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OPENING SPEECH

Charles-Albert Florentin

Cluster Manager
CleanTech,Luxinnovation

Muller Caroline

Cluster Manager - Materials & Manufacturing, Luxinnovation

LUXEMBOURG MATERIALS & MANUFACTURING CLUSTER

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INTRODUCTION TO WASTE HEAT VALORISATION

Alexandre Bertrand

Senior Researcher & Technology Associate, LIST-ERIN

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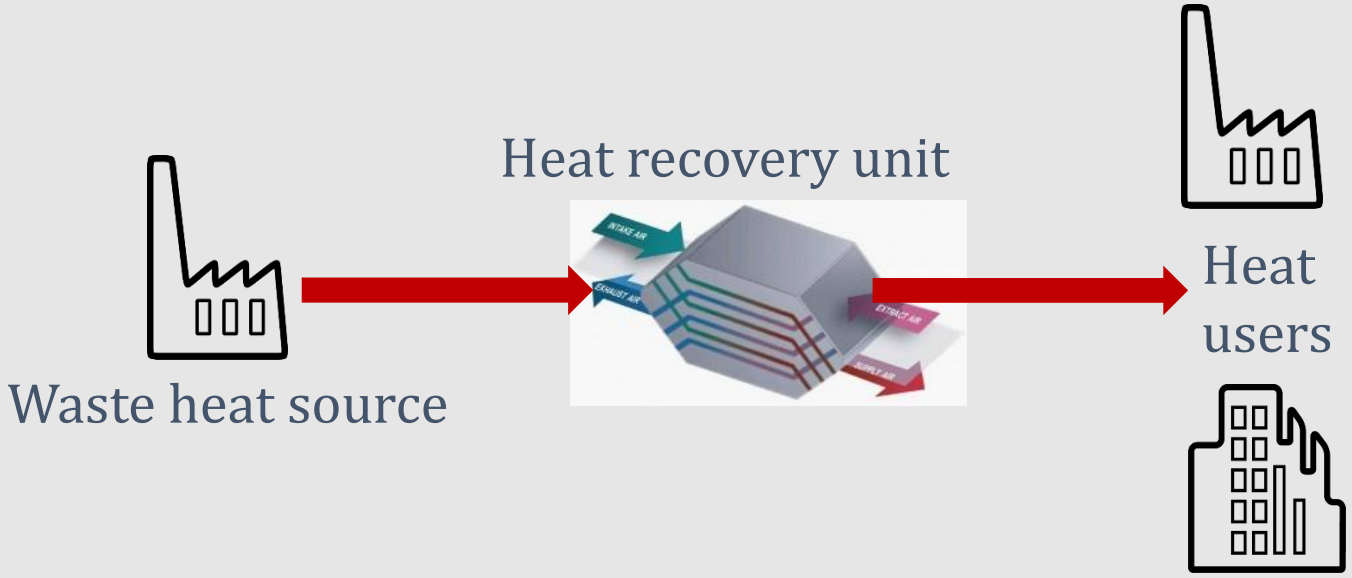
INTRODUCTION TO WASTE HEAT VALORISATION

