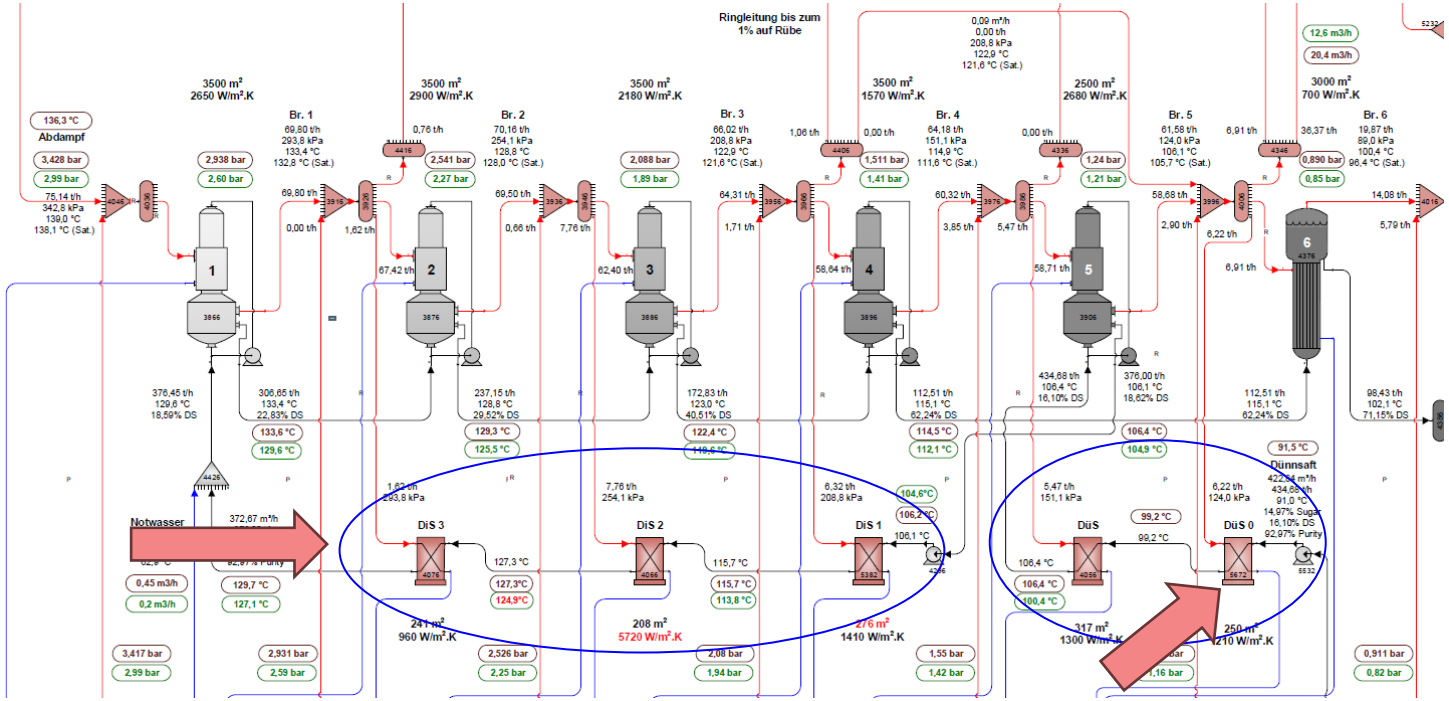
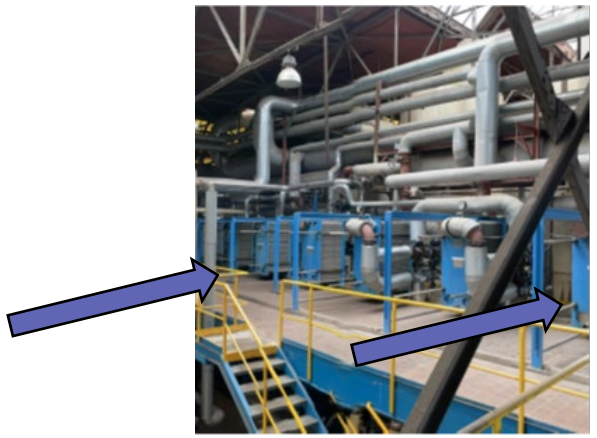
# INDUSTRIAL EXAMPLE #1 – LOW INVESTMENT

