Welcome to streamSAVE Dialogue Group

- Today's topic: Heat Recovery & Refrigeration systems
- Please rename yourself in zoom: Name (organisation, country code)
- Agenda (times are CEST):
  - **15:05** Heat recovery: focus on how to define the system boundaries for heat recovery measures
  - **15:20** Heat recovery: best practice example from Austria
  - **15:35** Open discussions and Wrap-up
  - **15:40** Preview of the streamSAVE Training Module
  - **15:50** Refrigeration systems: focus on costs related to commercial and industrial refrigeration systems
  - **16:05** Refrigeration systems: overview of methods used in the French white certificates scheme
  - **16:20** Open discussions and Wrap-up

Heat Recovery in Industry

Christoph Ploiner, Austrian Energy Agency

Dialogue web-meeting – 19th October 2021

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Term of final energy savings

- Article 7 requires the implementation of measures to save final energy.
- Reason: Energy that is not needed in the first place does not have to be produced.
- The term "final energy" is defined in the standardized specifications for energy statistics and can be described as energy delivered to final costumers (households, agriculture, industry, services, transport).

Definition of heat recovery

Reutilization of thermal energy from excess heat as well as waste heat generated from transformation processes.

Some examples:

- Economizer to improve efficiency in thermodynamic cycles
- Waste heat from engines and compressors
- Waste heat from chemical reactions
- Recuperators or buffer storage for reusing heat in shift operations
- Heat exchanger in ventilation systems

Focus on industry

- High potentials
  - 26% of final energy consumption in EU27
  - $^2/_3$ thereof heat related
- High temperature levels
- High energy quantities in individual industrial facilities
- Potential of improving competitiveness of affected implementer
- Broad range of use cases
- Calculation methodologies were developed for three use cases:

Heat recovery for (1) feeding back into the process, (2) feeding another application (3) feeding into district heating networks

Terms on-site & same process

- Same process: Energy flows within a production chain.

  Example food production: Consecutive heating and cooling process steps → Use energy derived from cooling.

- On-Site: The heat is recovered and used within the same company, without using commercial heat networks.

  Example: The waste heat from compressed air systems is used to heat the office rooms.

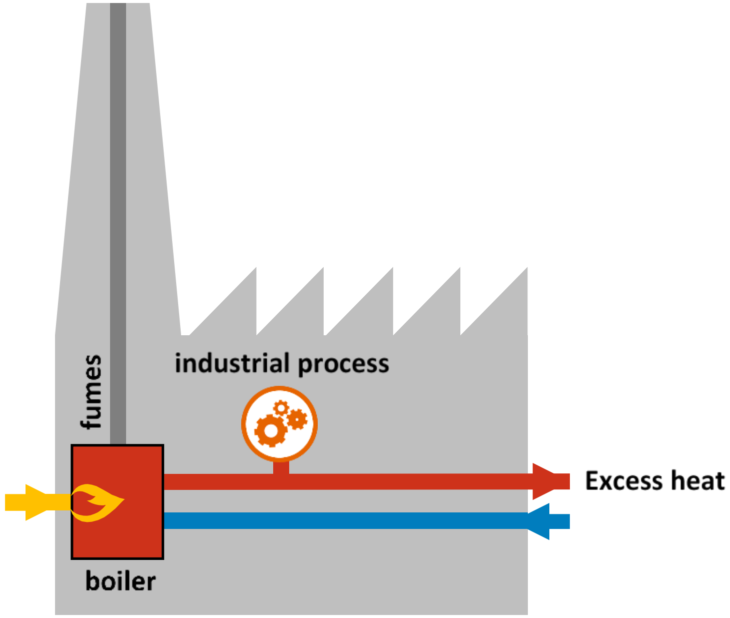
Principle of final energy savings

$$FES = FEC_{Baseline} - FEC_{Action}$$

FES	Final energy savings
FEC	Final energy consumption
Baseline	Index for the situation before implementing the energy saving action
Action	Index for the situation after implementing an energy saving action

Baseline situation

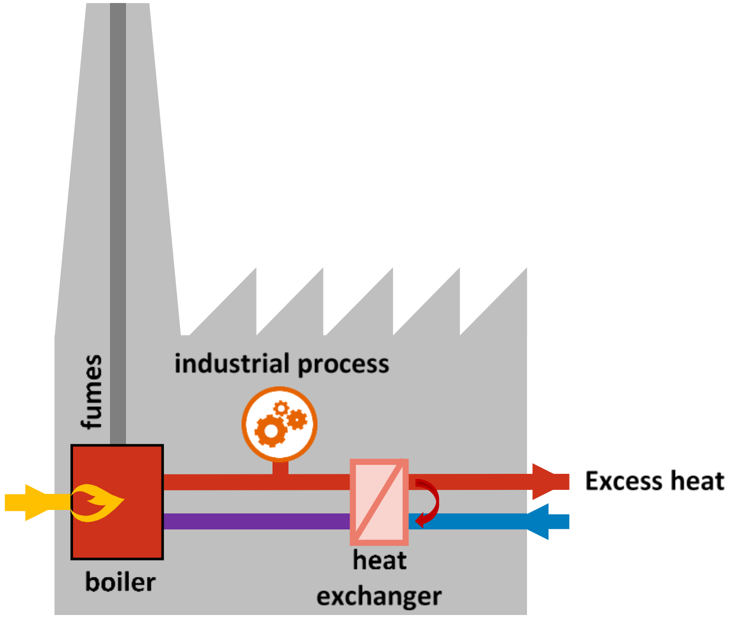
- Heat production to operate an industrial process.
- Excess heat will be cooled down or get lost due to:

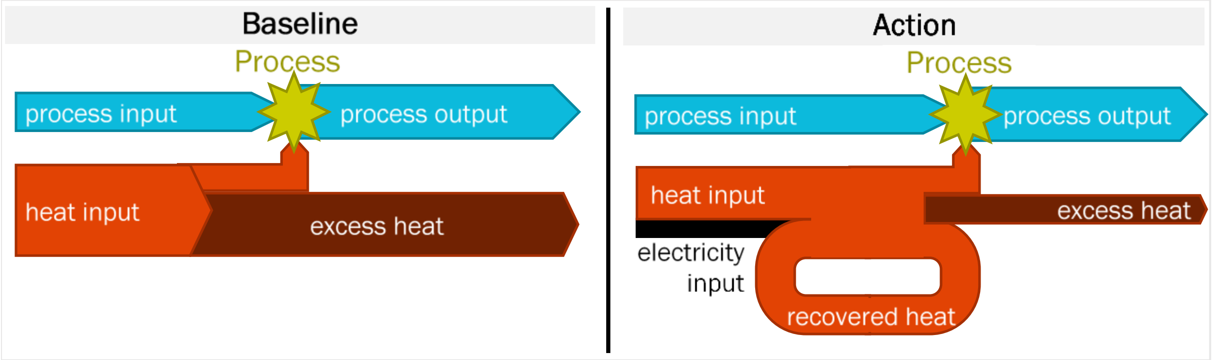


  - unusable temperature level after the process
  - different temperature levels in-between production steps
  - Timely discontinuity of process cycles (e.g. shift operation of production)

Heat recovery | feedback into the process

- Reduces the energy input by feeding back excess heat into the same process.
- Final energy saving within the affected process

