SHS AS A TECHNOLOGY PLATFORM FOR SUSTAINABLE & COMPETETIV ADVANTAGE

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OVERVIEW

- Today' s drying technology and it' s energy usage
- **S**uper**H**eated **S**team, as the drying medium of the future
  - Energy demand to evaporate water
  - Comparing **SHS** vs. air as heating medium
- **SHS** conveying
  - Overview
  - Status
- **SHS** drying
  - Global petfood production with air & SHS drying
  - Energy impact of implementing SHS applications in Mars dry factories
  - Best way of energy recovery
  - Mass balance of a typical extrusion line
  - Example for vapour compression and the needed energy demand
- **Conclusion**

Drying of Food

Drying is one of the oldest and most fundamental method for food preservation

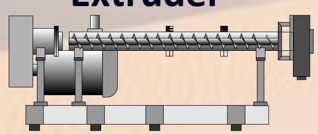
Energy demand to evaporate *900 kt of water/year

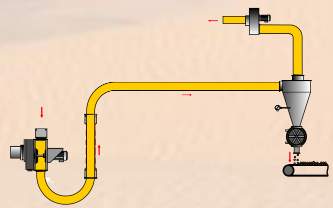
*** Data’ s from 2010**

Specific Evaporative capacity
2,725 kJ/kg = 0.757 kWh/kg

Air Conveying

Single Screw Extruder





to produce the total amount of dry product (globaly) on extruder lines we have in Minden

Total need 2,452.5 TJ to evaporate 900kt of water to produce *3,500 kt of petfood per year

Air Drying vs. SHS Drying

Advantage of air drying

- Product temperature during Drying is around 83°C

Disadvantages of air drying:

- Exhaust of air drying is warm moist air at a temperature of > 80°C
  - Low level of temperature, therefore less efficient in energy recovery
- Exhaust air is not condensable
  - Bio filter is needed
    - Moist exhaust air needs bio filter to reduce odours
  - No way to reuse the water
- Fire and explosion risk by using high drying temperatures (> 135°C)
- Condensation risk in dryer entrance and dryer exit
- Condensation risk and energy losses by using air conveying

Advantage of SHS drying:

- 15 to 20% less energy consumption comparing to air drying
- Steam, **S**uper**H**eated above 100°C, a non visible Gas which is capable to evaporate water. This gas is condensable.
- Due to high specific heat capacity and low viscosity, pasteurizing or sterilising of product is possible
- **SHS (in our application)** is a gas at nearly atmospheric pressure, no risk of safety
- **SHS** atmosphere nearly airless. No oxidation.
- **SHS** can also used for conveying without any risk of condensation, therefore no salmonella growth

Disadvantages of SHS drying:

- Product temp. is 100°C or more.

Why Drying with **SHS**

Thermodynamic advantages of SHS Drying vs. Air Drying:

Overall heat transfer coefficient c and viscosity η

$H = m \cdot c \cdot \Delta T$

$RE = \frac{w \cdot d_P \cdot \rho}{\eta (1-\varepsilon)}$

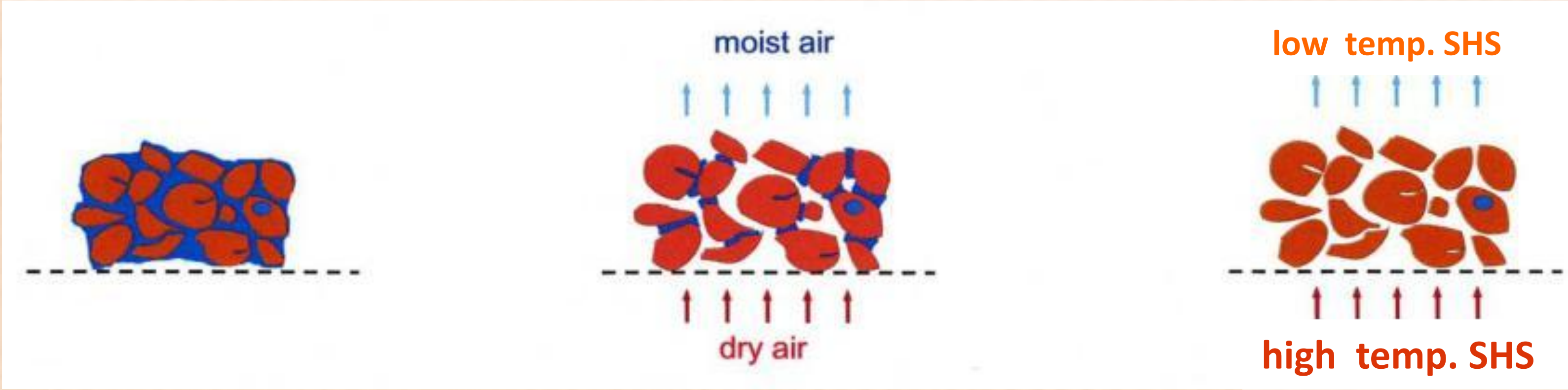
	T [°C]	**STEAM**	**AIR**
c [kJ/(kg K)]	100	2.042	1.012
	150	1.980	1.018
η [10-6 kg/ms]	100	12.27	21.94
	150	14.18	24.07