- **Thick juice pre – heating**
- **Engineering approach: pinch analysis → identification of pinch → modification of heat exchanger ➔ 2 new heat exchangers for Vap5/Vap3 application – minimization of dT before pre-evaporator: higher surface area and better utilization of vapours**



**Fossil energy consumption**

State 2019 1.070 kWh/$t_{WS}$

3.31MM BTU/ $st_{WS}$

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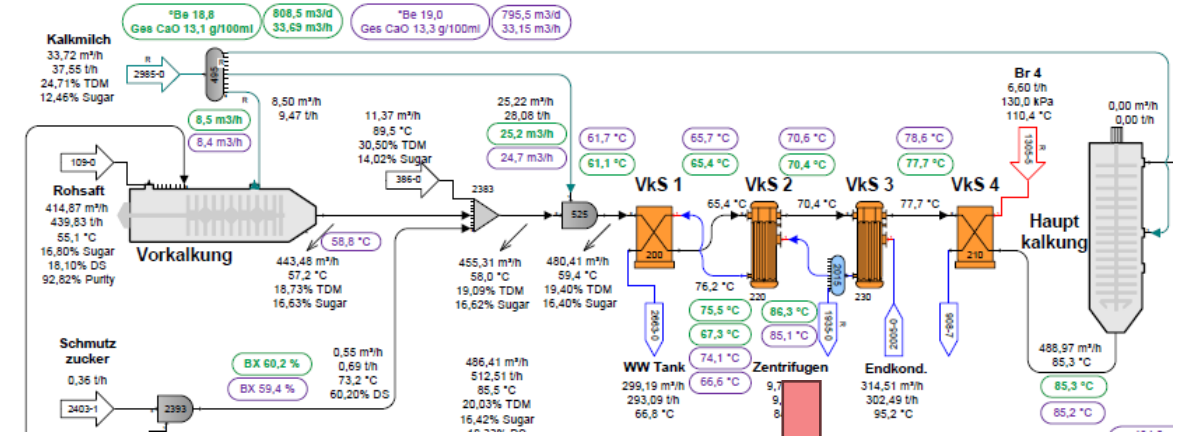
# INDUSTRIAL EXAMPLE #2 – LOW INVESTMENT

- **Limed juice – heating**
- **Driving force dT → construction VS heating efficiency → application of plate HEs, k-values**