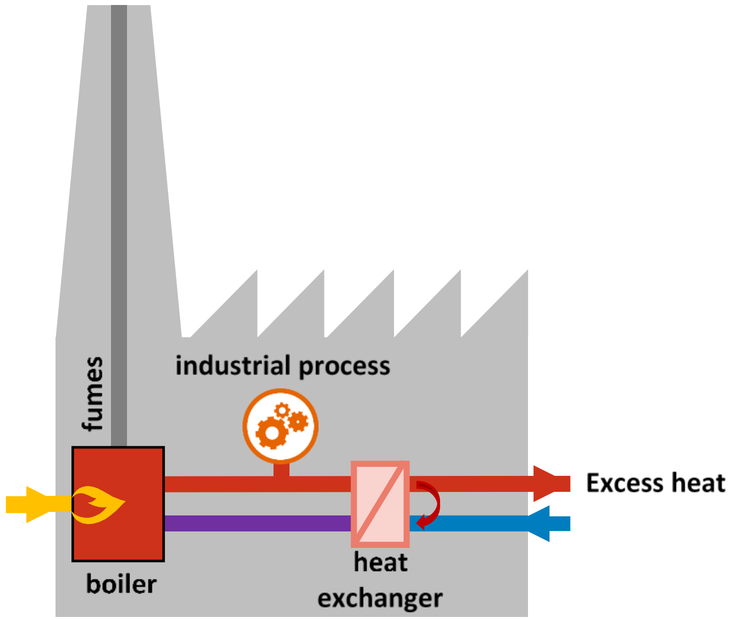




Heat recovery | feedback into the process

Calculation formula

$$TFES = \left(\frac{FEC_{Baseline}}{po_{Baseline}} - \frac{FEC_{Action}}{po_{Action}}\right) \cdot \mathrm{po}_{Action}$$

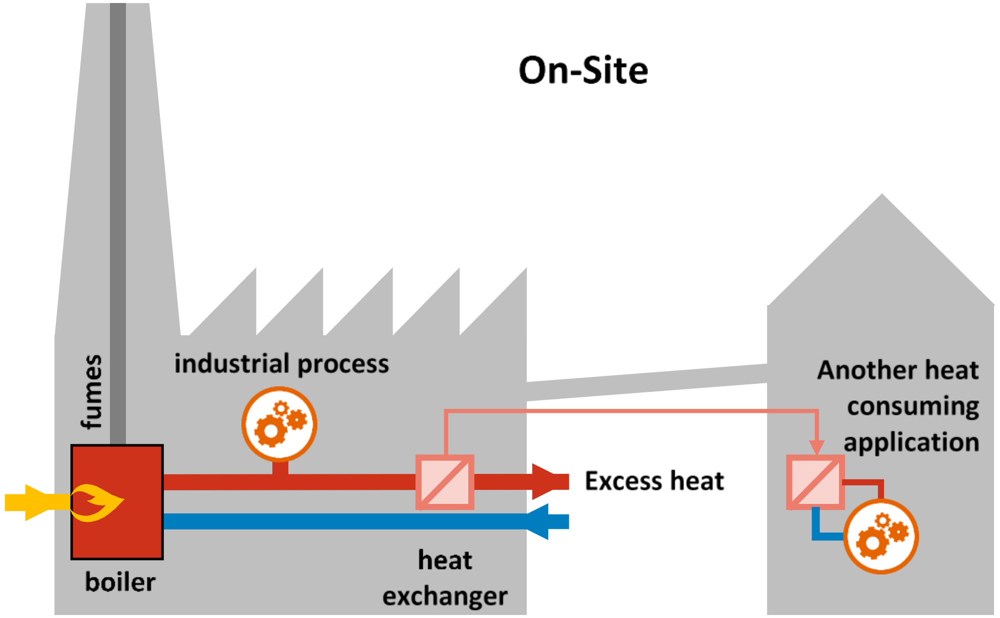


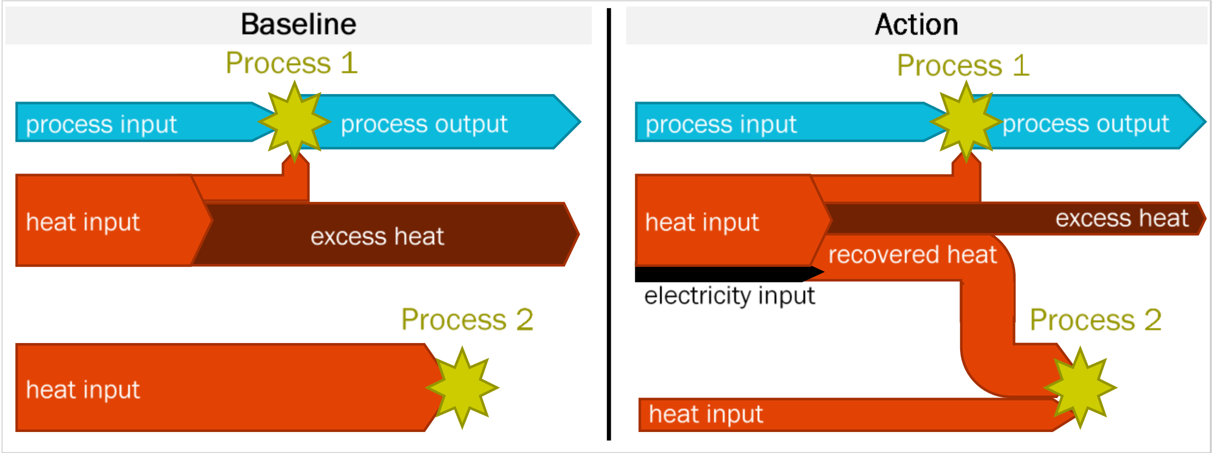
TFES	Total final energy savings [kWh/a]
FEC	Final energy consumption [kWh/a]
po	Production output [units/a]
Baseline	Index for the baseline situation of the action
Action	Index for the situation after implementing the action

Do not forget the power inputs of auxiliary systems (i.e. additional pumping energy)

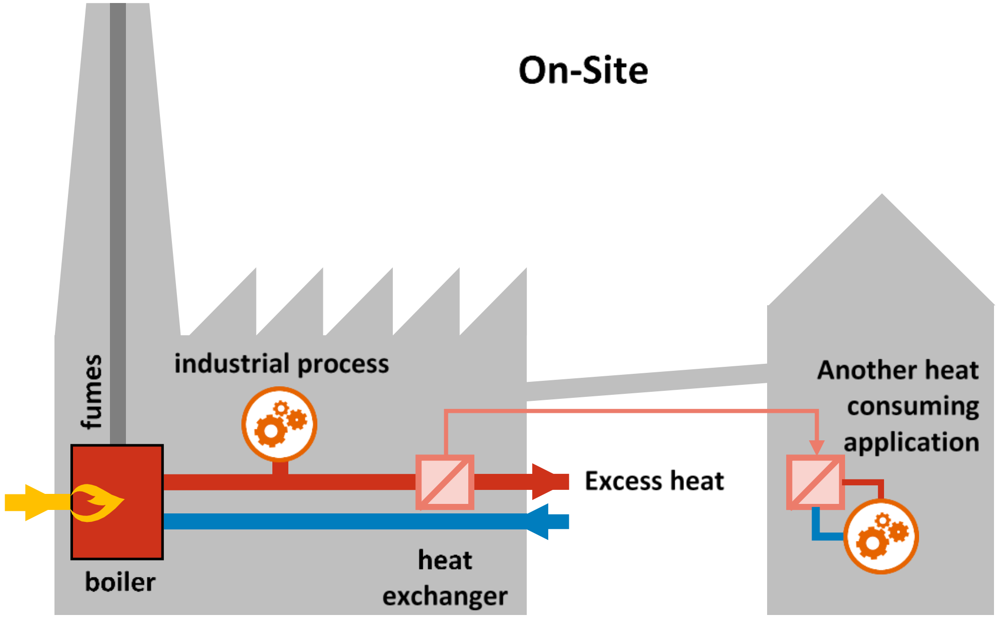
Heat recovery | feeding another application