As higher c value as higher drying rate

As lower η value as better penetration

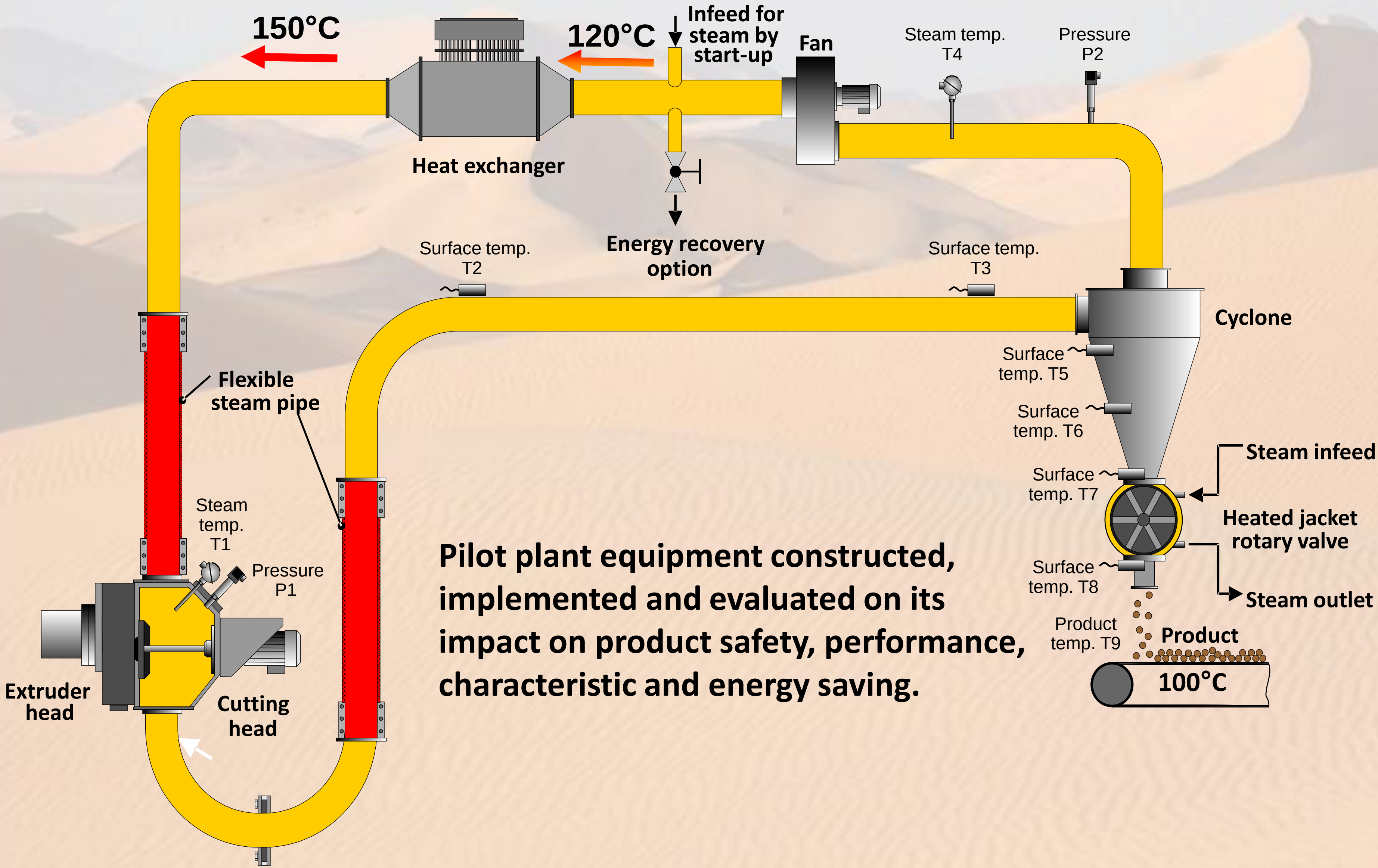
not condensable

condensable



SuperHeated Steam Conveying

SuperHeated Steam Conveying



Pilot plant equipment constructed, implemented and evaluated on its impact on product safety, performance, characteristic and energy saving.