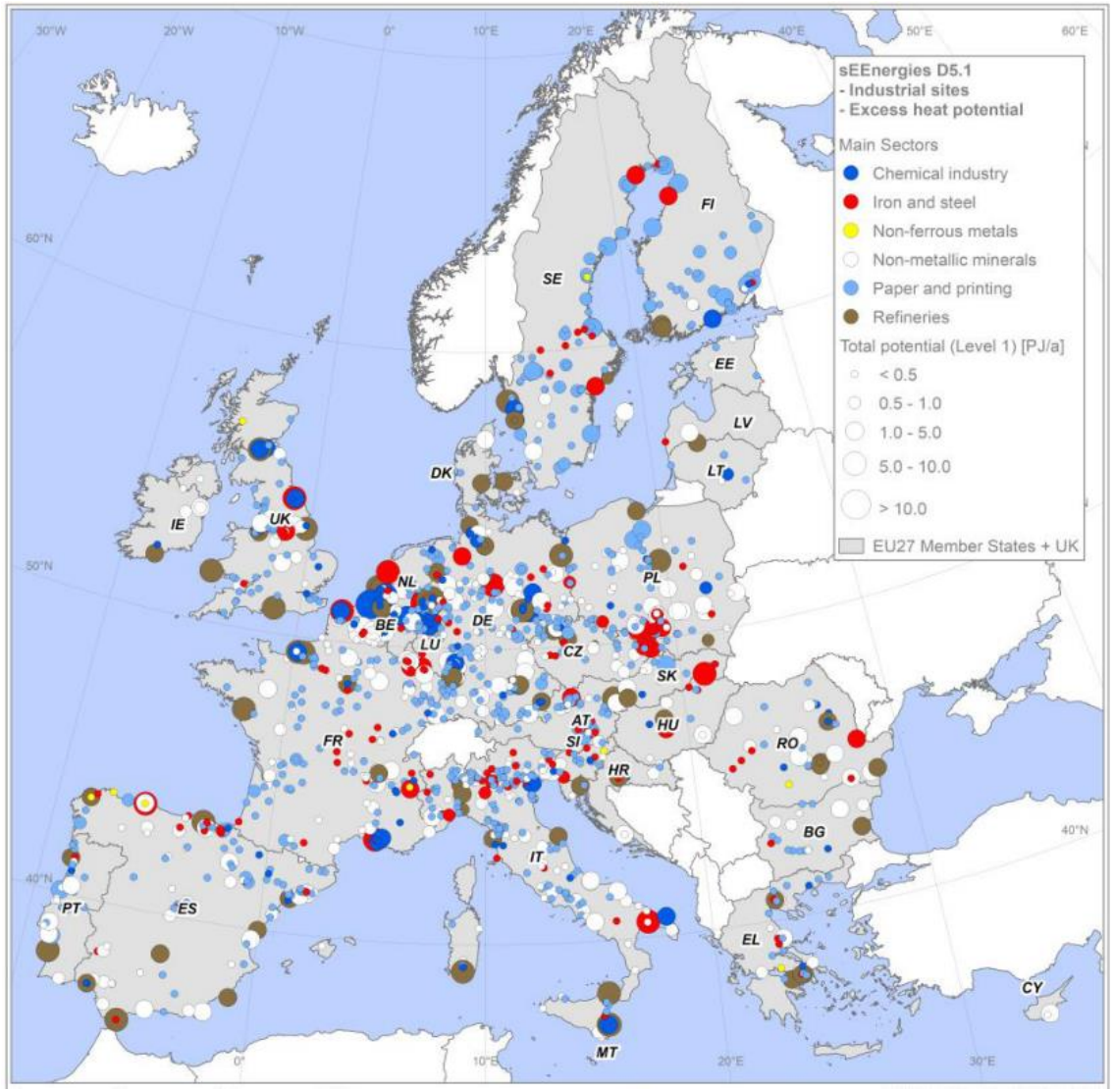
Alex Bertrand
26/03/2024



LUXEMBOURG INSTITUTE OF SCIENCE AND TECHNOLOGY
LIST

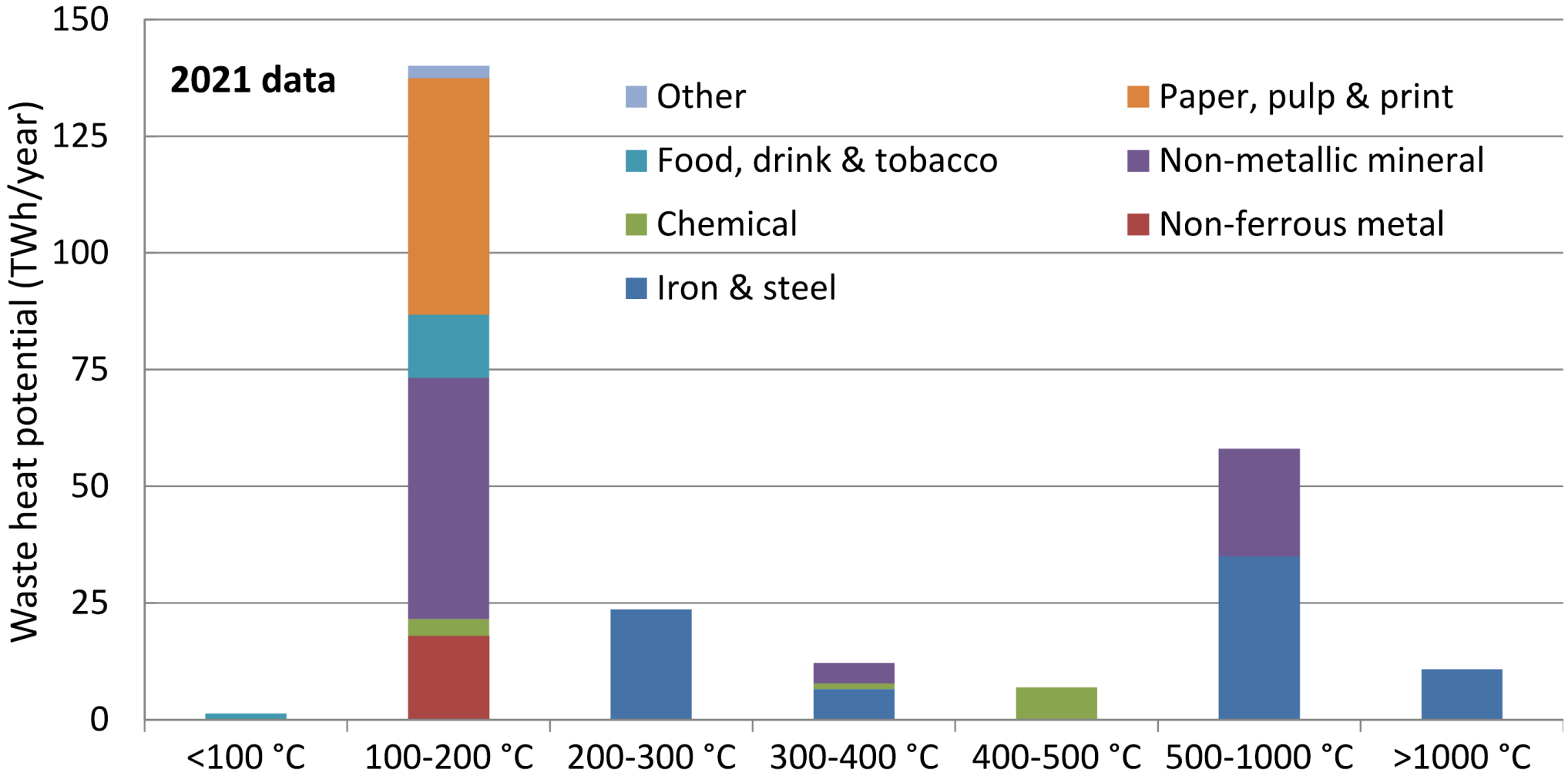
THE POTENTIAL

Global waste heat market estimated at 66 B€ in 2020, 134 B€ in 2030



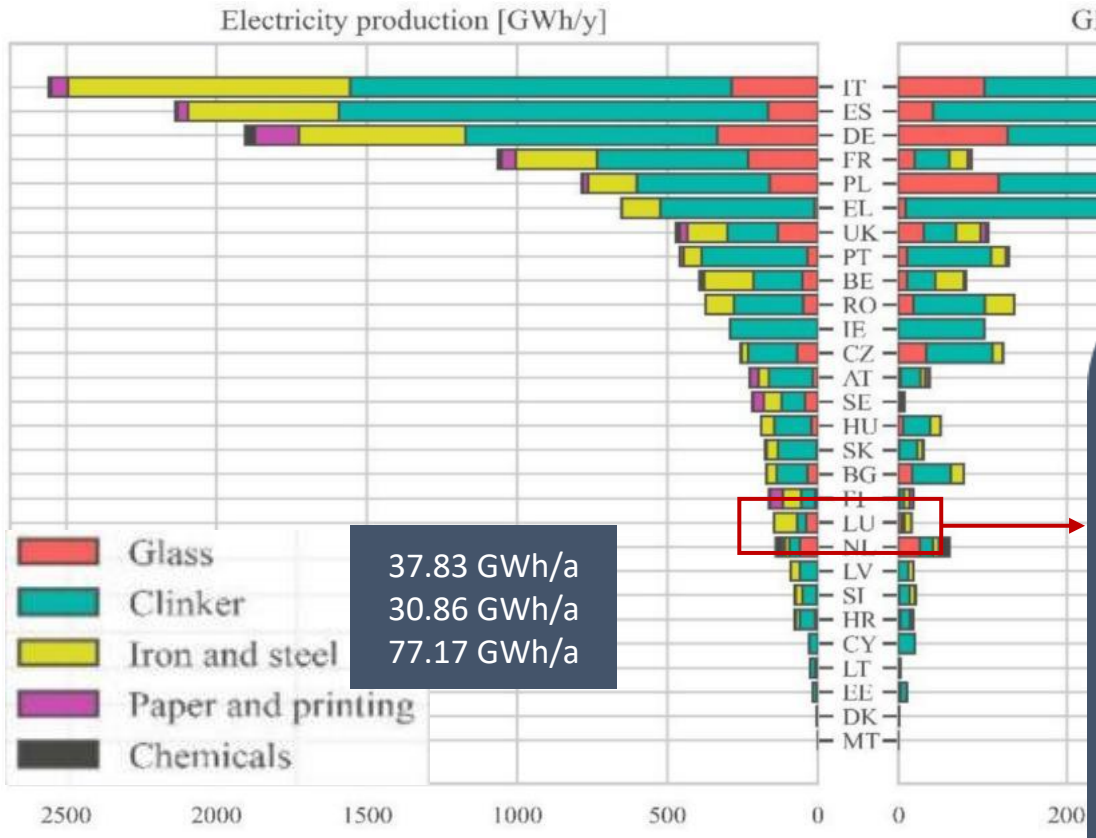
https://www.seenergies.eu/2020/06/03/excess-heat-potentials-of-industrial-sites-in-europe/

THE EUROPEAN POTENTIAL



https://doi.org/10.1016/j.applthermaleng.2024.122957

the Waste Heat to Power potential



37.83 GWh/a
30.86 GWh/a
77.17 GWh/a

Luxembourg industrial waste heat valorisation:

Steam and Organic Ranking Cycles potential

Feed-in Tariffs
95 – 266 €/MWh

Electricity Production
146 GWh/y

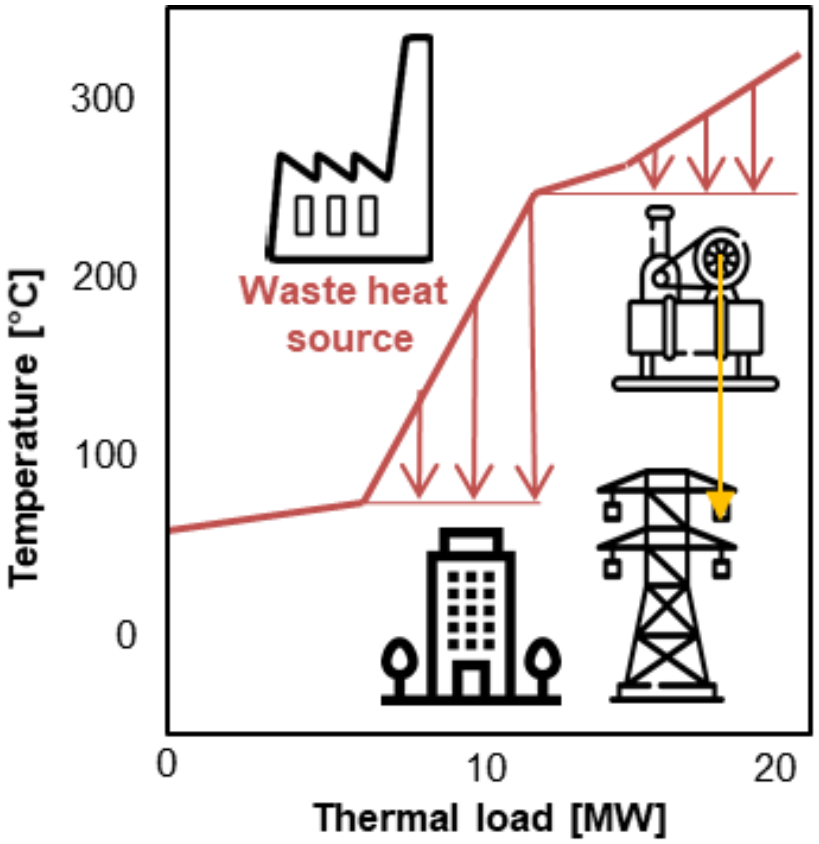
Saved CO_2 Emissions
15'460 tons/y

Revenues
19 M€/y

Jobs Creation
35

https://doi.org/10.1016/j.egyr.2022.09.075

THE MAJOR ISSUES IN DESIGN- COMPLEXITY AND ECONOMIC VIABILITY



Waste heat valorisation
→ quantity AND quality

Waste heat valorisation
→ Availability/demand over the year

Low energy prices
→ high RoIs

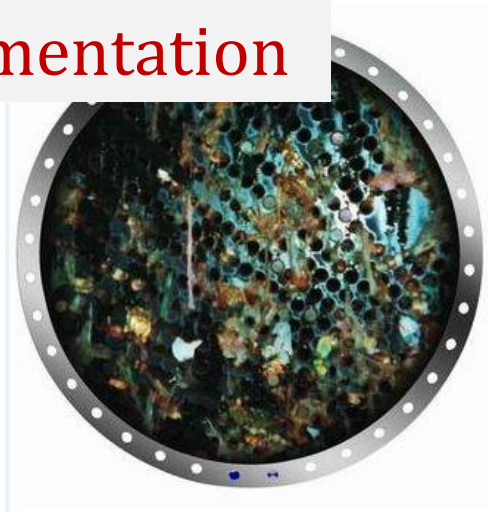
Icons from www.flaticon.com/

THE MAJOR ISSUE IN OPERATION – FOULING

Corrosion

Crysallisation

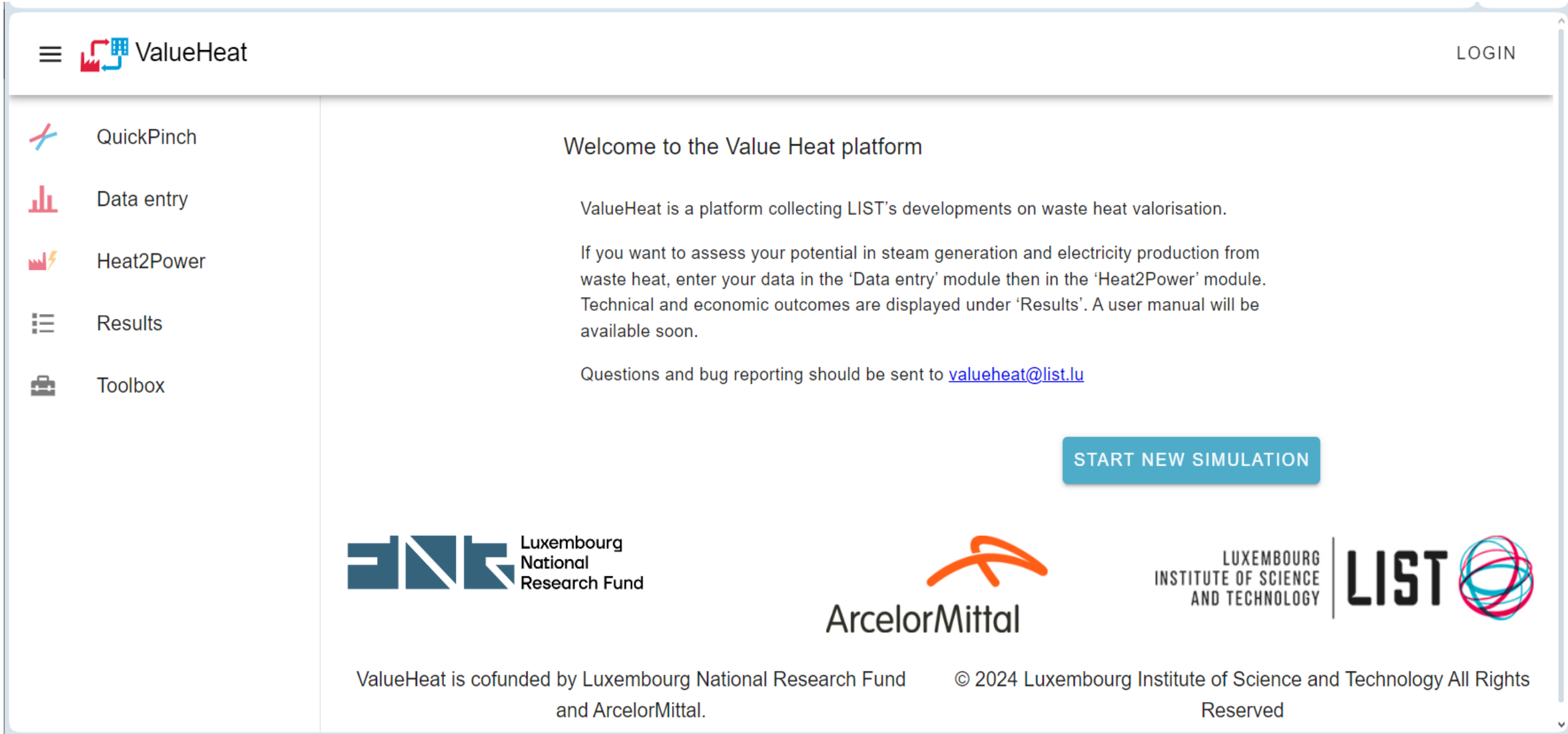
Sedimentation



Bio. activity

https://chempds.blogspot.com/2018/12/types-of-fouling-in-heat-exchangers_18.html

THE VALUEHEAT PLATFORM



Thank you for your attention

Any questions ?