- Reduces the energy input of another heat consuming application (e.g. space heating of on-site buildings, drying plants)
- Final energy saving on-site





Heat recovery | feeding another application



Calculation formula

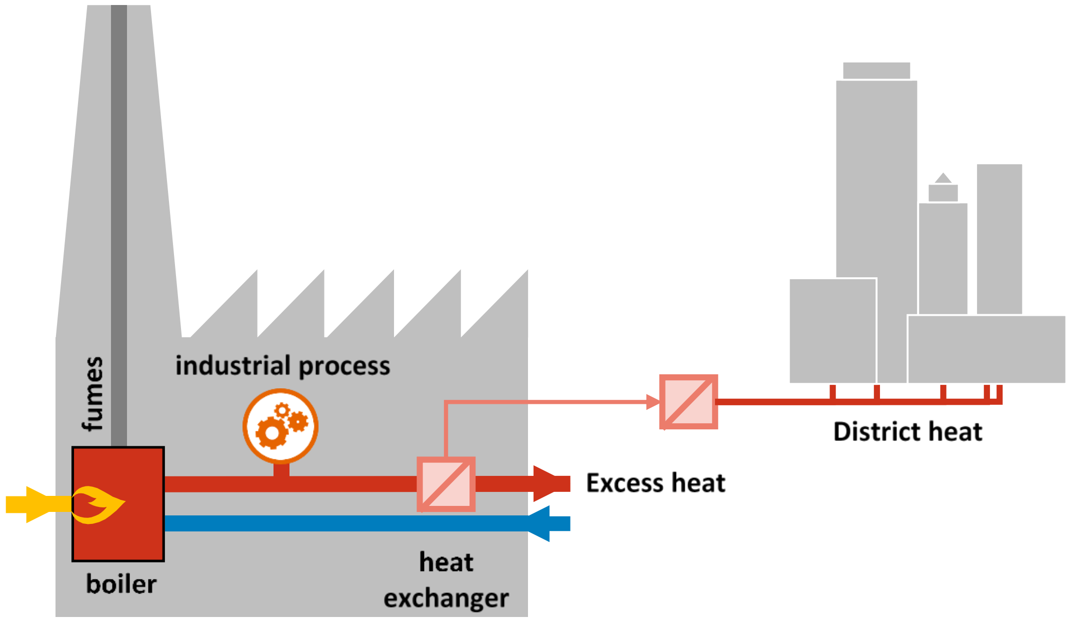
$$TFES = Q_{rec} \cdot \frac{1}{eff_{mhs}} \cdot f_{BEH}$$

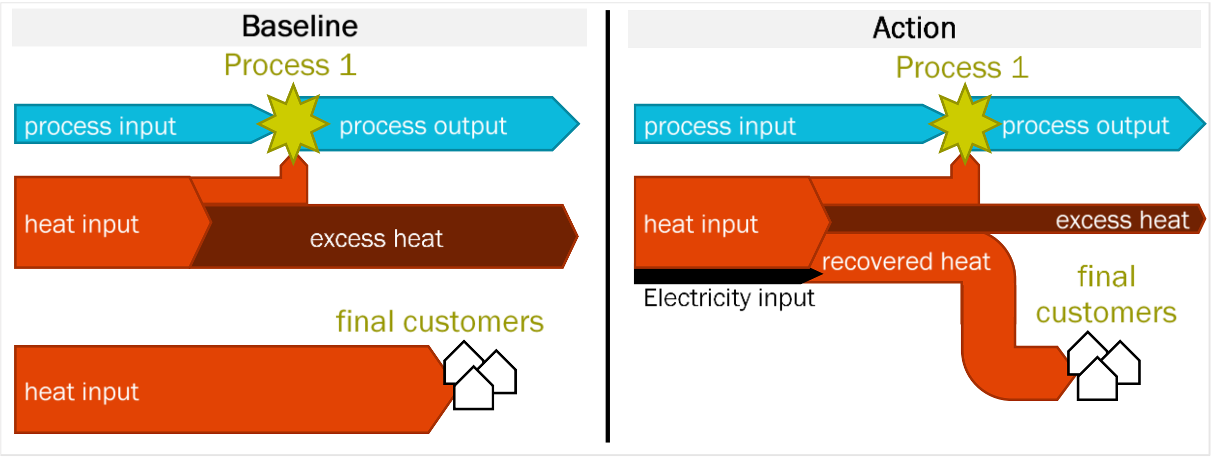
TFES	Total final energy savings [kWh/a]
Q_{rec}	Recovered heat consumption of the application [kWh/a]
eff_{mhs}	Conversion efficiency of the main heating system of the relevant application [dmnl]
f_{BEH}*	Factor for correction of behavioural effects [dmnl]

* in case relevant; e.g. increased space heating temperature

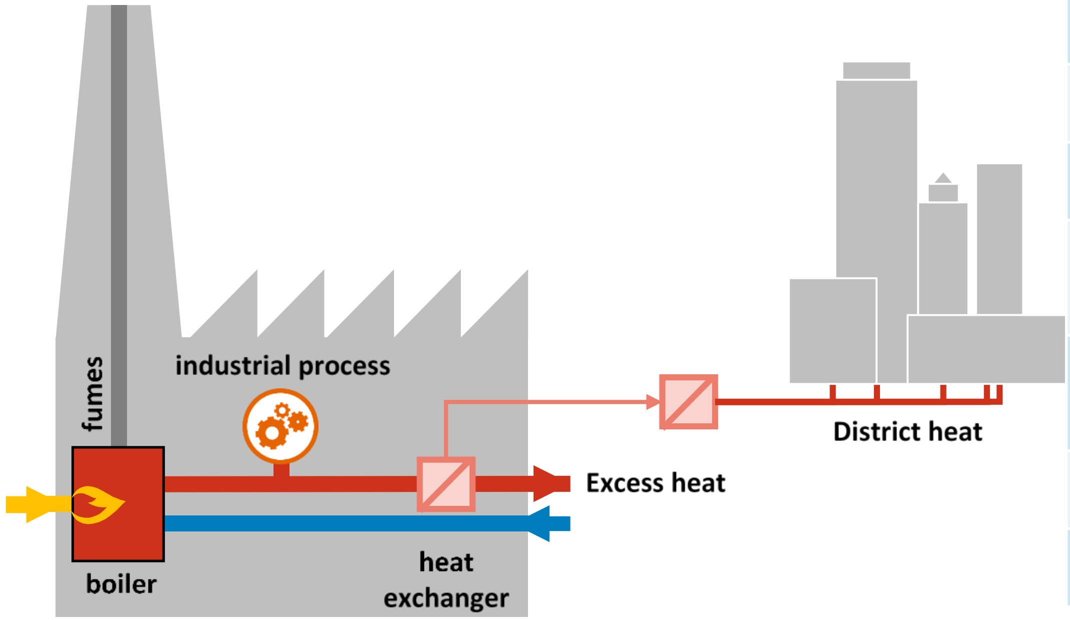
Heat recovery | feeding into district heat