**before**

**after**

**Fossil energy consumption**

State 2019 1.040 kWh/$t_{WS}$

3.21MM BTU/ $st_{WS}$

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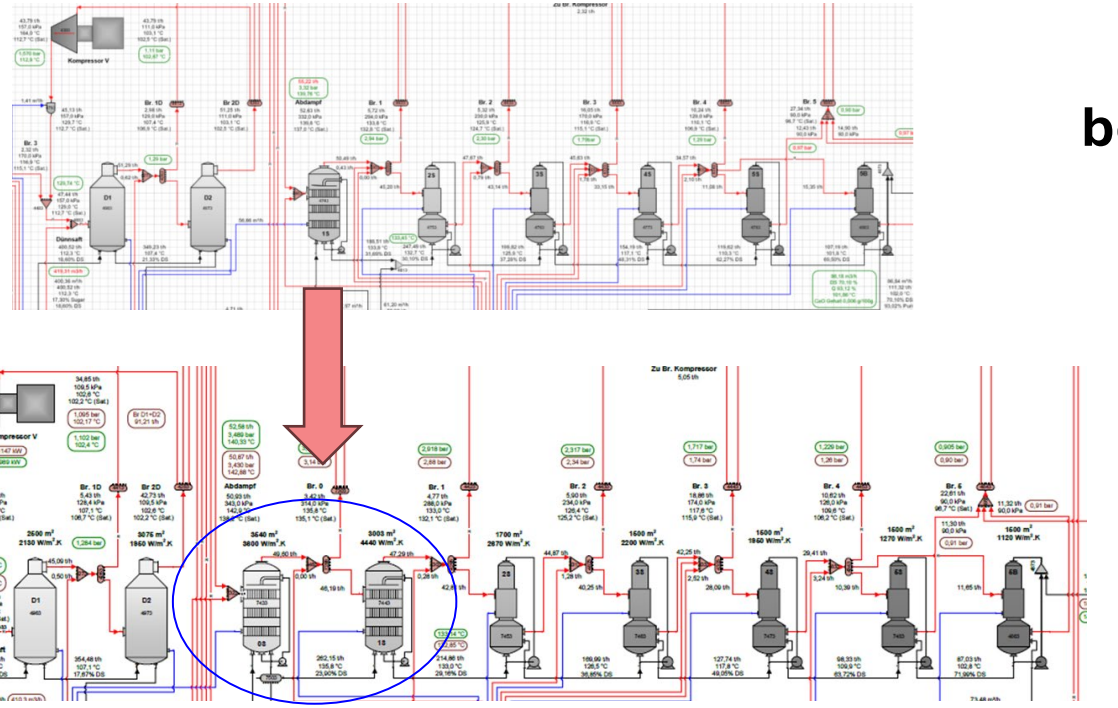
# INDUSTRIAL EXAMPLE #3 – MODERATE INVESTMENT

- **Evaporation station: 6 static effects plus 2 dynamic effects under vapour compression**
- **Extension of static evaporation line: 6 → 7 effects**
- **Based on evaporators analysis → better Δp, better utilization of vapours**
- **Reduction of electrical power for the dynamic evaporation effects**

**Fossil energy consumption**

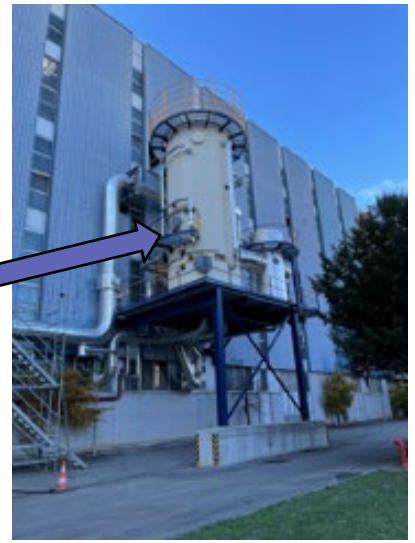
State 2024 890 kWh/$t_{WS}$

2.76MM BTU/ $st_{WS}$



**before**

**after**



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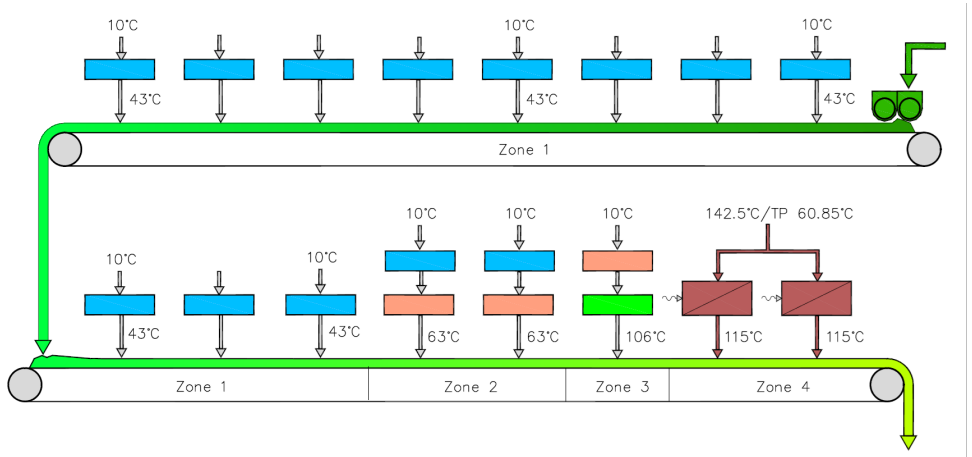
# INDUSTRIAL EXAMPLE #4 – LOW TEMPERATURE DRYING – HIGH INVESTMENT