Food safety and quality validation

Necessary Food Safety features:

1. **No condensation** (temp. above 120°C) → 👍
2. **Self-sanitization** (prevents salmonella growth) → 👍
3. **No cross-contamination** (sliedly positive overpressure) → 👍
4. **System operation** (start, stop, die-plate change) → 👍

Product Quality & energy recovery status:

Palatability (Parity with current air conveying) → 👍

Possible accumulation of volatiles (vapor pressure in the kibble is higher than in the system, therefore it should no risk) → 👍

No temperature loss during Conveying → 👍

A process steam used for conveying (flash off, etc.) can be recovered → 👍

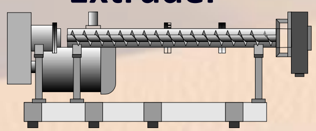
SuperHeated Steam Drying

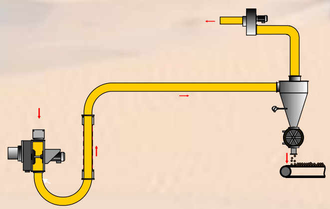
Energy demand to produce 1t of dry product

Specific Evaporative capacity
2,725 kJ/kg = 0.757 kWh/kg

Air Conveying

Single Screw Extruder





to produce the 1t of dry product on a std. extrusion line in Minden

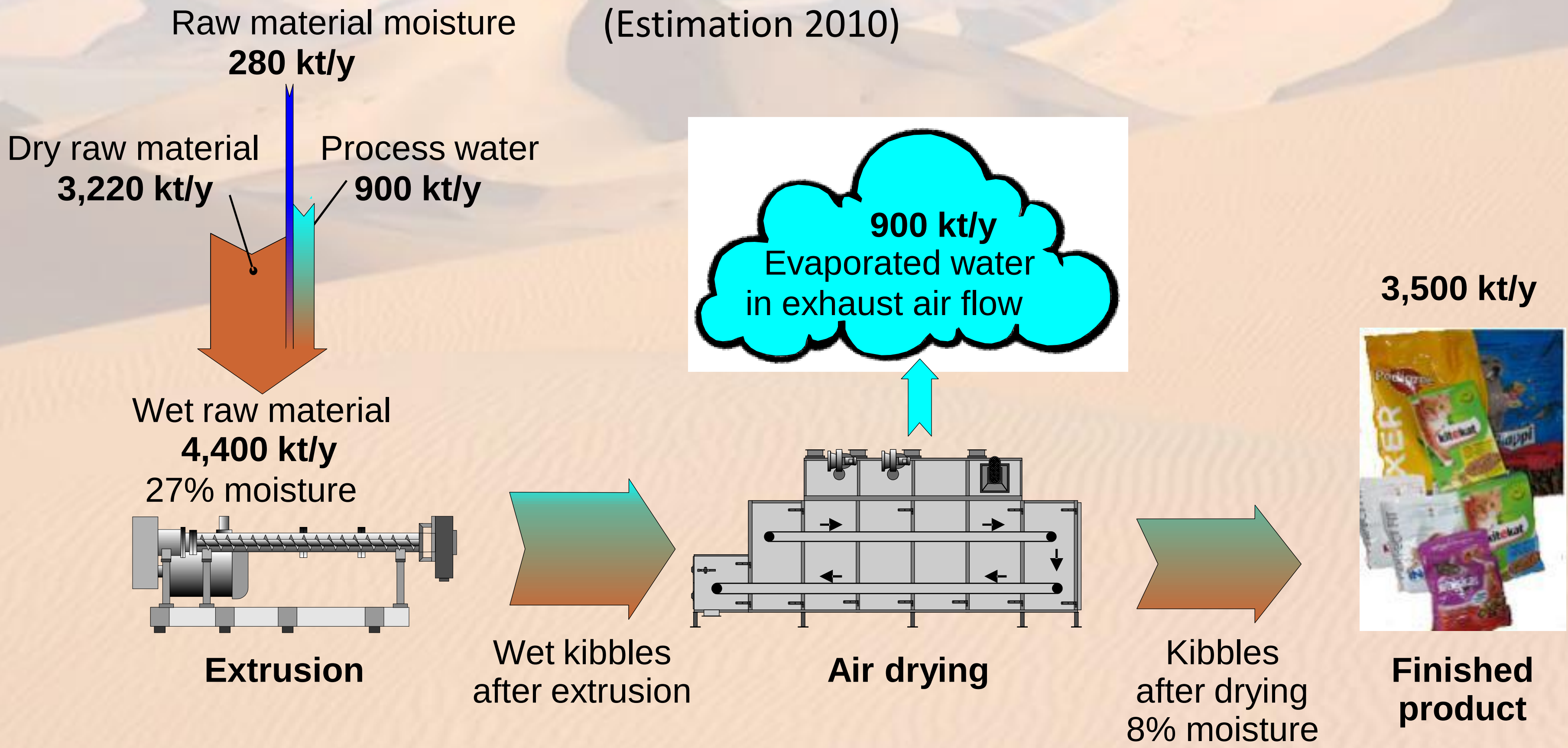
Electr. energy cost: 10.9 €ct/kWh
Gas energy cost: 4,3 €ct/kWh