- Reduces the energy input of final customers (difference to reference heating system)
- Final energy savings occur at the final customer





Heat recovery | feeding into district heat



Calculation formula

$$TFES = Q_{EH} \cdot (1 - HL_{DHG}) \cdot \left(\frac{1}{eff_{Baseline}} - \frac{1}{eff_{Action}}\right) \cdot (1 - f_{ei}) \cdot (1 - f_{BEH})$$

TFES	Total final energy savings [kWh/a]
Q_{EH}	Excess heat fed into the district heating grid [kWh/a]
HL_{DHG}	Heat losses in the district heating grid [dmnl]
$eff_{Baseline}$	Conversion efficiency of the reference heating systems [dmnl]
eff_{Action}	Conversion efficiency of the district heat consuming heating systems [dmnl]
f_{ei}	Factor to calculate extrinsic incentives [dmnl]
f_{BEH}	Factor to calculate rebound effects [dmnl]

Q&A Session

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Optimization of an energy recovery system in a pulp production plant

Dr. Johann Geyer

(19.10.2021)

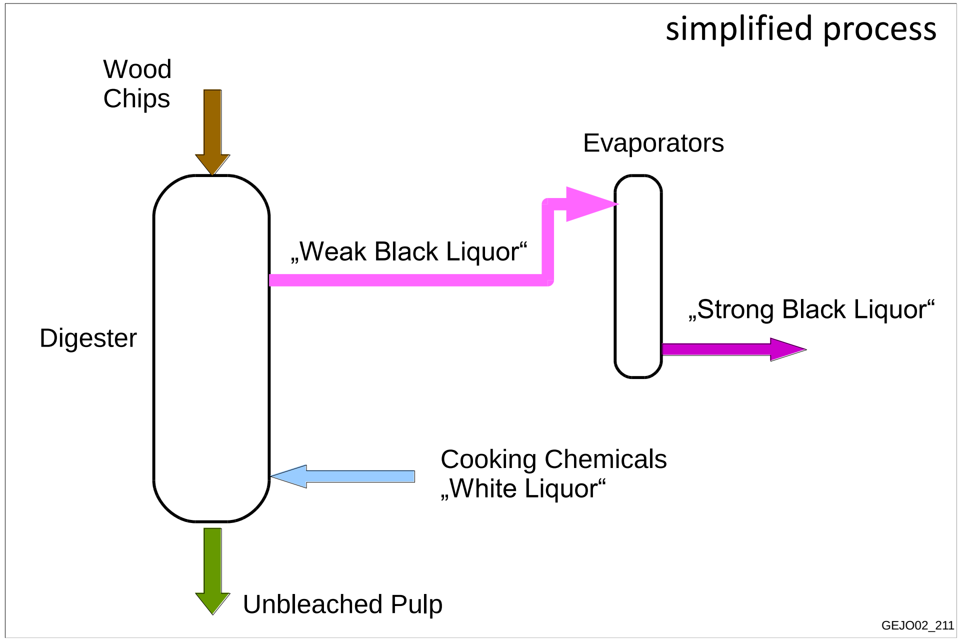
Enertec Naftz & Partner GmbH & Co KG

Agenda

- Basics
- Optimisation measure
- Impact

Basics

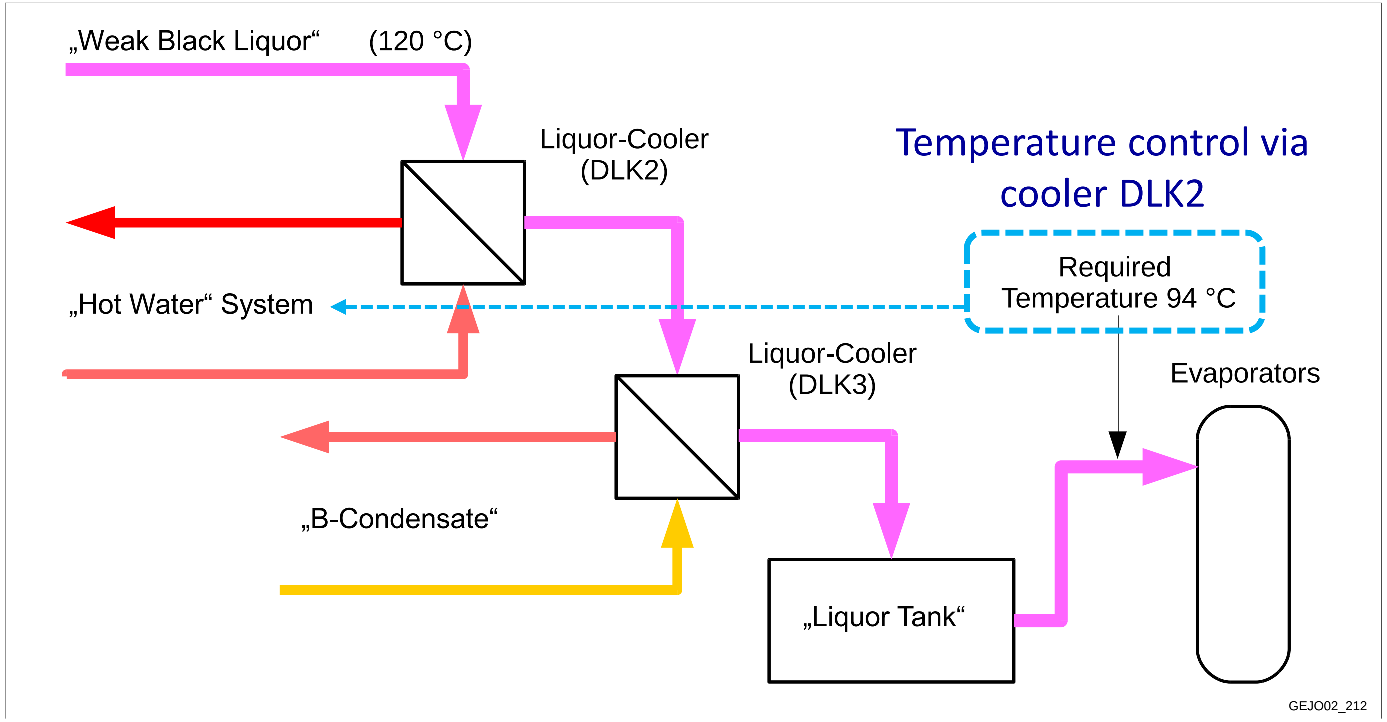
- Pulp production is an energy-intensive, complex process
- Basis: Cooking of wood chips in a cooking-liquor