- **Excellent example of “green” drying in beet processing, with high investment costs**
- **Pressed pulp dried with residual heat (hot water, end condensate, carbonation vapours, boiler house gas-off)**
- **Combination of mechanical and thermal water removal from thin pulp layer**




**Hot condensate** 14.5 MW FW+HC 1'200'000 kg/h Vorlauf 48°C / Rücklauf 37.4°C

**Carbo-Vap** 3.6 MW Glykol Carbobrüden 140'000 kg/h Vorlauf 68°C / Rücklauf 45°C

**Boiler gas-off** Rauchgas 77'000 kg/h 142.5°C

**Hot water** 1.25 MW Heisswasser 68'000 kg/h Vorlauf 120°C / Rücklauf 104°C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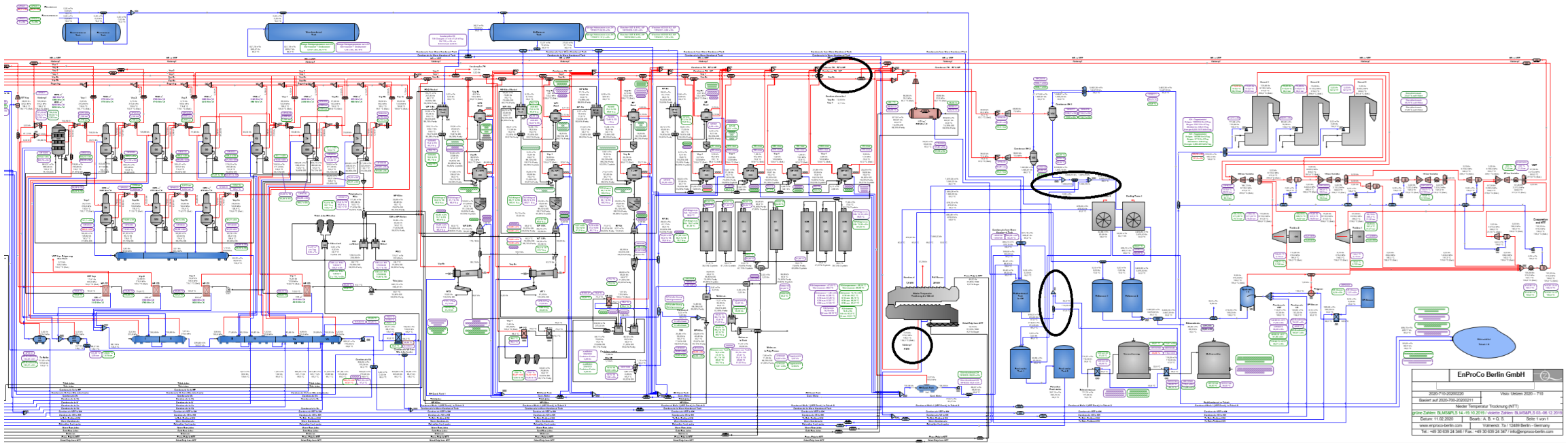
# INDUSTRIAL EXAMPLE #4 – LOW TEMPERATURE DRYING