Valueheat@list.lu

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IMPORTANCE OF WASTE HEAT RECOVERY IN LUXEMBOURG

Denis Sijaric

Ministère de l'Economie

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Importance of waste heat recovery in Luxembourg

European and national context

Version 26.03.2024

LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie

Waste heat in European laws and regulations

Energy Efficiency Directive (UE) 2023/1791

Art. 25 (4) : *… if potential for the application of efficient district heating from waste heat is identified, MS shall encourage the development of installations for the utilisation of waste heat…*

Art. 25 (6) : *… regional and local authorities shall prepare local heating and cooling plans and map the potential for increasing energy efficiency, including … waste heat recovery …*

Art. 26 (1) : *… an efficient district heating and cooling system shall use at least …. 50 % waste heat …*

Art. 26 (6) : *… data centres with a total rated energy input exceeding 1 MW shall utilise the waste heat recovery applications …*

Art. 26 (7) : *… an installation level cost-benefit analysis is carried out when newly planned or substantially refurbished … in order to assess utilisation of the waste heat on-site and off-site …*

Art. 26 (14) : *… any available support for cogeneration is subject to the electricity produced originating from high-efficiency cogeneration and the waste heat being effectively used …*

Waste heat in European laws and regulations

COMMISSION REGULATION (EU) 2024/264 on energy statistics

How waste heat is counted in official energy statistics …

3.2.1.10. Heat from chemical processes

Heat originating from processes without input energy, such as a chemical reaction. Excludes **waste heat** originating from energy-driven processes, which should be reported as heat produced from the corresponding fuel.

3.3.2. HEAT (DERIVED HEAT)

… . All heat produced, except for heat produced by autoproducers for their own use and not sold, is to be reported; all other forms of heat are reported as use of products from which the heat was produced.

Waste heat in national laws

Definition in “Energy transition draft law“

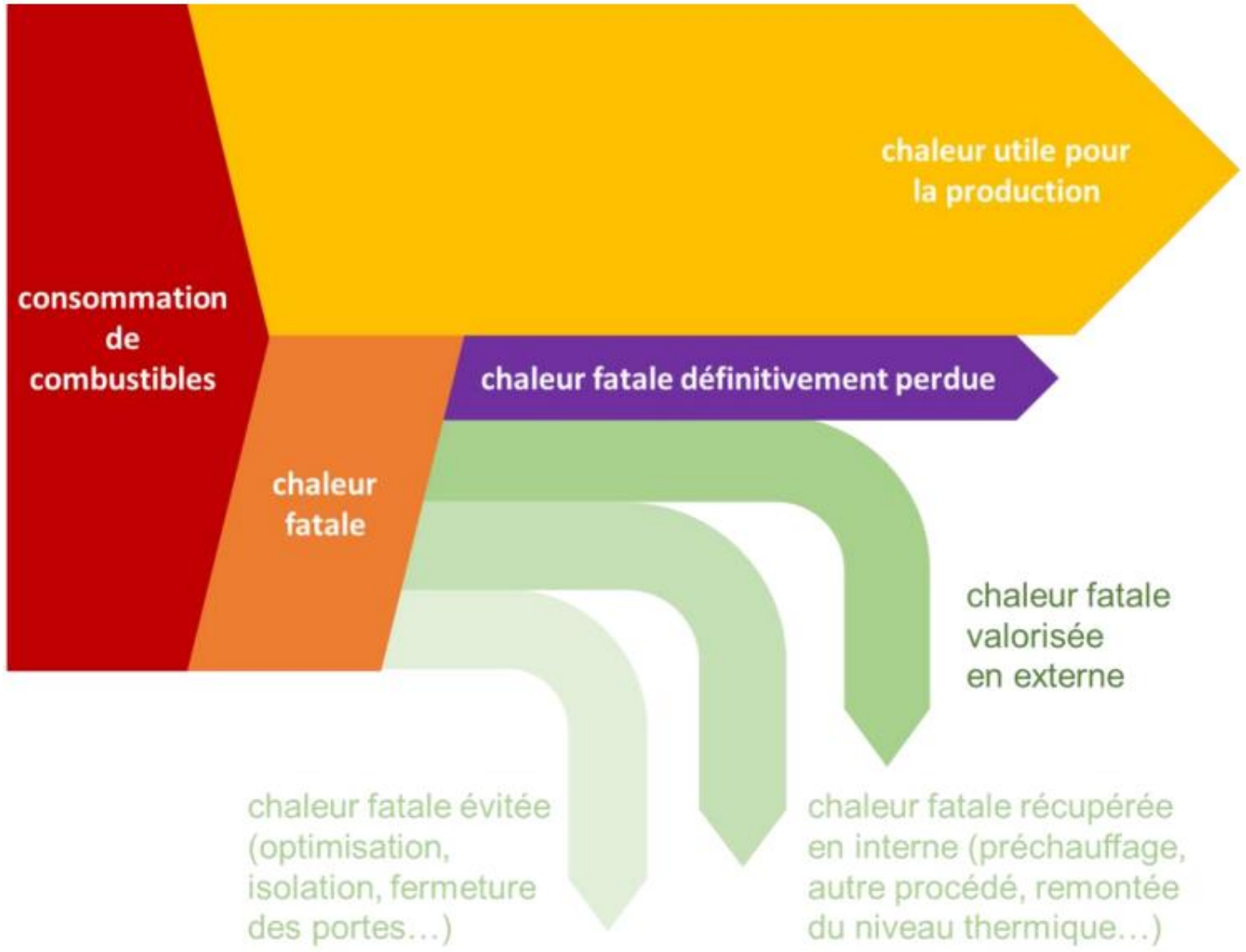
« chaleur et froid fatals » :

La chaleur ou le froid inévitablement produits en tant que sous-produit dans des installations industrielles ou des installations de production d'électricité, ou dans le secteur tertiaire, et qui, faute d'accès à un système de chauffage ou de refroidissement urbains, ne seraient pas utilisés et se dissiperaient dans l'atmosphère ou dans l'eau, lorsqu'un processus de cogénération est ou sera utilisé ou lorsqu'il n'est pas possible de recourir à la cogénération ;

Waste heat valorisation forms

The way it should be:

1) Optimize to avoid
2) Recover for internal use
3) Recover and feed-in



© ADEME, La chaleur fatale industrielle (mars 2015)

Waste heat recovery and energy efficiency

Most important messages:

- Waste heat recovery measures **reduce the final energy consumption** and by that contribute in **achieving our national energy efficiency targets**

*1. **Prioritize** the **on-site valorisation** of waste heat (self consumption)*

2. Then consider providing the excess heat directly to your "neighbours" and potential nearby consumers (local communities)

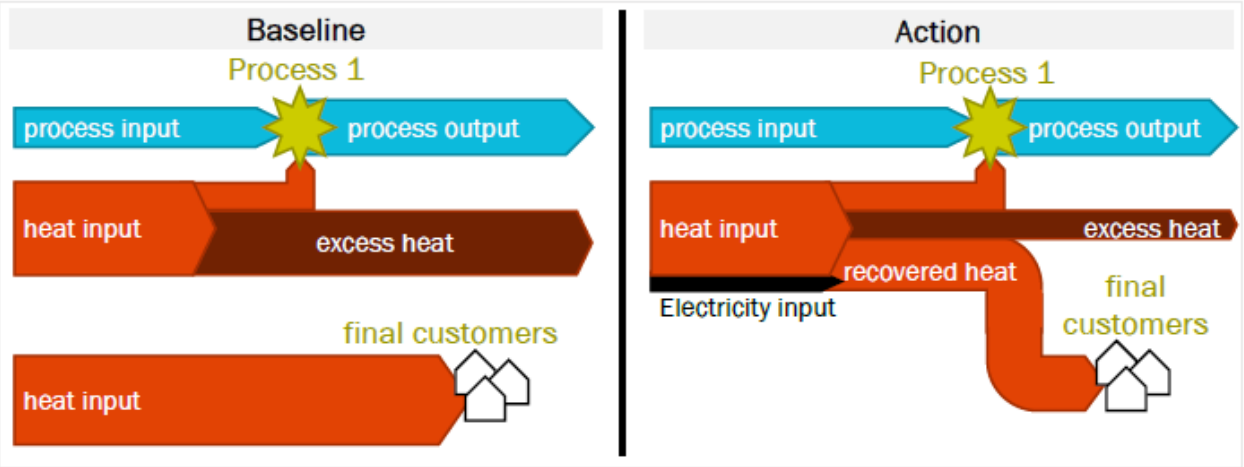
3. Finally, if not possible to valorise it by any other manner, provide your excess waste heat to nearby district heating networks

- **Important: Waste heat is a form of energy you already paid for, so make sure to use it's full potential !**
- Waste heat recovery measures are getting **more and more profitable** over the last few years, as the **climbing energy prices pull the ROI down** ; projects are being realized today that were not profitable some years ago
- Don't forget the **public subsidy opportunities** (Ministry of Economy) **and** the **private sector incentives** (Energy Efficiency Obligation Scheme, EEOS)

Waste heat recovery measures in the EEOS

Eligibility of WHR measures in the national Energy Efficiency Obligation Scheme (EEOS):

Special methodological consideration in the case of heat recovery for feed-in to a district heating grid



Final energy savings can only be achieved at end-user level in case of lower conversion losses in their specific heating system as a result of switching to district heating. If additional district heating connections are triggered by feeding recovered heat into the district heating network, this can therefore lead to final energy savings. *(The actual saving is calculated by the difference of the conversion efficiencies of the district heating connection to the reference heating systems)*

Waste heat recovery and energy efficiency

Waste heat is a form of energy you already paid for, so make sure to use it's full potential !