**To produce 1t of finished product (7% moisture), we have to evaporate 17% moisture.
90.1kWh per 1 t**

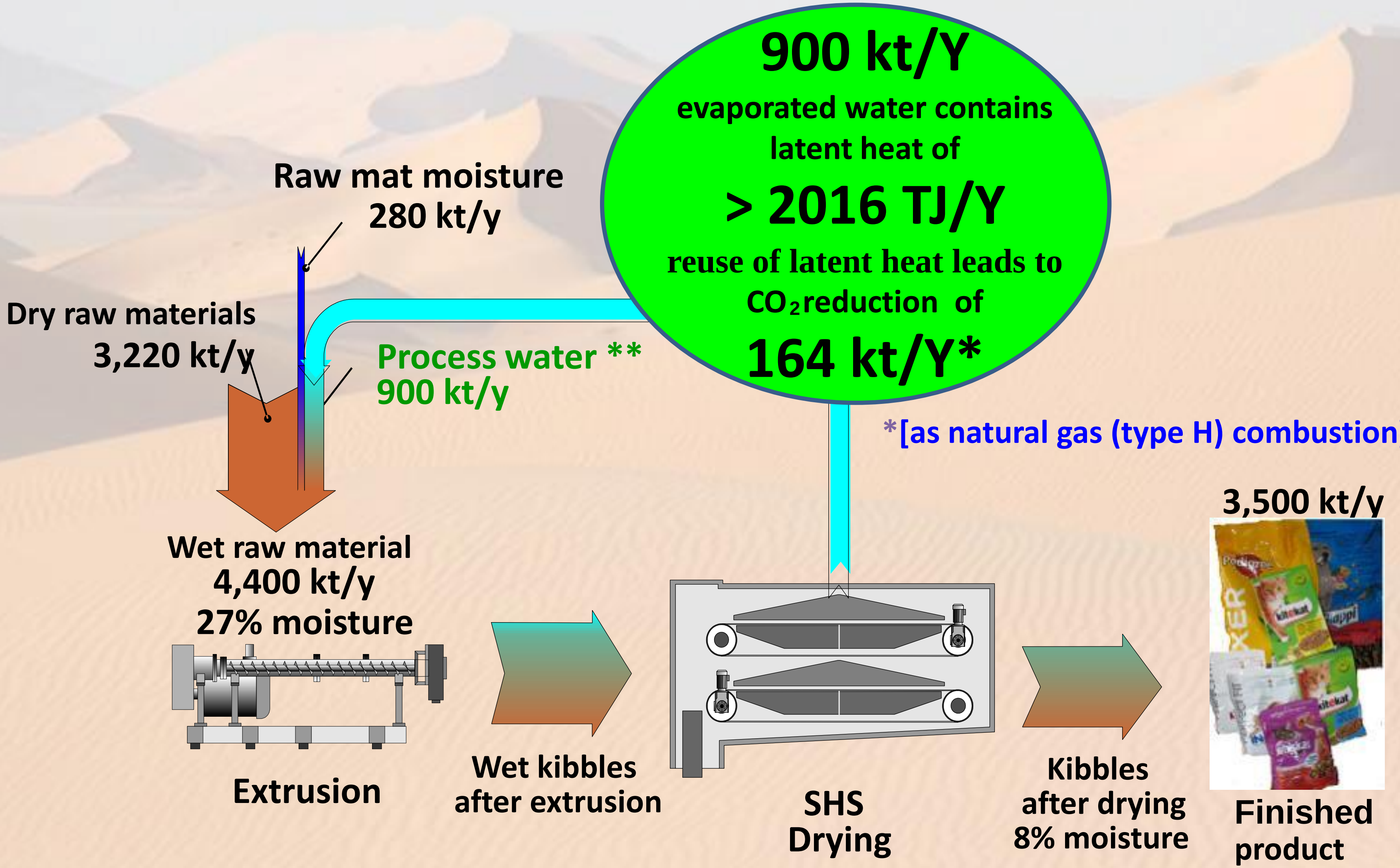
MARS petcare deutschland

Global Dry Petfood Production/Year

(Estimation 2010)