- **Selection of heat sources in treated factory → balancing, pinch analysis, exergy balance of residual streams**
- **In detail knowledge of processing technology → essential issue**
- **Fossil fuel consumption VERSUS processing costs VS residual heat balance**



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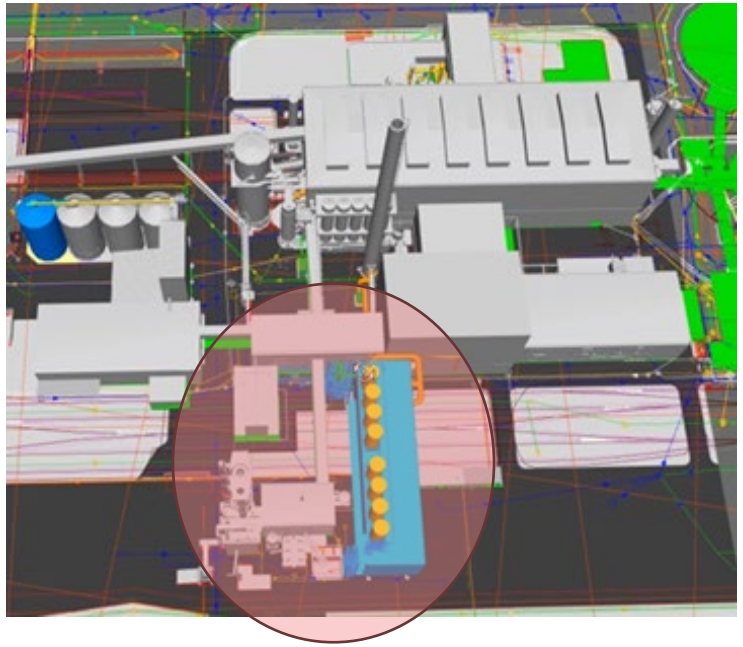
# INDUSTRIAL EXAMPLE #4

- **Finalisation works in progress, commissioning Summer 2025**
- **End drying to DS > 96 %**
- **Project predicted with economy indicators – strong influence of $CO_2$-emissions**

**Fossil energy consumption**

Prediction 700 kWh/$t_{WS}$

2.17MM BTU/ $st_{WS}$



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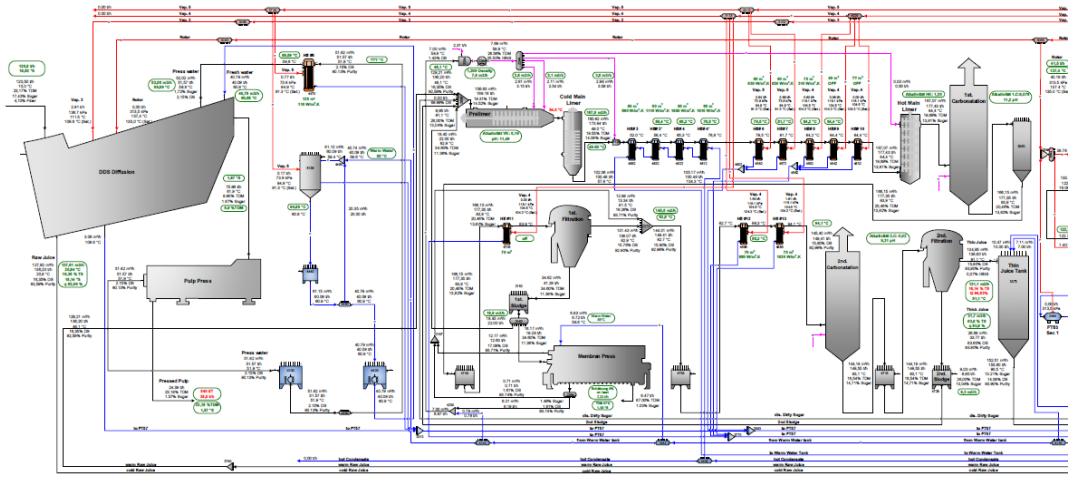
# INDUSTRIAL EXAMPLE #5 – RAW SUGAR REFINING - MODERATE INVESTMENT