Thank You.

Denis SIJARIĆ
Dossiers efficacité énergétique

LE GOUVERNEMENT DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Economie
DG Énergie – Direction de l'Efficacité Énergétique

4, place de l'Europe . L-1499 Luxembourg
Tél. (+352) 247-74116

E-mail : denis.sijaric@energie.etat.lu
www.gouvernement.lu . www.luxembourg.lu

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WASTE HEAT RECOVERY IN INDUSTRIAL PROCESSES

Thomas Merzkirch

Manager of Portal Solutions,
AIO Technologies

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MONITORING ENERGY CONSUMPTION FOR A SUSTAINABLE BUSINESS DEVELOPMENT

EDL PORTAL AS ENERGY MONITORING TOOL

14.03.2024

Do you know exactly what is, energy speaking, happening in

Do you want to be notified when a process does not run as ex

Do you want to be able to display, manage and optimize your

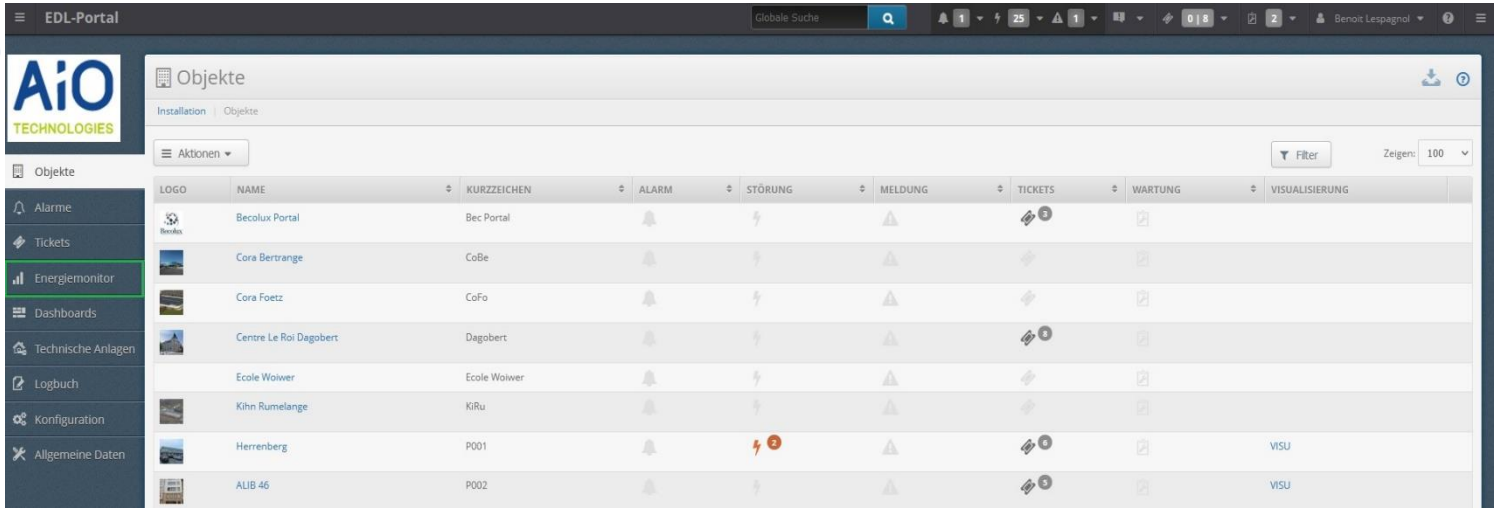
Do you want all of the above without needing several differen and/or tools?

EDL PORTAL

The EDL Portal is a collection of various functions related to plants, buildings and/or energy.

Portal main functions :

- Management of buildings and technical installations
- Management of links to plants (BMS, displays, cameras, etc.)
- Alarm management including statistics
- Remote alerting (SMS, pager, email)
- Ticketing system
- Energy monitoring
- Document management
- Management of companies, groups and users
- …



EDL Portal main overview

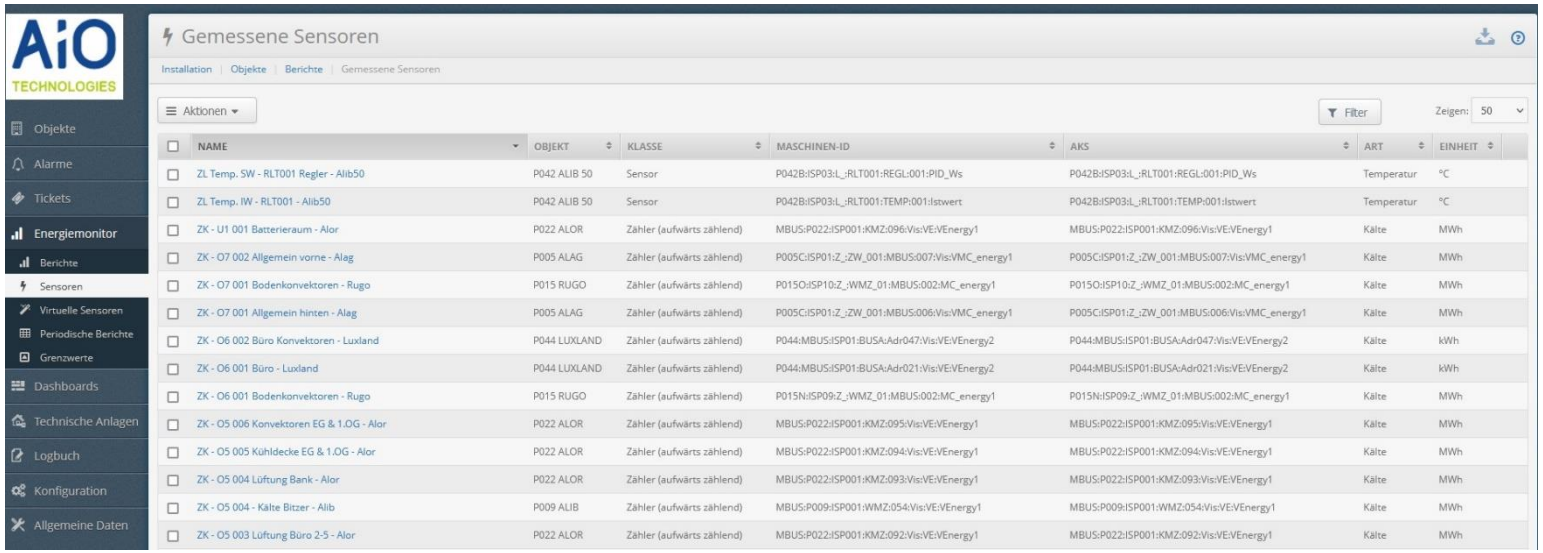
ENERGY MONITORING

The energy monitoring (EM) system, allows the energy consumption to be monitored and to react if necessary. The EM analyses the data in a cyclical interval (normally daily) and issues alarms if certain criteria is met.

The system is optimized for automatic data acquisition, but it can also operate with manually entered data (e.g. values imported via CSV files).

The EM system comprises 5 modules:

- Sensors
- Limit value monitoring
- Virtual sensors
- Reports
- Periodic reports

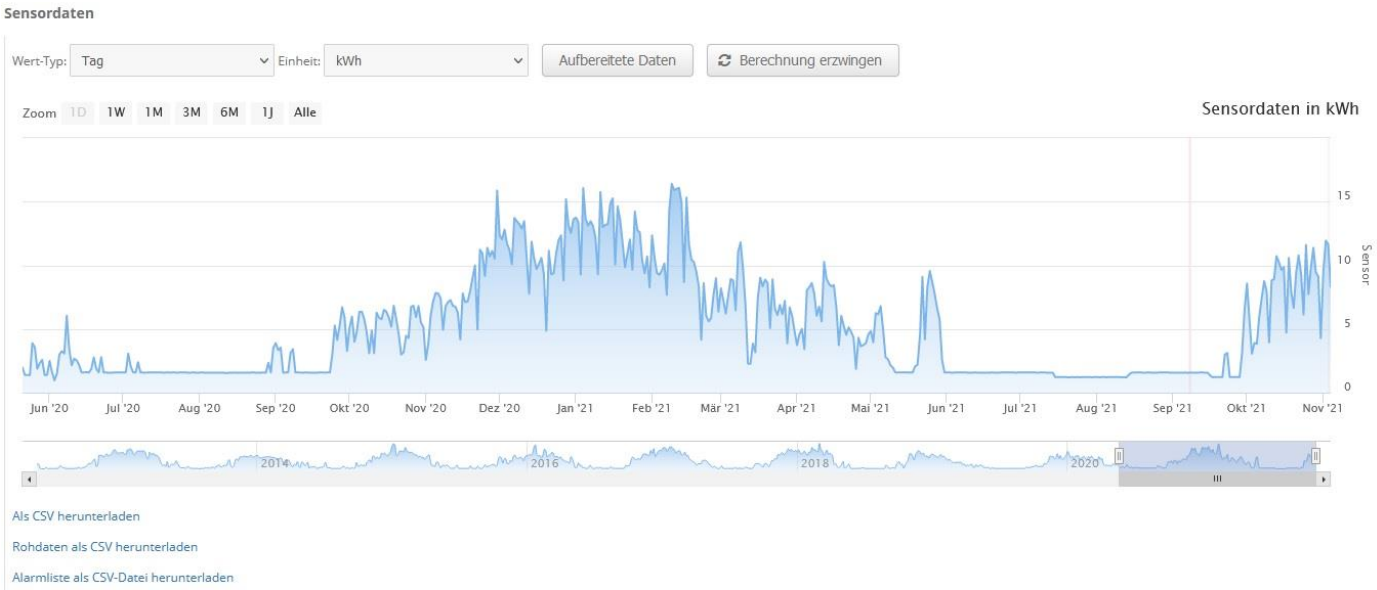


List of sensors

ENERGY MONITORING - SENSORS

Sensors include physical sensors (temperature, humidity, pressure, ..) and counters (heat, cooling, water, ..). Parameters recorded on control systems, such as operating hours, and state measurements (on/off) are also referred to as sensors.