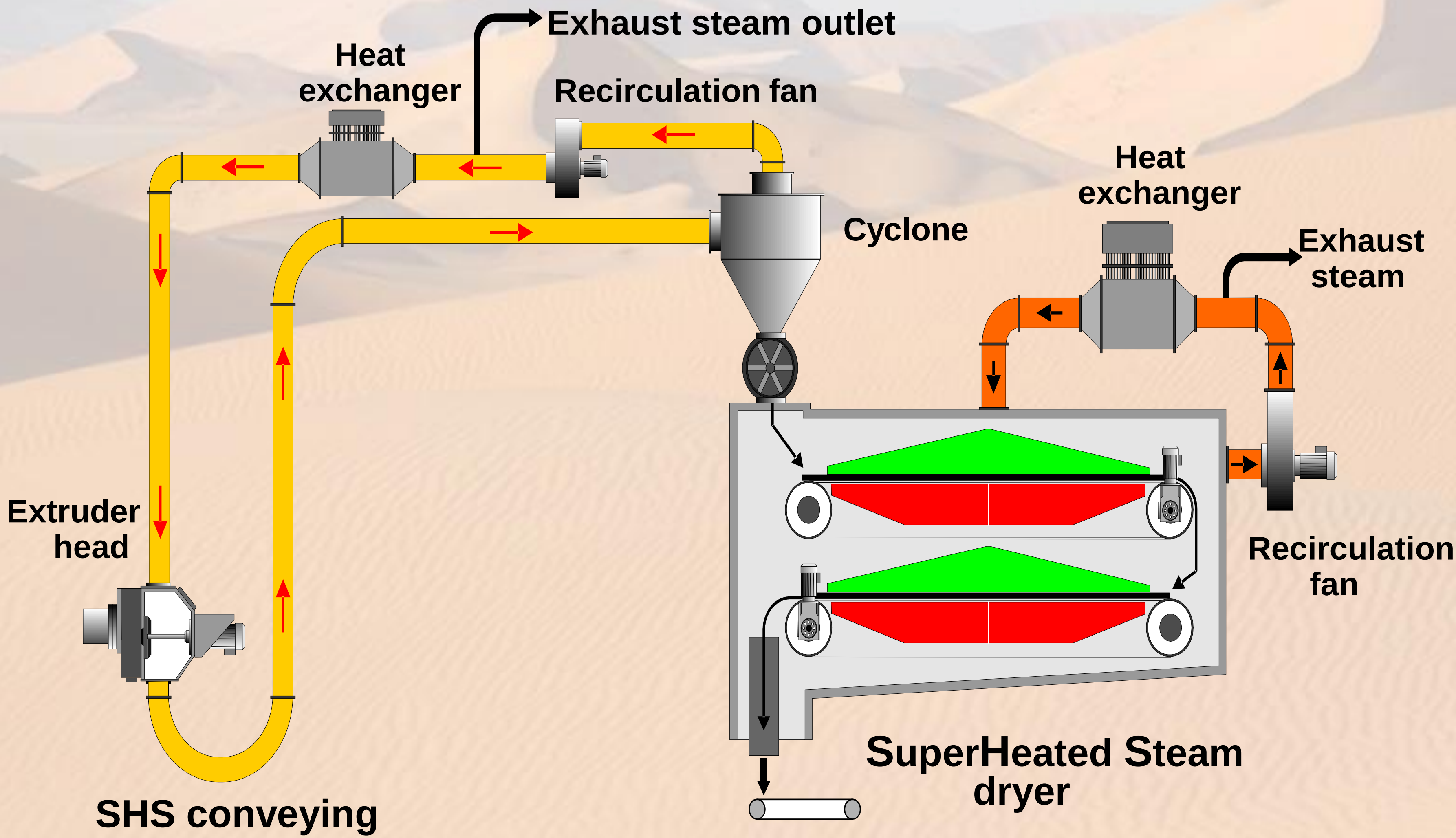


Future Global Dry Petfood Production/Year



** reuse of condensate as process water has to be validated

Optimized SHS Drying Process



Energy Recovery

Recovery by condensation

- By condensing the 120°C SHS

  95% of the energy can be recovered by condensation. That means, cooling water is needed and we will end up with a huge amount of water (condensate), which has 95°C and the 50°C warm cooling water after cooling.