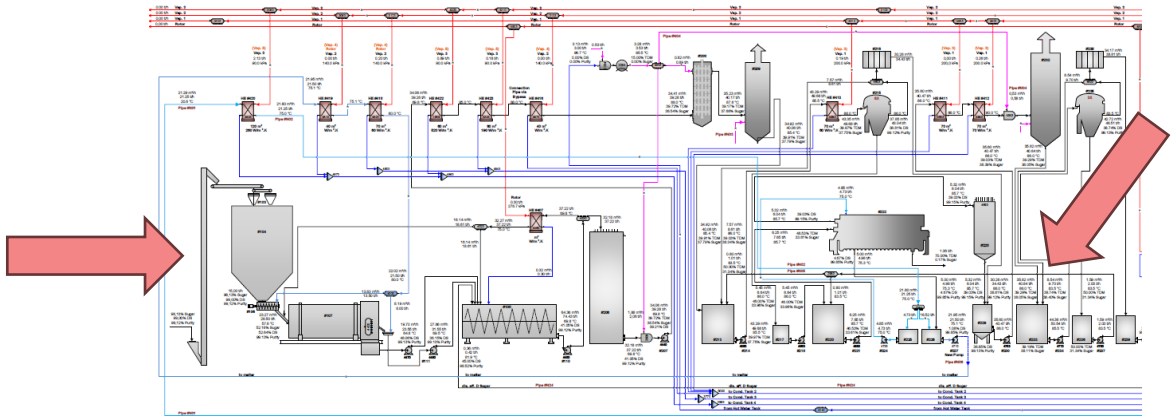
- Raw sugar refining in beet factory? → summer campaign – mostly sugar house operations
- Investment for melting and pre-treatment required
- Lime kiln out of performance→ CaO external + boiler house gases/booster $CO_2$
- In the case of good quality of raw sugar → any de-colorization required



Beet campaign

## Extraction/melting/purification

### Refining campaign

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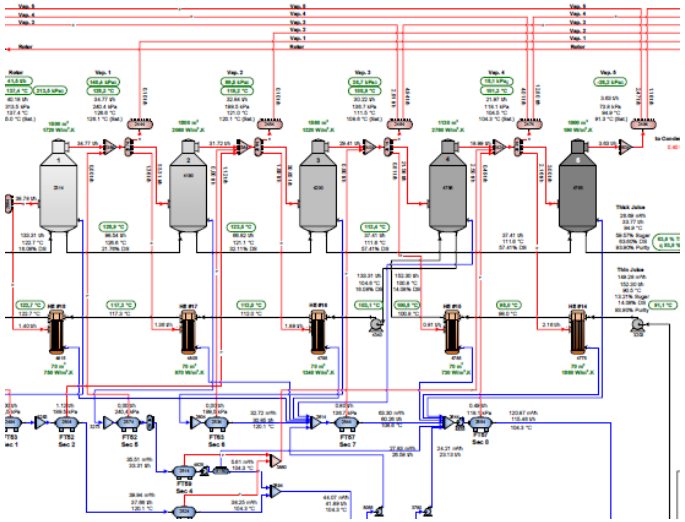
# INDUSTRIAL EXAMPLE #5