NAME	EZ - C2 001 Heizung - ISP02 - Rugo
MASCHINEN-ID	P015G:ISP02:E_:M_BUS_:_EZ_:001:Vis:E:VE_Tot
AKS	P015G:ISP02:E_:M_BUS_:_EZ_:001:Vis:E:VE_Tot
OBJEKT	P015 RUGO
KOMPONENTE	VM - Rugo [aio-mwa051vm09]
KLASSE	Zähler (aufwärts zählend)
ART	Elektrizität
EINHEIT	kWh
KOMMASTELLEN	0
LETZTES UPDATE	04.11.2021 15:42:05
LETZTE DATEN	04.11.2021 15:30:00
LETZTE ROHDATEN	19.450 kWh
LETZTE SAUBERE DATEN	0 kWh
DATUM VOM WERT AUF GLS	04.11.2021 15:42:34
AKTUELLER WERT AUF GLS	19.450 kWh
INBETRIEBNAHME	14.05.2012
DATENPUNKTE PROTOKOLLIEREN NUR ÄNDERUNGEN	Nein
MUSS SICH ÄNDERN INNERHALB	+6 Stunde/n
GRENZWERT-REGELN	
ÜBERGEORDNETE	Übergeordnete anzeigen
KOMMENTARE	Kommentare anzeigen

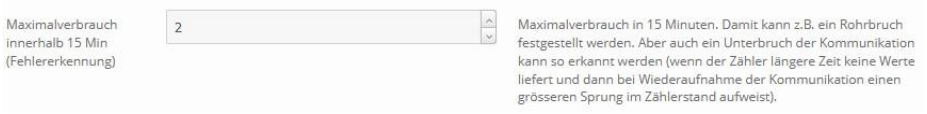


Counter detailed view

Sensors can be managed and their data displayed. Each sensor can be visualised without having to create a report. Missing or incorrect data are highlighted in red in the graphic.

Sensor values surveillance

Maximum consumption within 15 minutes



It can be defined how much the value can change within 15 minutes before an alarm is generated. This allows to identify abnormal consumption peaks. For example an torn waterpipe

Example of an alarm triggered by the max. consumption within 15 minutes surveillance

Sensor failure detection

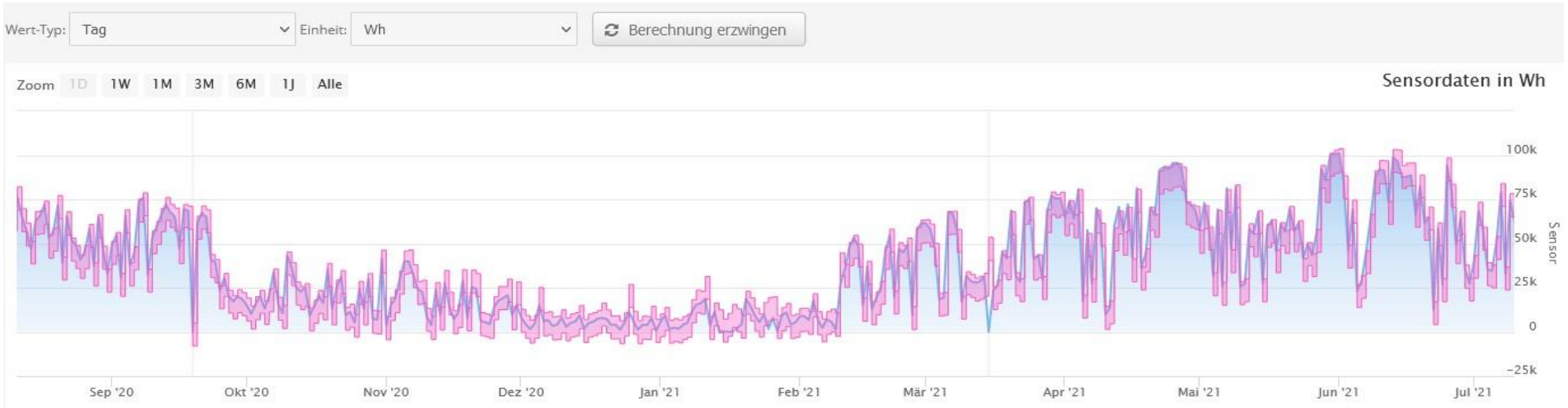
A time can be specified in which the value must change, else an alarm will be generated. This allows to identify communication problems.

Example of an alarm triggered by the sensor failure detection surveillance

ENERGY MONITORING – LIMIT VALUE MONITORING

It is possible to monitor each sensor and virtual sensor for limit values. The following monitoring functions are available for this purpose:

· Upper limit value
· Lower limit value
· Value in range
· Value out of range
. Relative to another sensor



Example of a "relative to another sensor" limit value monitoring: the energy production of a solar inverted is being monitored in accordance with the solar radiation

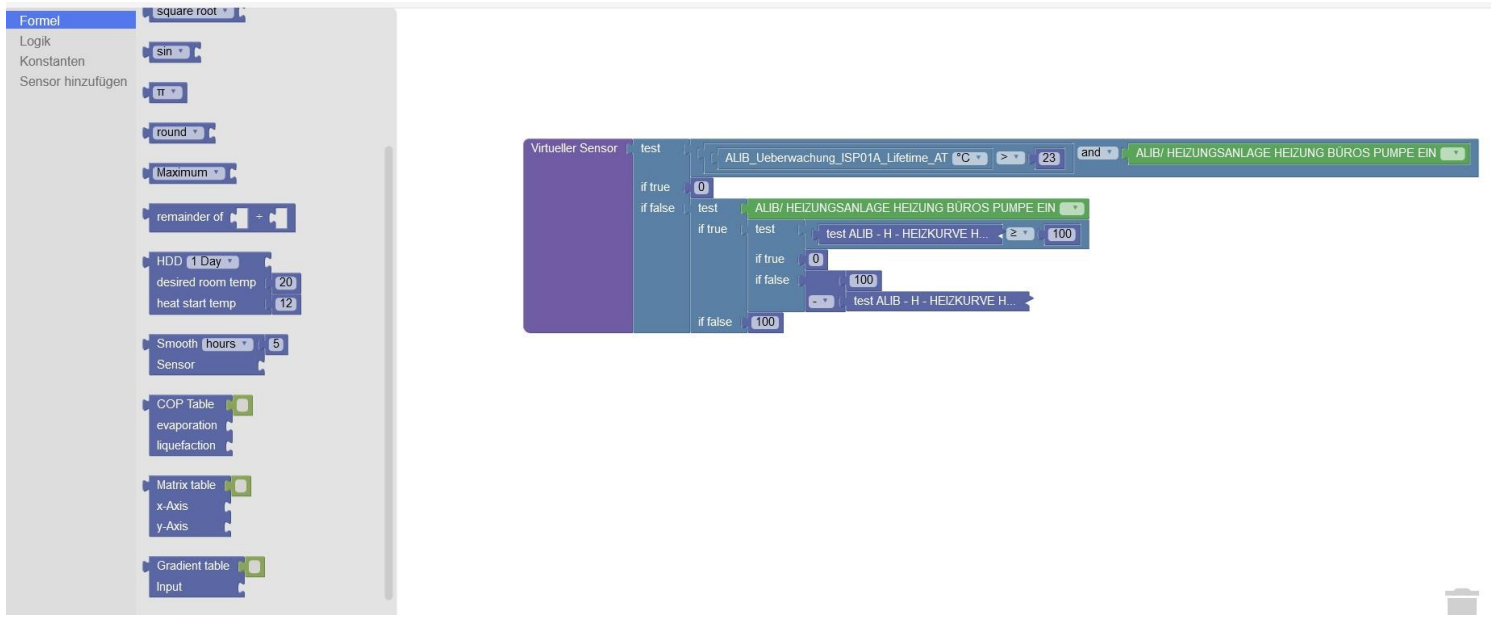
If a limit value is exceeded or undercut, an alarm can be generated.

ENERGY MONITORING – VIRTUAL SENSORS

Virtual Sensors are values that are calculated based on other sensors (real or virtual).
Energy consumption per square meter, a calculation of the degree days or the efficiency of a heat pump are examples of virtual sensors.

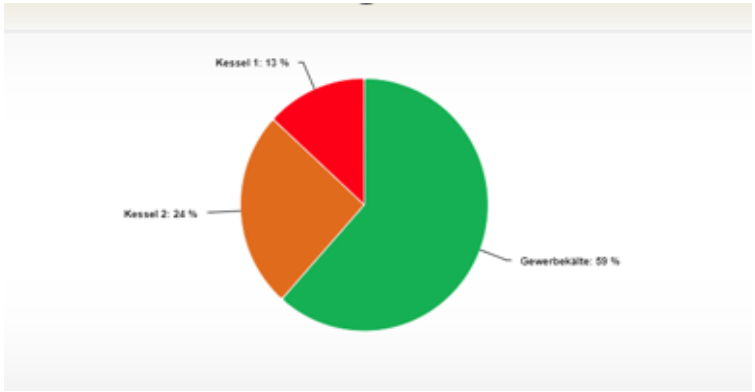
Extensive mathematical functions and Booleans operators are available.

With the graphical formula editor, complex calculation models can be created very easily and intuitively. A comprehensive library of premade function blocks is available for this purpose.