Total amount of water after condensation

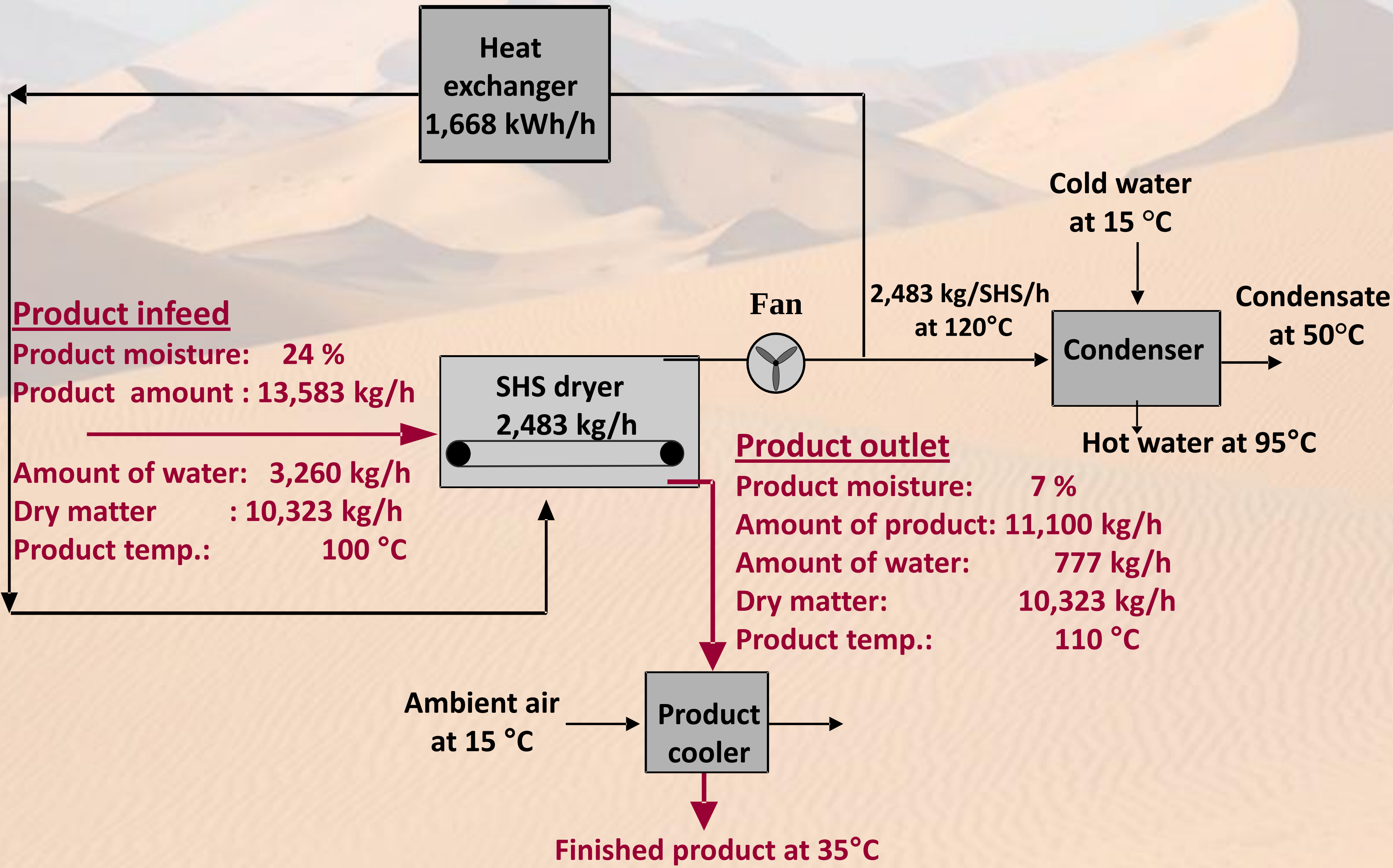
2,483 kg/h condensate at 95°C
29,6 m³/h Water 60°C

Recovery by Vapour compression

- Vapour compression can compress the exhaust SHS from 1,02 bar at 120°C up to 10 bar at 180°C.
- This steam can be used as primary energy to operate the SHS dryer after reaching stable conditions
- The output of the heat exchanger is 130°C Water at 10bar. Enough energy for additional recovery

Theoretical efficiency >70 %

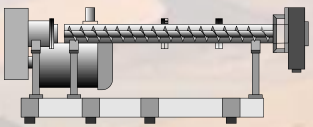
Mass Balance Diagram of an SHS Dryer



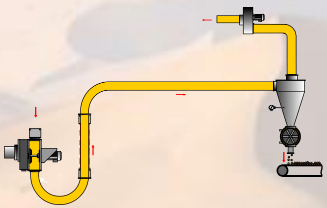
Influence on Different Process Configurations