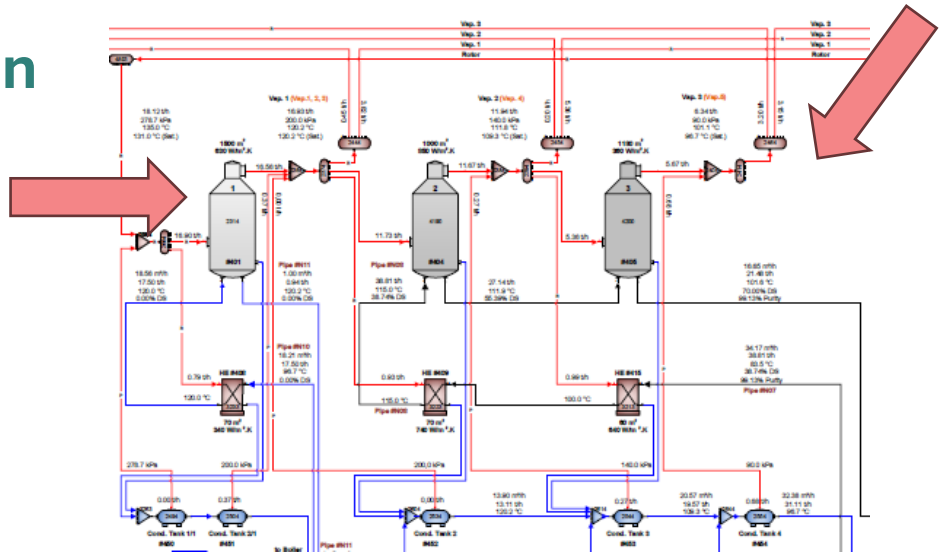
- **Raw sugar refining in beet factory → summer campaign**
- **Evaporation → mostly with moderate budget possible to re-equipped**



## Beet campaign

## Refining campaign

## Evaporation



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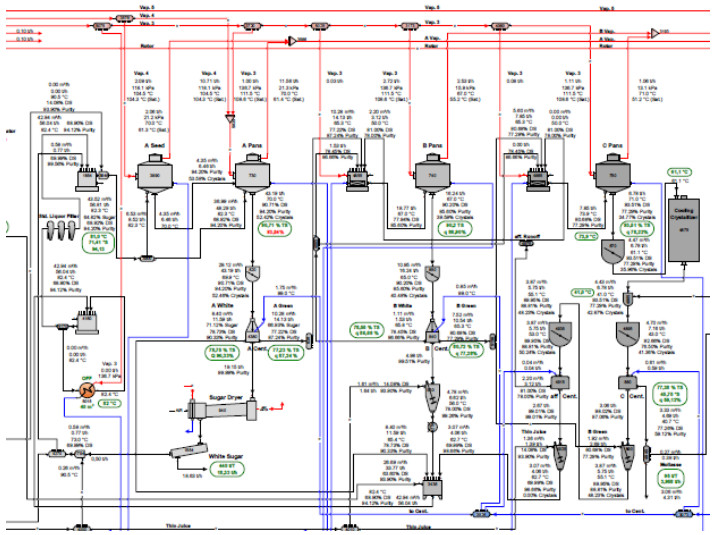
# INDUSTRIAL EXAMPLE #5