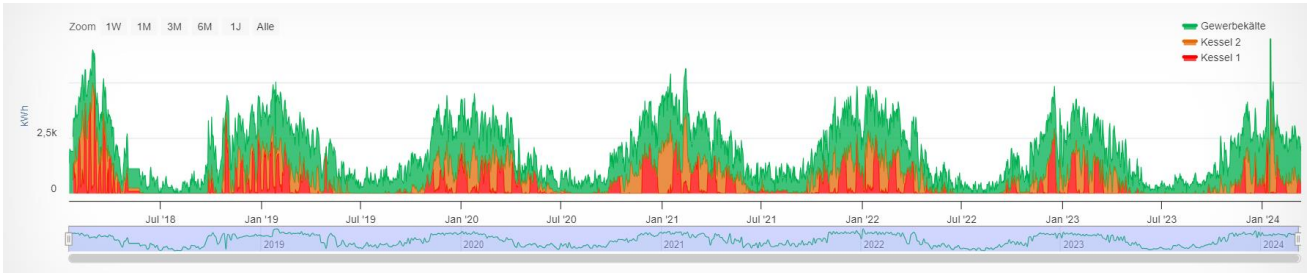


Graphical formula editor

ENERGY MONITORING – REPORTS

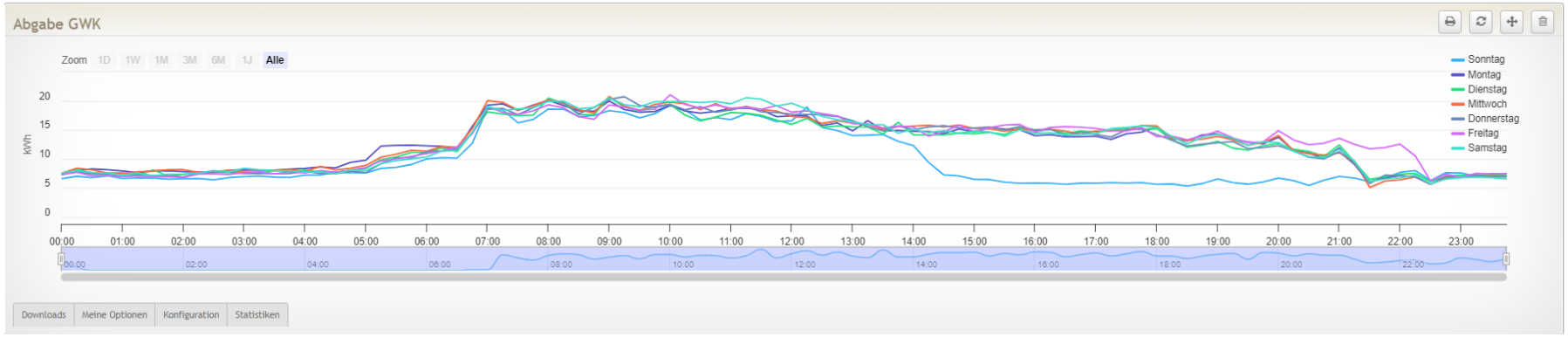


Example of a pie chart graphic: Yearly production of the two heatings and the heat recovery of the commercial refrigeration in green.
In this case the building is heated by 59% of reused energy.



The dayly heat production gives us an good indication of the needed energy per season

Example of a week load graph: it is also verry important to know, when and in which amount the energy is available, so we can adapt the system to our needs.



35, rue Gabriel Lippmann
Parc d’activité Syrdall, 3
L-5365 Munsbach

T. +352 27 84 54-1
F. +352 27 84 54-45
E. aio@aio.lu

14.03.2024

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RECOVERY OF THE HEAT EXCESS AT ARCELORMITTAL BELVAL PLANT

Fanny Deroche

Design Engineer, Dalkia

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LUXINNOVATION

Waste heat recovery and valorisation in industral proccess

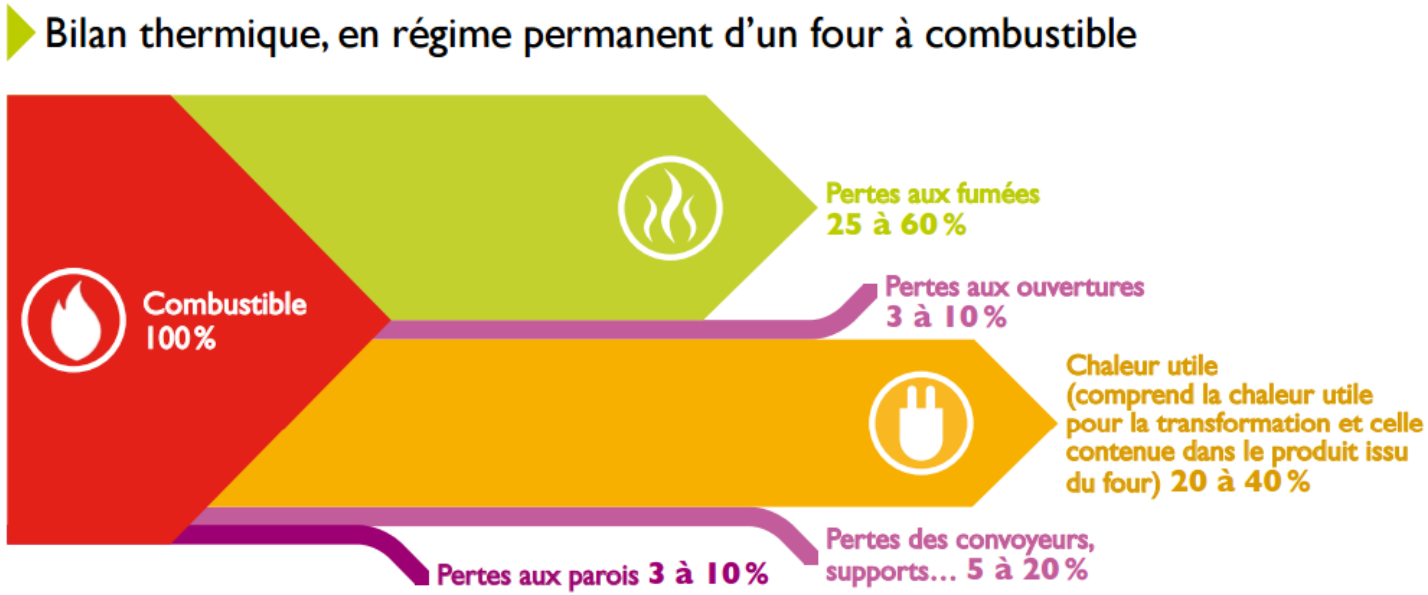
ARCELOR MITTAL BELVAL PLANT

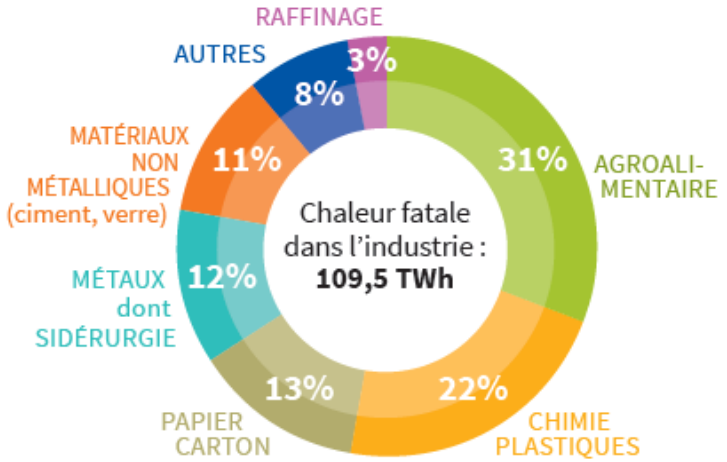
26/03/2024

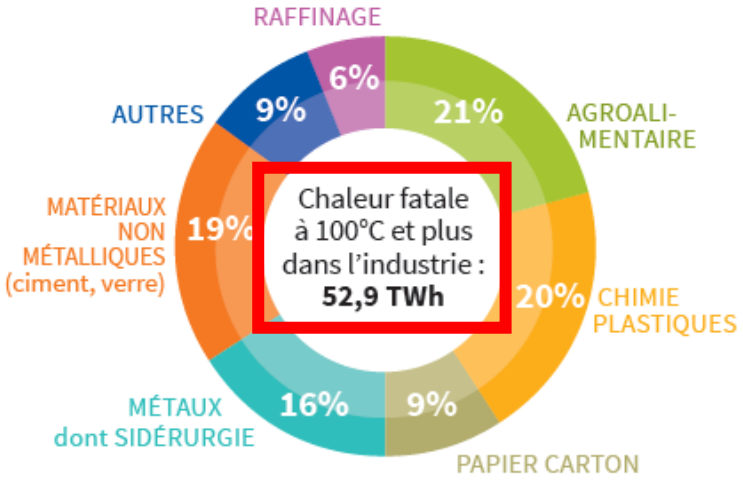
F. DEROCHE

WASTE HEAT

- ADEME report (2017) :
- Waste heat is energy not consumed or lost by an industrial process.







*fuel consumption in industry in France: 315 TWH (2013 figures)

CONTEXT

Belval Plant (Luxembourg) :

- Manufacture of large width sheet piles and profilesFonctionnement 3X8
- Electrique kilnfour + Laminator
- Processing kiln n°2 :
  - Natural Gas
  - An air preheater already integrated on
  - Flue gas at 400°C

Project :

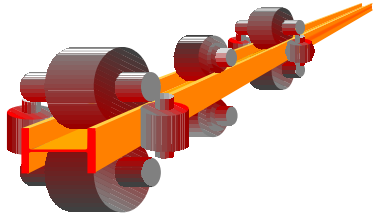
- Heat recovery on the flue gas : 5 MW
- Valued Energy : 18 GWh / an => ≈ 5 000 tons CO2
- Use in Sudcal's heat network : 58%

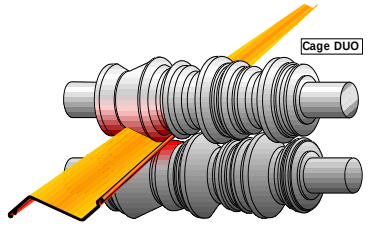
Constraints :

- Natural draft in the chimney
- Maintain kiln pressure
- Short time to prepare the conduite during the annual shutdown

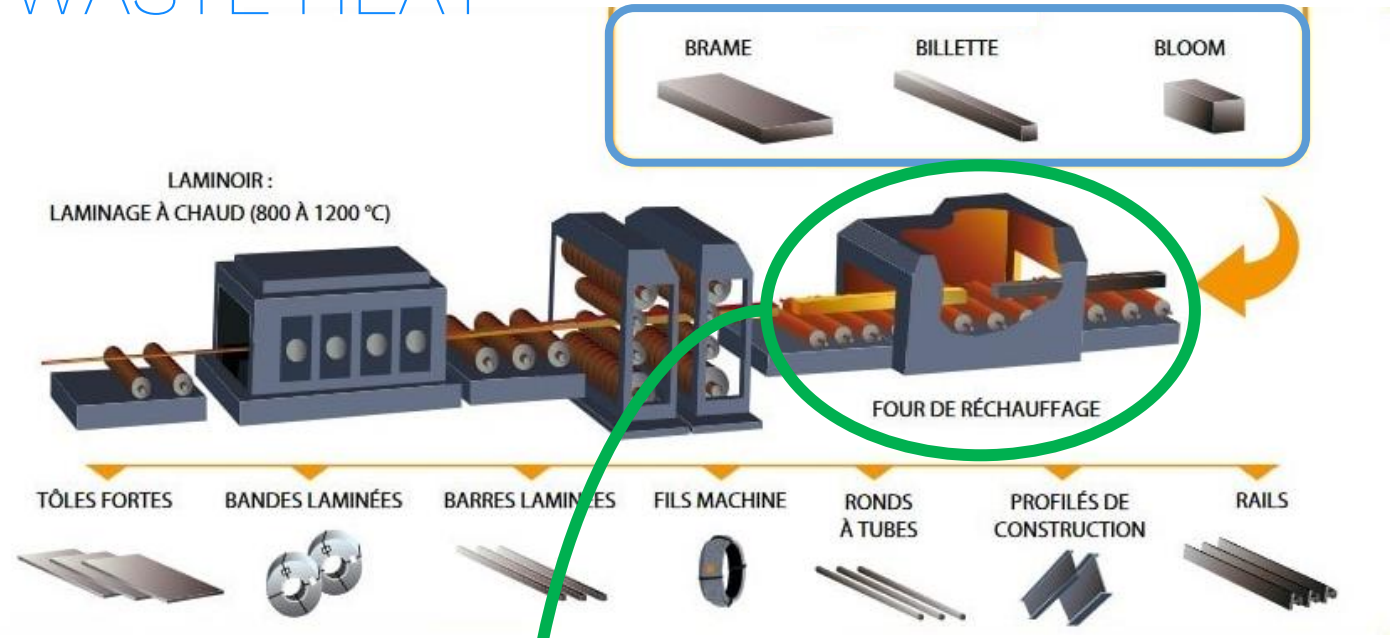
Objectif :