Energy demand per t of finished product

Single Screw Extruder



Air Conveying

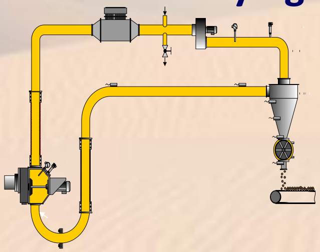


Specific Evaporative capacity
2,725 kJ/kg = 0.757 kWh/kg

7.29€ /t product

100%

SHS Conveying

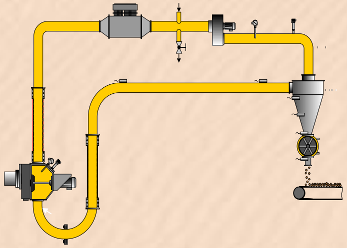


Specific Evaporative capacity
2,380 kJ/kg = 0.661 kWh/kg

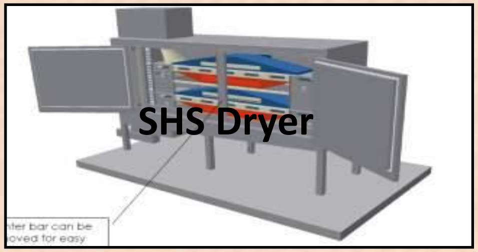
6,35 €/t product

87%

SHS Conveying



Specific Evaporative capacity
2,426 kJ/kg = 0.673 kWh/kg



6.47 €/t product

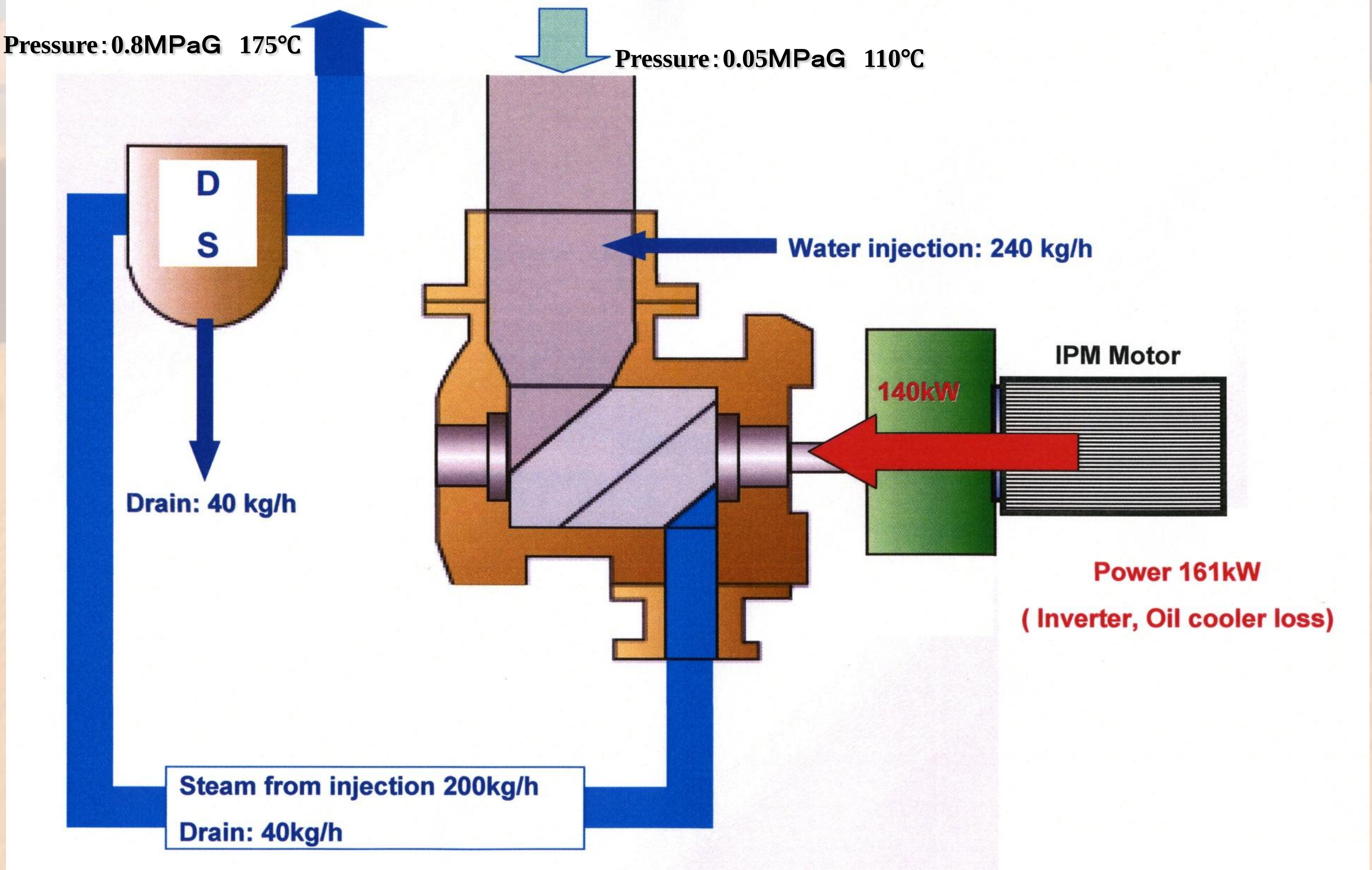
88%

Maximum saving without energy recovery ➔ 12%

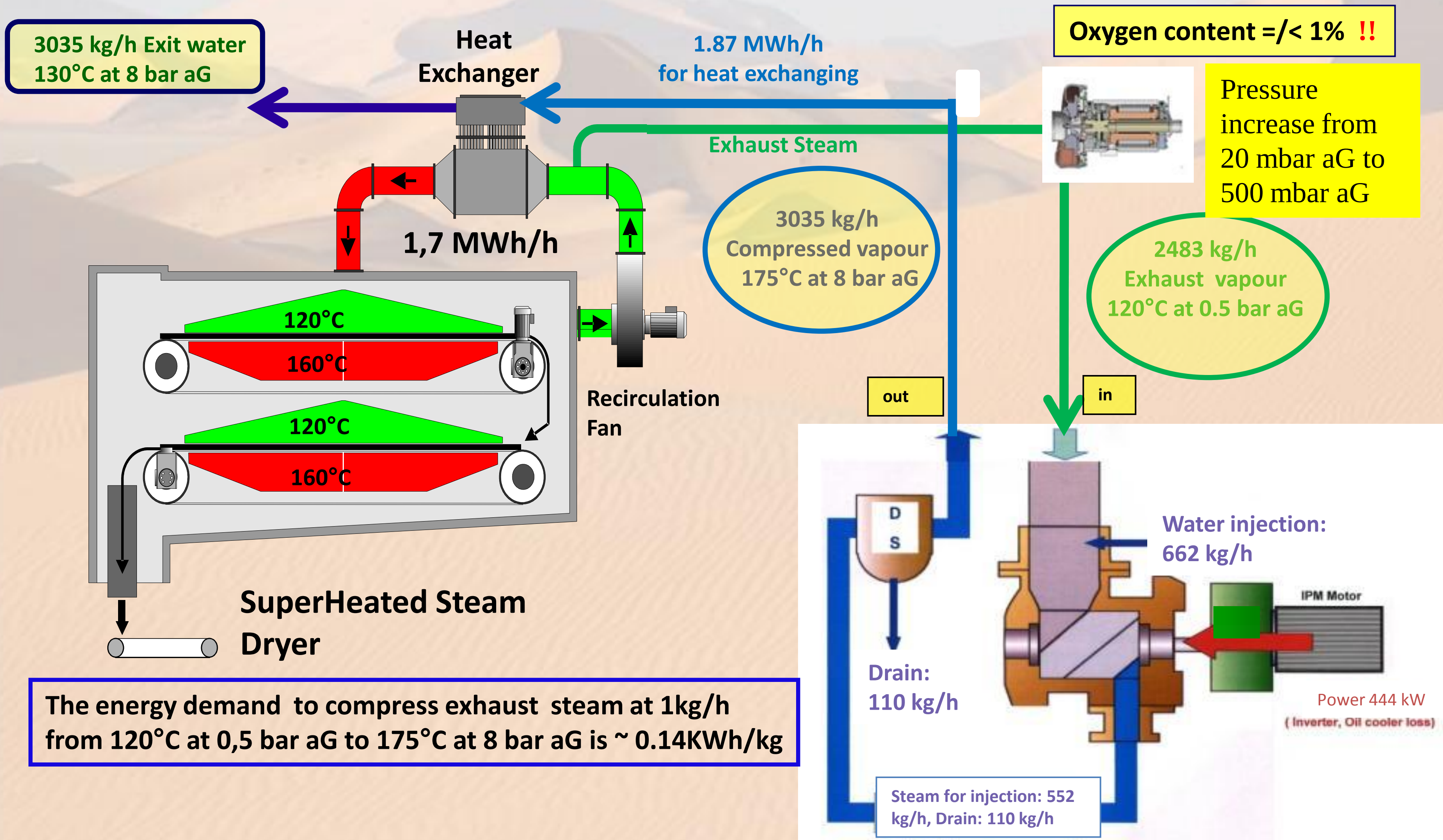
Mass balance of an identified vapour compressor

Outlet steam 1,100 kg/h

Inlet steam 900 kg/h



SuperHeated Steam drying combined with Vapour Compression for energy recovery



The energy demand to compress exhaust steam at 1kg/h from 120°C at 0,5 bar aG to 175°C at 8 bar aG is ~ 0.14KWh/kg

Conclusion

1. This type of drying process is suitable for drying petfood.
2. No change in product quality.
3. Energy saving is possible.
4. No exhaust flow, no odours.
5. Condensate from drying and conveying can be used in the factory instead of fresh water. Has to be validated
6. No Fire and explosion risk.
7. SHS that constantly circulated is capable of creating a close loop sterile/aseptic system.
8. Vapour compression can deliver a up scalable process to recover energy theoretical estimated to ~ 70%

Next steps

- Energy saving by using vapour compression (existing technologies ?)
  - does that technology can handle our steam (quality of steam)
  - feasibility, reliability and all the cost (investment operation and maintenance)
  - when is that technology available?


MARS
Thanks!