- The liquor from this cooking process (“Weak Black Liquor”) has to be cooled down to a certain temperature level for subsequent processing (concentration in evaporation plant)
- Cooling is done by various heat recovering systems
- Unused waste heat is cooled to the environment

Basics

- Liquor cooling system (before implementation of the optimisation measure)



– Heat demand in “Hot Water system” is lower than heat recovery capacity
  ⇨ Excess heat is cooled to the environment

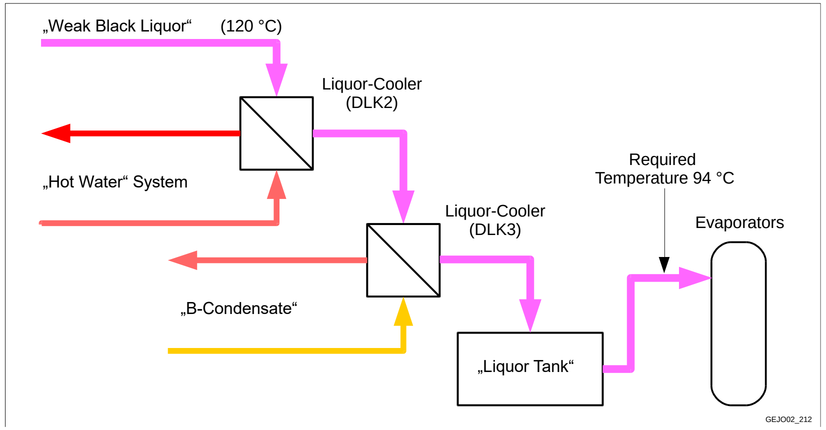
– DLK2 reduce temperature level for subsequent HR (“B-Condensate”)
  ⇨ Recovery capacity lower than heat demand for “B-Condensate” (additional steam demand)

Basic Situation

- Liquor cooling system (before implementation of the optimisation measure)

In principle:

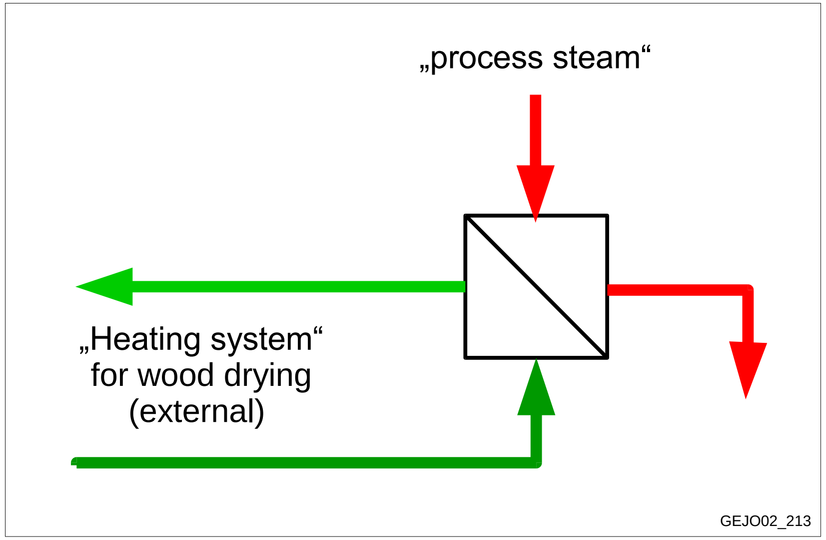
– Heat potential from the “Weak Black Liquor” is bigger than the heat demand in the “Hot Water System” + B-Condensate System”



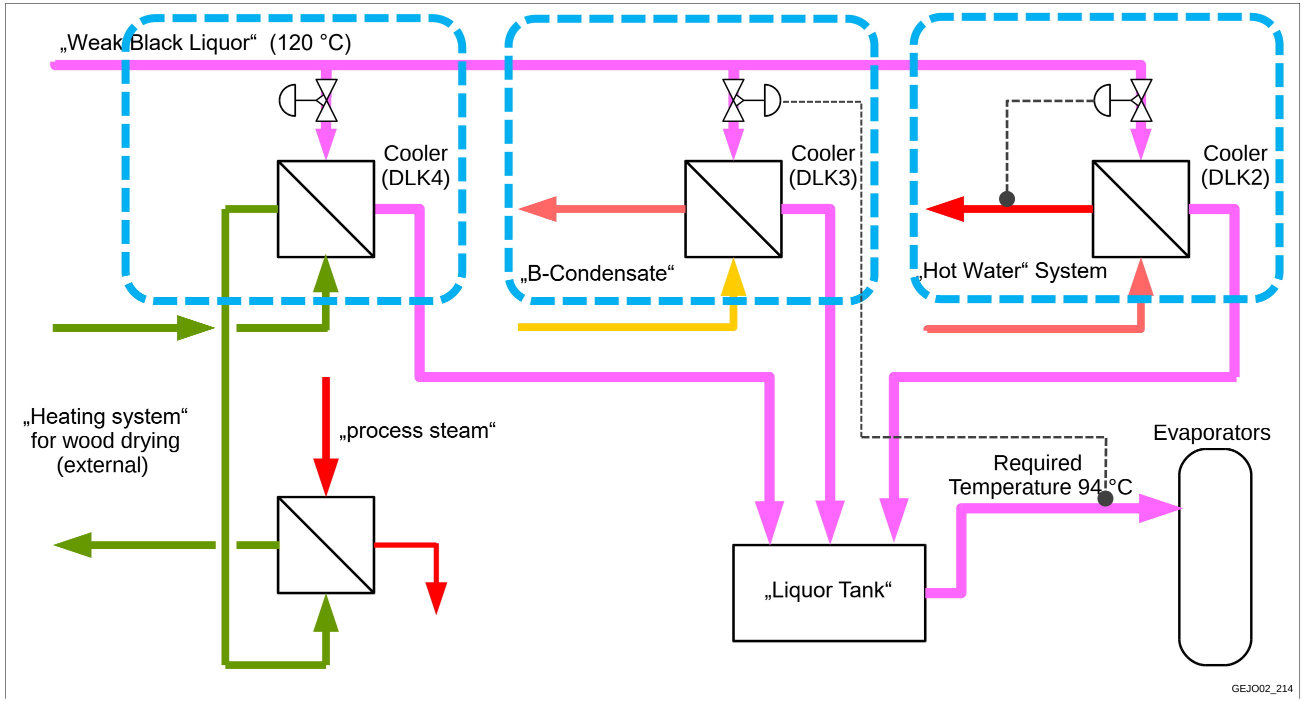
In addition:

– The plant supplies heat (for wood drying) to a nearby sawmill

– For this purpose, heat is extracted from the process steam system



- Liquor cooling system (after implementation of the optimisation)



- Regulation of cooler DLK2 according to demand of “Hot Water System”
  ⇨ increased HR capacity for other potential users
- Rearrangement of cooler DLK3 ⇨ increased “source temperature”
  ⇨ increased HR – capacity ⇨ reduced steam demand in “B-Condensate” system
- Additional heat recovery cooler DLK4
  ⇨ used for preheating (as much as possible!) ⇨ reduced steam demand for heating system for wood drying