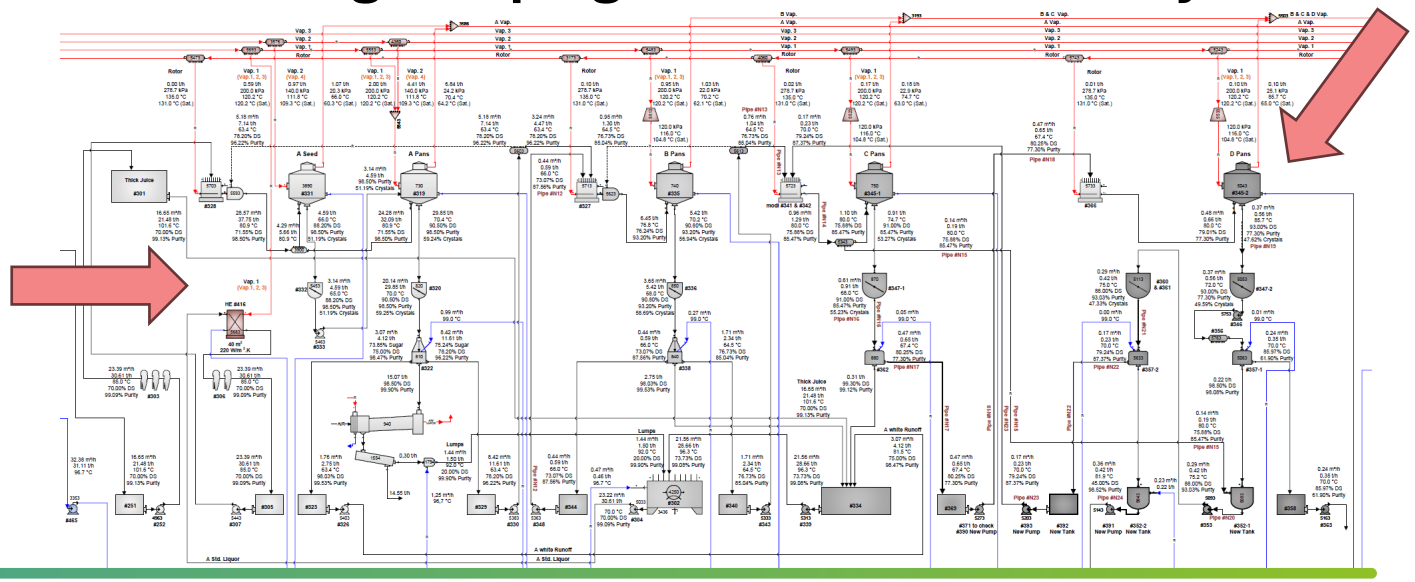
- **Raw sugar refining in beet factory → summer campaign**
- **Success depends on installed machinery → equipment VS sugar loss in molasses**



## Sugar house operations

**Beet campaign:**
**3-product scheme**

**Refining campaign: 3-strikes + recovery**



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# INDUSTRIAL EXAMPLE #5 – RAW SUGAR REFINING

- **Raw sugar refining in beet factory → summer campaign**
- **Improvement of factory yield → basic & detailed engineering project, realizations 2022, 2024**

## Summary:

- **Refining effort depends strongly on installed machinery, especially in sugar house → increase of strikes essential, technology audit required**
- **Melting line, tanks and vessels should be installed, pipework improved**
- **Crucial task is the degradation of sucrose in strikes related to molasses purity → correlation between investment and yield of sugar → feedstock and sugar prices balance**
- **Refining campaign favourable only by reasonable price of feedstock/sugar**


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# CONCLUSIONS

- Systematic way to reduce fossil energy with advanced engineering tools
- Limitation by conventional technology development (investment)
- In EU, the only sustainable solution is the “green” processing
- 2030 → carbon free production? Renewable energies?
- Summer raw sugar refining campaign in beet factory? Possible!

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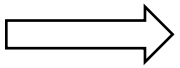
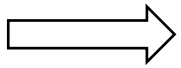
# Official target of EU

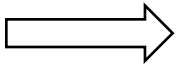
**Fossil energy consumption**
State 2019 1.100 kWh/$t_{WS}$
3.4MM BTU/ $st_{WS}$



**Stand 2020**
**1.000 kWh/$t_{WS}$**
**3.1MM BTU/ $st_{WS}$**



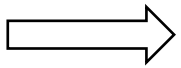
**Fossil energy consumption**
State 2024 890 kWh/$t_{WS}$
2.76MM BTU/ $st_{WS}$



**2030**

**Fossil energy consumption**
Prediction 500 kWh/$t_{WS}$
1.55MM BTU/ $st_{WS}$

**Vapour compression, MVR, TVR**
**Heat pumps**



**2035**

**Fossil energy consumption**
Prediction 0 kWh/$t_{WS}$
0MM BTU/ $st_{WS}$

**Carbon free = renewable energies**
**Bio-boiler house, geothermal energy, solar/wind**

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