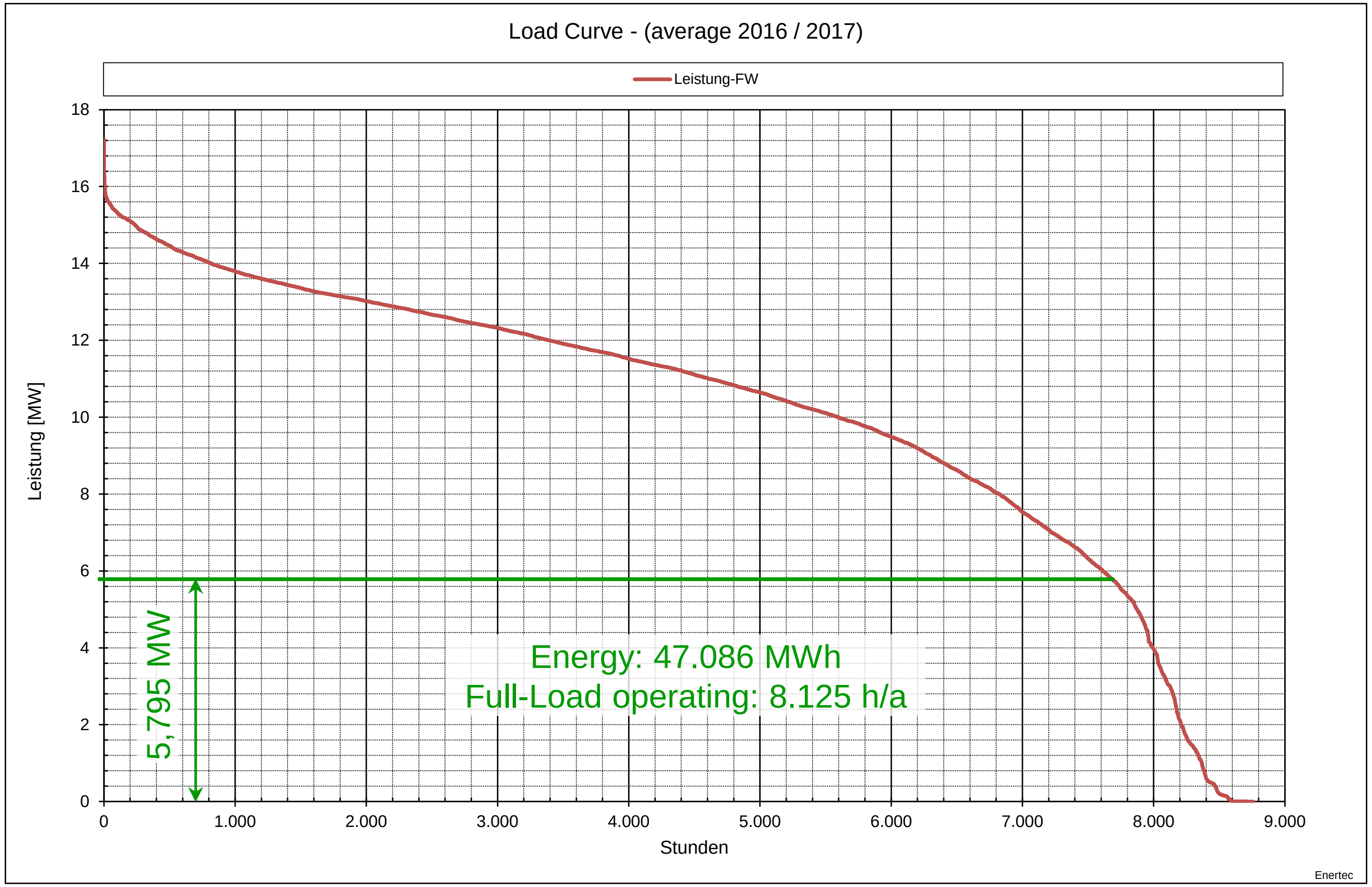
Impact of the measure

- Calculation of energy savings is based on recorded date before and after the implementation of the measure
  - Temperatures, volume flows, heat generation of the liquor cooling system
  - Annual load curve of the wood drying system

Weak Black Liquor - cooling system			
Cooler		“before”	„after
Heat output (average) DLK 2	[kW]	8.582	956
Heat output (average) DLK 3	[kW]	3.058	4.495
Heat output (average) DLK 4	[kW]	-	5.795
Liquor temperature (evaporator in)	[°C]	93,6	93,6

Impact of the measure

- Sorted annual load curve (heating system for wood drying)



⇨ Preheating with DLK4 result in 47.086 MWh/a energy savings (process stream)

Impact of the measure

- Energy savings calculation
  - ⇨ Increased heat recovery reduces demand for steam from the process steam system
  - ⇨ Process steam is generated by a bark boiler

Savings calculation			Remark
Additional heat output DLK 3	[kW]	1.437	
Annual operating time	[h/a]	8.500	downtime for maintenance and repair included
Annual energy saving	[MW/a]	12.212	
Additional heat output DLK 4	[kW]	5.795	
Annual operating time (full load)	[h/a]	8.125	takes into account load curve
Annual energy savings	[MW/a]	47.085	
Total energy savings (steam)	[MWh/a]	59.297	
Boiler efficiency	[%]	82,0	
Total energy savings	**[MWh/a]**	**72.313**	fuel energy, bark

Thank you for your attention

DI Dr. Johann Geyer
Enertec Naftz & Partner GmbH & Co KG
office@enertec.at

Legal Background

- Austrian Obligation Scheme 2014-2020 referred to “sales to final customers”
- In this specific case, the waste heat was delivered free of charge to the nearby site, therefore not considered a sales activity
- EEOS 2021 – 2030 is directed at final energy consumption, which challenges the eligibility of such actions

Discussion on heat recovery

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Refrigeration systems

María López, Juraj Krivošík , Michal Stasa

Dialogue web-meeting – 19th October 2021

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Summary of the last meeting (1)

- The scope of the methodology: focus on new installations or the replacement of air-chilled or water-chilled central compression refrigeration units, and high temperature process chillers.

Summary of the last meeting (2)

- Eurovent's ESEER index seemed to be outdated and not used anymore
- Ecodesign regulation for air heating and cooling products (EU) 2016/2281 - using new set indicators SEER (Seasonal Energy Efficiency Ratio) or SEPR (Seasonal Energy Performance Ratio)
- Discussions and polls suggest that methodologies will be based on SEPR value

Scope of the methodology

- The savings calculation methodology targets:
  - New installations or the replacement of air-chilled or water-chilled central compression refrigeration units;
  - High temperature process chillers: "capable of cooling down and continuously maintaining the temperature of a liquid, in order to provide cooling to a refrigerated appliance or system, the purpose of which is not to provide cooling of a space for the thermal comfort of human beings; delivering its rated refrigeration capacity, at an indoor side heat exchanger outlet temperature of 7ºC, at standard rating conditions"[5]
- Limitations:
  - Central compression refrigeration units with compressors power by electrical energy.
  - Cooling systems using free cooling or heat recovery are not covered.
- Sources:
  - Austrian catalogue on bottom-up calculation methodologies[1]
  - multEE project[2]

[1] Anlage 1 BGB1. II, Nr. 172 (2016). Verallgemeinerte Methoden zur Bewertung von Energieeffizienzmaßnahmen, 100–103. https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2016_II_172/COO_2026_100_2_1241958.pdfsig

[2] Document with general formulae of bottom-up methods to assess the impact of energy efficiency measures. https://multee.eu

[5] Comission Regulation (EU) 2016/2281 implementing Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products, with regard to ecodesign requirements for air heating products, cooling products, high temperature process chillers and fan coil units.

Data sources for indicative values

$$TFES \text{ or EFE} = n \times Pc \times h_{FL} \times \left(\frac{1}{\text{SEPR}_{Ref}} - \frac{1}{\text{SEPR}_{Eff}} \right)$$

Baseline system data

New system data

For air-chilled coolers	[-]
$SEPR_{Ref}$	5.62
$SEPR_{Eff}$	6
For water-chilled coolers	**[-]**
$SEPR_{Ref}$	8.76
$SEPR_{Eff}$	11.41
Lifetime of savings	**[a]**
Lifetime of savings	8

Database of Eurovent certified air-chilled and water-chilled refrigeration units under the LCP-HP (Liquid Chilling Packages and Heat Pumps)[4]:

- $SEPR_{Ref}$: average of all units in the market.
- $SEPR_{Eff}$: average of units exceeding reference value.

⟶ Data obtained from Eurovent website

→ Commission Recommendation about transposing the energy savings obligations (Indicative lifetime for commercial refrigeration)[5]

[4] https://www.eurovent-certification.com/en/third-party-certification/certification-programmes/lcp-hp

[5] Commission Rrecommendation (EU) 2019/1658 on transposing the energy savings obligations under the Energy Efficiency Directive

Data sources for indicative values

$$TFES \text{ or EFE} = n \times Pc \times h_{FL} \times \left(\frac{1}{\text{SEPR}_{Ref}} - \frac{1}{\text{SEPR}_{Eff}}\right)$$

New system data

Baseline system data

For air-chilled coolers	[P_c]
Cooling power	≤ 600 kW
For water-chilled coolers	**[P_c]**
Cooling power	≤ 1.500 kW
Full-load hours	**[h_{FL}]**
Full-load hours	Project specific
Number of cooling systems	**[n]**
Number of cooling systems	Project specific

LCP-HP (Liquid Chilling Packages and Heat Pumps) Programme by Eurovent:

→ Capacity limits of certified units: air- and water-chilled, cooling mode

→ Full-load hours are project specific.

→ Number of units for specified cooling power (Pc). Project specific.

Summary of the last meeting (3)

- The standard EN14825:2018 may include complementary indicative values that could be relevant for the streamSAVE methodology.

Overview of costs related to Refrigeration systems

- The cost associated with the transcription to a more efficient refrigeration system include the following cost components:
  - Investment costs

    Considers the purchase cost of the equipment, accounting for process chiller, equipment transport to the site, construction, assembly, equipment rental, as well as labour and contractor fees.
  - Variable operating costs

    The operating cost are due to electricity
  - Repair and maintenance costs

TAXES ARE NOT INCLUDED

Overview of costs related to Refrigeration systems

Investment costs	[euro2010]
Air-Cooled	[2,354 – 2,999]
Water-Cooled	1,610 – 3,689]
Operating costs	[euro/a]
Electricity	Prices for electricity have been included in the guideline
Maintenance costs	[euro2010/a]
Air-cooled	[1,007 – 3,107]
Water-cooled	[840 – 7,340]
Lifetime	[a]
	8 years

Overview of costs related to Refrigeration systems

- Some considerations:
  - These values are indicator and in no case should be taken as an estimated value for design
  - The investment cost is strongly dependent on the selected capacity of the process chiller
  - The values presented have been annualized, taking into account the life time of the equipment (8 years, considering 4,380 load hours per year).
  - The indicative cost values are based on preparatory studies in frame of the Ecodesign Directive.

TAXES ARE NOT INCLUDED

Calculation methods for refrigeration systems in the French white certificates scheme

Jean-Sébastien Broc, IEECP

(with inputs from ADEME and ATEE)

Dialogue web-meeting – 19th October 2021

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

France's white certificates scheme

Les certificats D'ÉCONOMIES D'ÉNERGIE
MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE

- **Energy Efficiency Obligation Scheme** covering **all end-use sectors:** residential, services, industry, transport, agriculture
- **Single policy measure** reported by France to Article 7 EED

203 TWh (17.4 Mtoe) of cumulative energy savings for 2014-2018 (Art.7 EED)

- Two obligations: "classical" CEE and "energy poverty" CEE
- Ways for obligated parties (energy suppliers) to comply with the obligation:

Do their own programmes | Fund third parties' programmes | Buy certificates on the market | Delegate their obligation | Pay a penalty

3 main categories of action

Standardised actions

- **Standardised** calculations with **deemed savings**
- Currently **216 types** of standardised actions in the catalogue

Specific actions

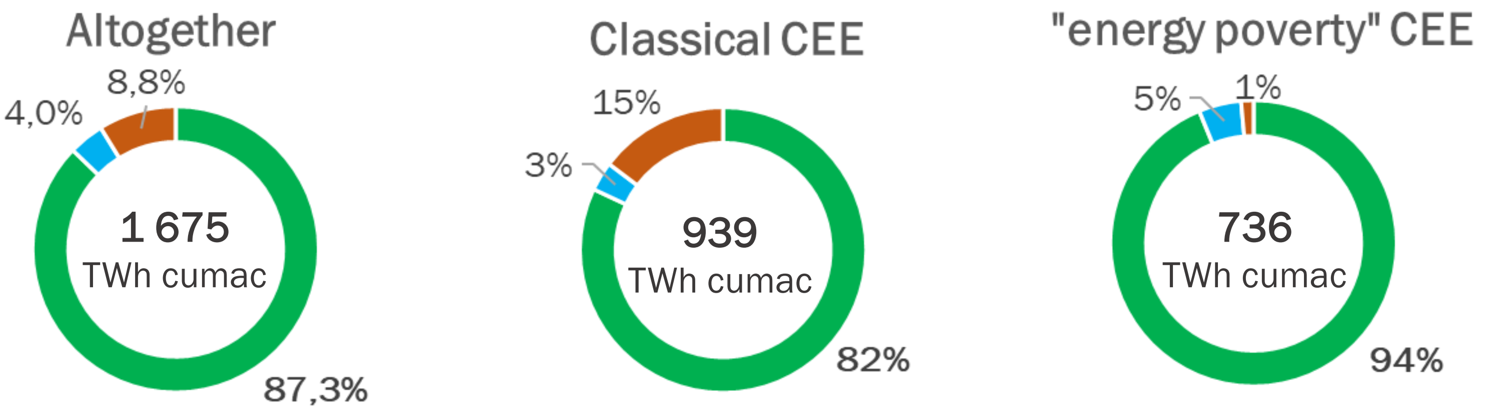
- Calculations based on energy audits (**scaled savings**)

Accompanying programmes

- Certificates with fix price (c€/kWh cumac): no savings calculation
  → *certificates not reported to Article 7 EED*

Standardised actions represent most of the white certificates

(statistics for white certificates delivered between 01 January 2018 and 31 August 2021; *source: CEE newsletter of September 2021, Ministry of Ecological Transition*)



"cumac" = **lifetime-cumulated** and **discounted** final energy savings (discount rate: 4%/year)

Standardised actions for refrigeration

- Examples of standardised actions **directly related to refrigeration systems**

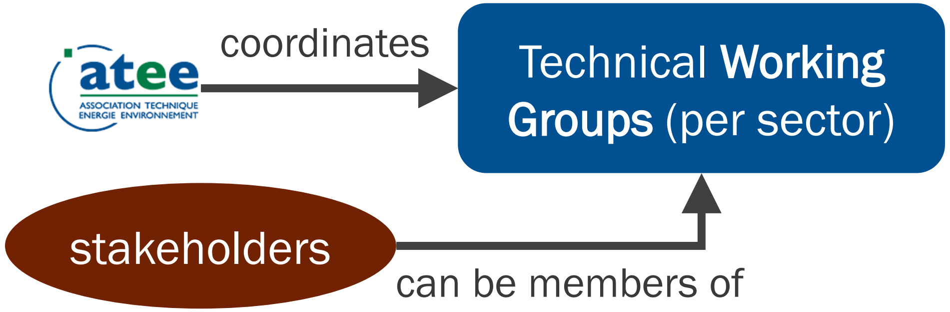
		TWh cumac	%
Services	BAT-EQ-117 Refrigeration unit using subcritical or transcritical CO_2 in commercial buildings	0,1	0,04%
Services	BAT-EQ-130 **Condensing refrigeration unit with high efficiency** in commercial buildings	0,2	0,07%
Industry	IND-UT-113 **Condensing refrigeration unit with high efficiency** in industry	2,1	0,8%
Industry	IND-UT-135 Freecooling with cooling water instead of a chiller (*published in September 2019*)	-	-
Industry	IND-UT-116 Control system to enable refrigeration system to work with high variable pressure	5,5	2,0%

- Standardised actions about **heat recovery on refrigeration systems**

Data for January 2018 – June 2019

IND-UT-117 Heat recovery on cooling units in industry	**58,1**	**21,5%**
IND-BA-112 Heat recovery on cooling tower in industry	6,6	2,4%
BAT-TH-139 Heat recovery on cooling units in commercial buildings	10,4	3,8%
AGRI-TH-104 Heat recovery on cooling units (other than milk tanks) in agriculture	5,8	2,1%

Process for defining deemed savings



- **Identify** candidates for standardised actions
- **Draft a proposal** including technical specifications, quality & other requirements, baseline & calculation formula, average values and related data sources

When a consensus is agreed upon by the group members

- **Technical & legal review** by ADEME & the ministry

- **Final validation & official publication** by the ministry

Reliability based on the **collective** process, **review** and **validation**
+ update / revision when needed (e.g., to take into account changes in regulations)

Condensing refrigeration unit with high efficiency in industry (1)

Technical specifications:

Installation of a refrigeration condensation system in a refrigeration unit that allows a small temperature difference between the refrigerant at condensing pressure and the cooling medium (air or water) at the condenser inlet.

Condensing system means here "condenser plus tower", "condenser only" or "tower only" if it feeds a water-cooled refrigeration condenser.

Requirements:

Installation by a professional.

Efficiency in terms of max. values of temperature difference set for the condensing unit

Energy efficiency improvement:

Energy efficiency is improved thanks to the decrease of the condensation temperature for the refrigerant.

Key parameters = average temperatures for each step of the refrigeration cycle

COP (Coefficient Of Performance) = $\frac{Cooling\ energy\ delivered}{Electrical\ energy\ absorbed} = \frac{T_{evaporation}}{T_{condensation} - T_{evaporation}}$

Condensing refrigeration unit with high efficiency in industry (2)

Key parameters = average temperatures for each step of the refrigeration cycle

COP (Coefficient Of Performance) = $\frac{Cooling\ energy\ delivered}{Electrical\ energy\ absorbed} = \frac{T_{evaporation}}{T_{condensation} - T_{evaporation}}$

COP increases (and energy consumption decreases) when the condensation temperature decreases

$$T_{condensation} = T_{cold\ source} + \Delta T$$

outdoor air or water (river)

Depends on the **refrigeration system**
→ Higher efficiency = smaller temperature difference
= lower condensation temperature

$$Energy\ efficiency\ gain\ (in\ \%) = \frac{COP_{efficient} - COP_{baseline}}{COP_{baseline}}$$

Condensing refrigeration unit with high efficiency in industry (3)

- Calculation of the annual final energy savings

$$= P_{refrigeration\,unit} \times equivalent\ hours\ of\ use \times energy\ efficiency\ gains$$

✓ in kW
✓ **collected for each action**

✓ in hours/year
✓ Estimated annual duration of use, corrected to count only the time where operating conditions enable high efficiency
✓ **Standard values** depending on the operation pattern or shift(s) per day (1*8, 2*8 or 3*8)

✓ in %
✓ Estimated based on a set of assumptions
✓ **Standard values** depending on the type of unit (air/air, air/water, water/water) and one the temperature difference (ΔT)

Condensing refrigeration unit with high efficiency in industry (4)

Les certificats D'ÉCONOMIES D'ÉNERGIE
MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE

- Examples of assumptions made:
  - Most refrigeration systems are over-sized → the compressor is effectively in used 80% of the time of use (i.e., when cooling is needed)
  - Baseline rate of equipment with high efficiency unit: 17% (based on a 2010 survey)
  - Baseline temperature difference (ΔT): 15 °C (air as cold source) or 10 °C (water)
  - Average temperature of the cold source (per area / climate zone)
- Estimated lifetime: 15 years (based on a 2008 survey on electric motors in industry, including refrigeration units)

Discussion on refrigeration systems

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Conclusions

This project has received funding from the Horizon 2020 programme under grant agreement n°890147. The content of this presentation reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.

Next steps

- Meeting minutes
  - please feel free to send us your suggestions
- All information will be included on the streamSAVE platform
  - in case not registered yet, we will show you how
- Training Module: available this Friday 22nd October
- The discussions continue in the online forum

Next Dialogues Group

- Dates for the next Dialogue Groups web meetings

Tuesday 9 November 3.00 to 4.30 pm CET	 **BACS & Public Lighting** 	Registration
Tuesday 23 November 3.00 to 4.30 pm CET	 **Electric Vehicles** **+ full demo of the Training Module**	Registration

Feedback

- Please, fill out our quick feedback survey
- You may also leave us a longer message
  - Via forum on the streamSAVE platform
  - Via the anonymous form (link in the chat)
  - Via dialogues@streamsave.eu
    - Please accept as sender
- To receive more info → register on the streamSAVE platform: https://streamsave.flexx.camp/signup-0818ml

Project Partners

vito

circe

European Copper Institute
Copper Alliance

SEVEn

AUSTRIAN ENERGY AGENCY

Jožef Stefan Institute

IEECP
INSTITUTE FOR EUROPEAN ENERGY AND CLIMATE POLICY

LIETUVOS ENERGETIKOS AGENTŪRA

ΚΑΠΕ
CRES

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

LGi
sustainable innovation

Thank you

Get in touch for more information!

Project coordinator - Nele Renders, VITO

All project reports will be available for download on the streamSAVE website www.streamsave.eu

Email the project at contact@streamsave.eu

Follow the project on LinkedIn @streamSAVEH2020

Follow the project on Twitter @stream_save