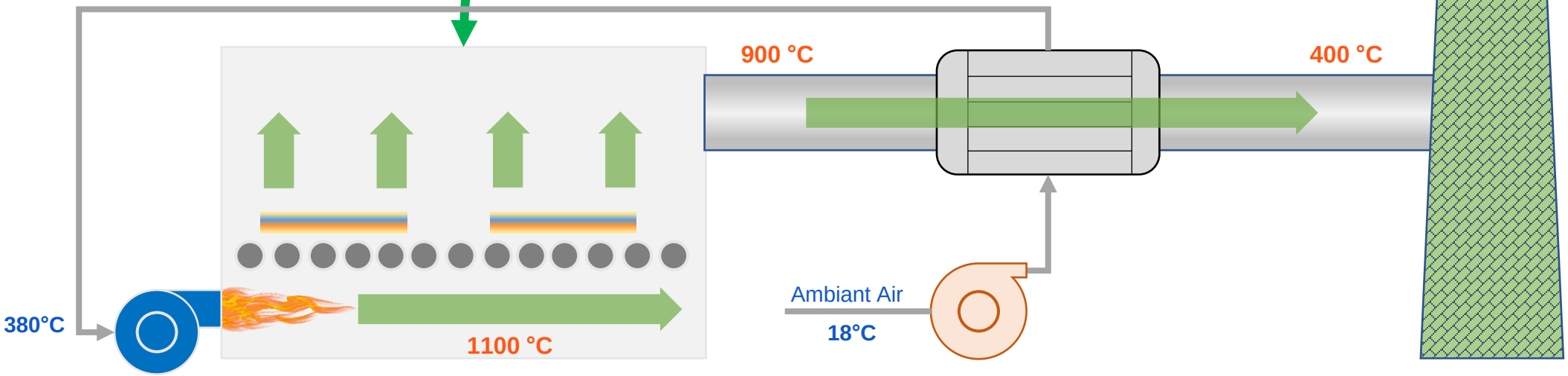
- ArcelorMittal's approach to sustainable development and the circular economy
- Willingness to contribute to the Grand Duchy's efforts to reduce energy consumption
- Valorize the waste heat





WASTE HEAT

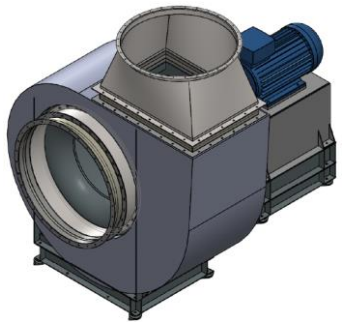

BRAME
BILLETTE
BLOOM
LAMINOIR :
LAMINAGE À CHAUD (800 À 1200 °C)
FOUR DE RÉCHAUFFAGE
TÔLES FORTES
BANDES LAMINÉES
BARRES LAMINÉES
FILS MACHINE
RONDS À TUBES
PROFILÉS DE CONSTRUCTION
RAILS

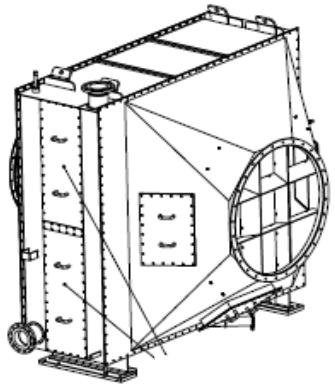

900 °C
400 °C
380°C
1100 °C
Ambiant Air
18°C

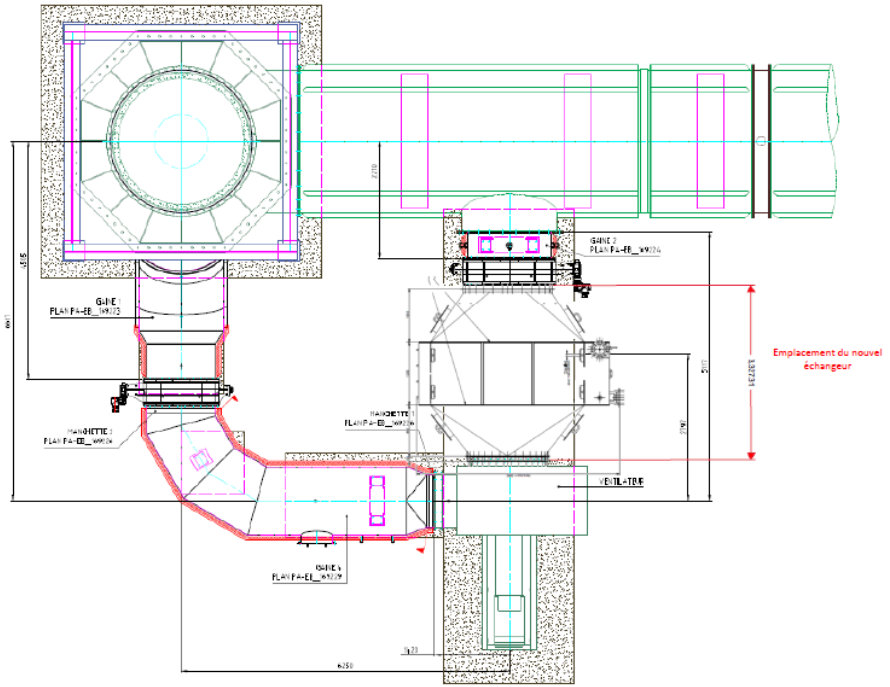
TECHNICAL SOLUTION

Heat Exchanger:

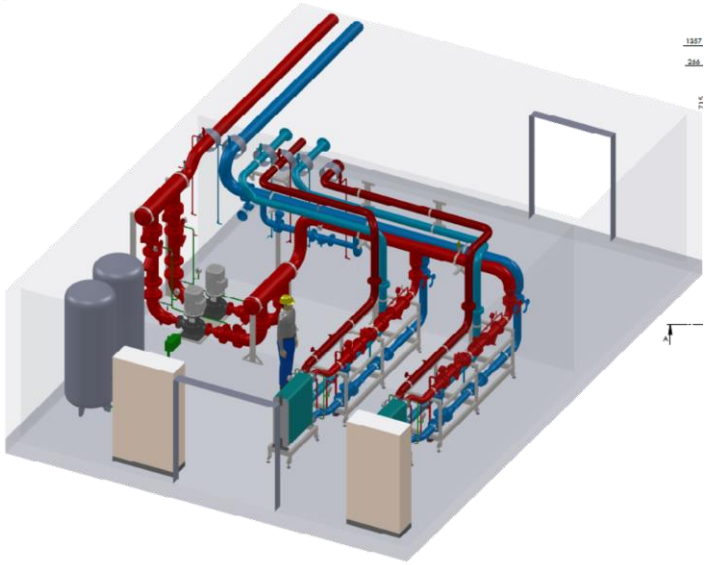
- Shut-off valve
- Exchangeur Flue Gas / Water
- Fan







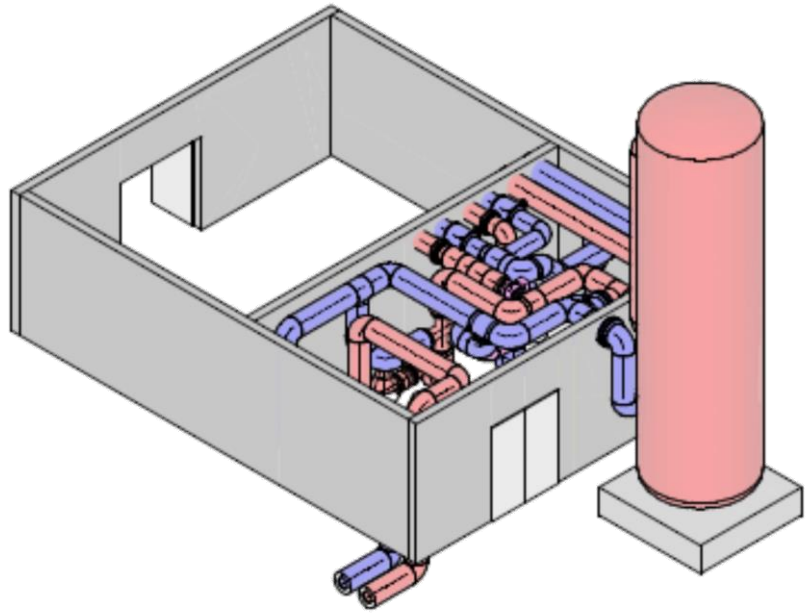
TECHNICAL SOLUTION



Heat Exchanger
- Shut-off valve
- Exchangeur Flue Gas / Water
- Fan

Sub-Sation :
- Hydraulics room
- 2 heat exchanger
- Expansion tank

Internal heat network :
- 350m between the Heat Exchanger and the Sub-Station



RESULTS

Energy and Carbon balance:

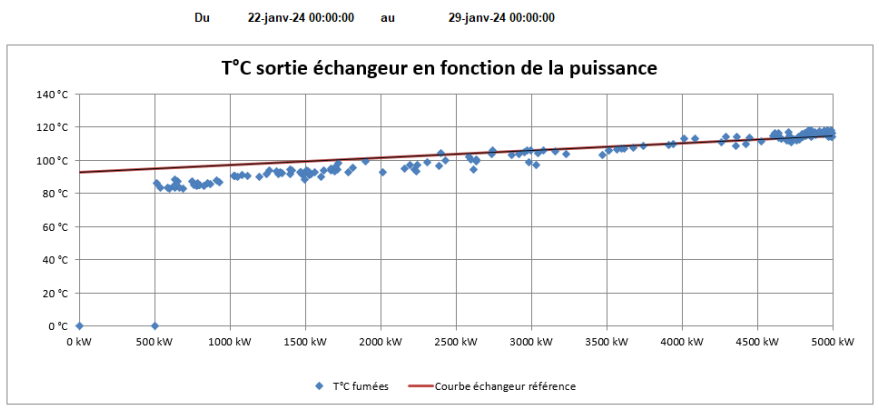
- Energy recovered annually in the network = 18 GWhu / year 4,000 housing equivalents
- 5,000 tons of CO2 avoided per year compared to all-gas heating

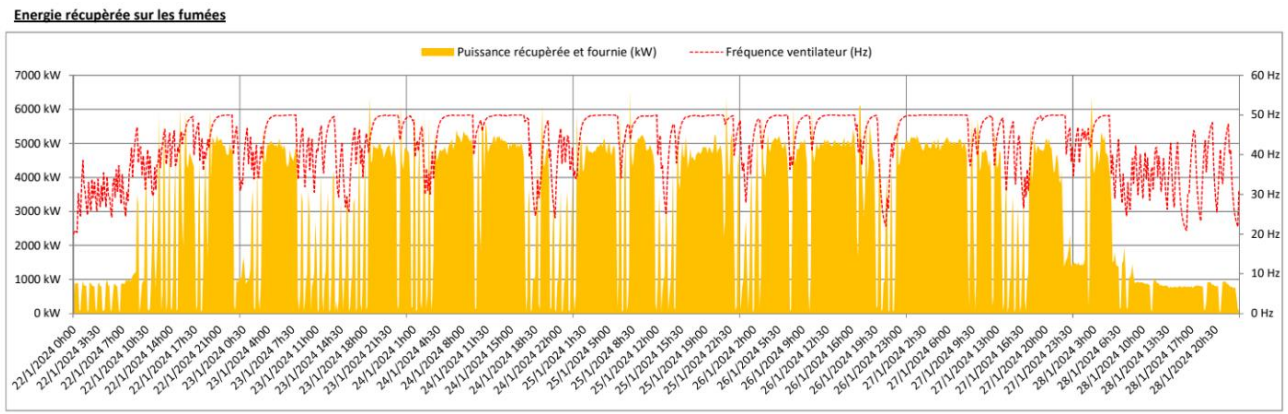
Arcelor / Dalkia collaboration :

- Operation, maintenance and repair carried out by Dalkia
- Weekly production monitoring : Energy Available VS Energy Valorised or not Valorised
- Cleaning the exchanger according to a fouling rate monitoring curve

Sudcal / Arcelor / Dalkia collaboration :

- Since commissioning, there has no impact on the ArcelorMittal process
- Sudcal, Arcelor and Dalkia meet every month to improve heat recovery and to plan everyone's maintenance





Energie cible (MWh)	467	100,0%
Energie récupérée et fournie (MWh)	539	115,5%
Energie non récupérée par Dalkia (MWh)	0	0,0%
Energie non fournie par Arcelor (MWh)	0	0,0%
Energie non enlevée par Sudcal (MWh)	0	0,0%
Energie compteurs primaire échangeur (MWh)	522	
Energie compteur secondaire Sudcal (MWh)	538	

Energie cible : Energie correpondant à la cible d'enlevement contrat.
Energie non fournie par Arcelor : Energie comprise entre la puissance maximale récupèrable sur les fours et 5MW.
Energie non enlevée par Sudcal : Lorsque la T°C entrée primaire des échangeurs est supérieure à 101°C, cela signifie que la régulation limite la puissance de récupèration sur les fumées. Cela signifie également que Sudcal n'enlève pas la puissance disponible. Dans ce cas, l'énergie non enlevée par Sudcal est la puissance entre le max récupèrable et la puissance réelle.
Energie non récupèrée par Dalkia : Cela correspond à la différence entre l'énergie récupèrable sur les fours et l'énergie produite dans le cas ou le réseau Sudcal enlève le maximum d'énergie.

dalkia
GROUPE EDF

THANKS

LUXINNOVATION
#MakingInnovationHappen

Coffee Break

Wifi : HOB Guest Wifi

Password : Guest@HoB

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KEY SUCCESS FACTOR OF A WASTE HEAT RECOVERY PROJECT

Jean-François Bastin

Head of Energy Audits and Special Studies,
Energie Agence

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GESTION DE L'ENERGIE
CONSEIL EN ENERGIE
FORMATIONS

B2B meet up on waste heat recovery in industry

KEY SUCCESS FACTOR OF A WASTE HEAT RECOVERY

Three practical examples

26 March 2024

Jean-François BASTIN

CONTENTS

Energieagence at a glance…

energieagence
energy efficiency first

ENERGIEAGENCE AT A GLANCE…

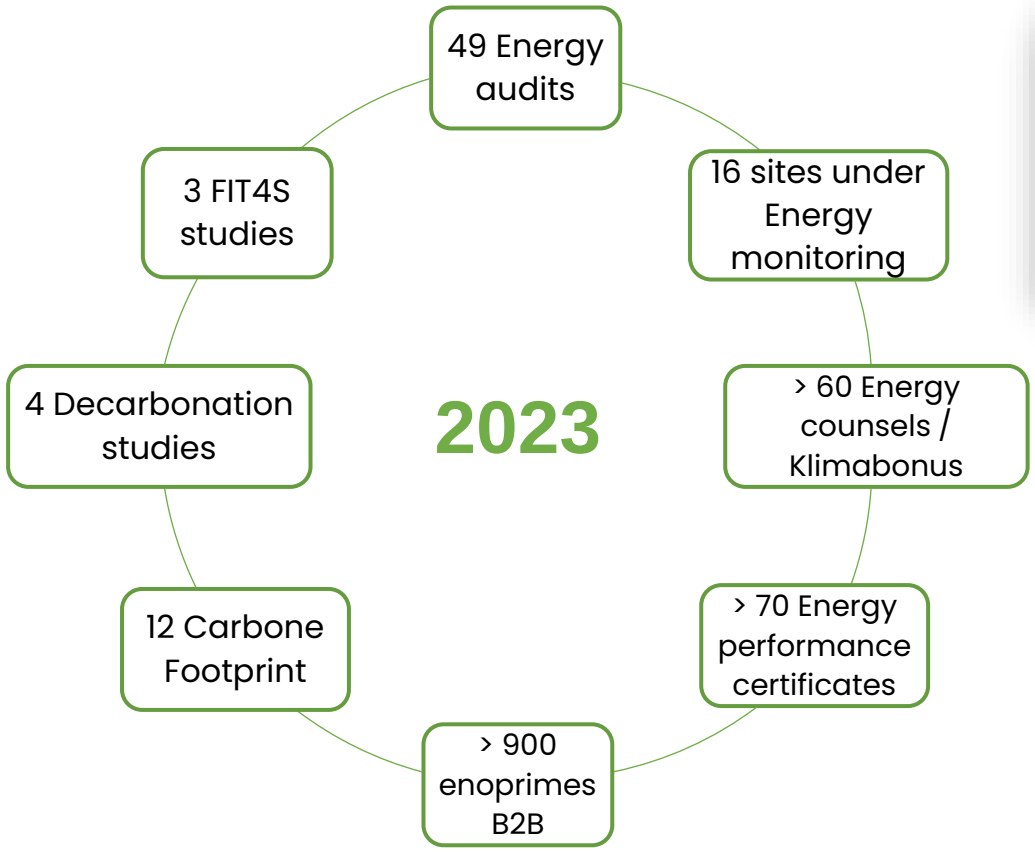
- **energieagence** offers services in the fields of energy efficiency and renewable energy sources, with a focus on consulting and training. energieagence is the brand name under which Agence de l'Energie S.A. conducts its business activities. energieagence is a partner in the nova naturstroum fund and a shareholder in the "Gemeng Hengischt", "Kehmen-Heischent" and "Burer Bierg" wind farms.
  - # No. 1 in industrial energy audits
  - One of the leading energy efficiency training centers in Luxembourg
  - Using knowledge from the field to inform public policy
    - Schwartz study
    - KPB
    - Audit database
    - Enoprimes database
    - Financing mechanisms

Revenues
> 2,9 M€
(2023)

> 650
persons
trained
(2023)

32
employees

ENERGIEAGENCE AT A GLANCE…



- **Follow-up** of 26 public buildings audited to measure actual energy savings
- KlimaPakt fir Betrieber : **Study of the potential for energy sharing** for 2 business parks (Lentzweiler & Ehlerange)

- 33.5 days of **training** (650 participants) organised for major industrial customers under the FEDIL Voluntary Agreement
- SIGRE : carrying out a circular economy study to create a resource concept
- **82 GWh** : volume of electricity under energy **monitoring**

- 16 **Energy Audits** in the industrial sector (automotive, metallurgy, plastics, food, aeronautic, tool manufacturing,…)
- 5 **Energy Audits** (11 sites) in the tertiary sector (banking, finance,…)
- 28 **Energy audits** of public buildings (schools, armed forces, administration,…)
- 5 **technical assistance projects** for industrial customers

ROLE OF ENERGIEAGENCE

- **During our energy audits carried out in Luxembourg industries, we regularly find :**
  - Unused waste heat
  - Waste heat recovery installations
    - Unused (out of order or faulty)
    - Underused
    - Inefficient
- **As a result of these audits, some customers have asked us to carry out studies with the aim of making (better) use of the potential for waste heat. The three cases presented today put into practice the results of the studies carried out by energieagence.**

Sources of waste heat recovery potential

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SOURCES OF WASTE HEAT RECOVERY POTENTIAL

- **Chimney fumes**
  - Boilers (medium temperature)
  - Furnaces (high temperature)
- **Air compressors**
  - Air-cooled (medium temperature)
  - Water-cooled (low temperature)
- **Chiller condensers** (low temperature)
- **Cooling towers** (low temperature)
- **Steam generation**
  - Condensates
  - Drains
  - Vents
  - Boiler economiser and condenser
- **Waste water**
- **Process water**
- **…**

- **Waste heat is not only available in plants with energy-intensive processes !**
- **Waste heat is available in a lot of utilities, so in almost all companies !**

Our Strategy

Measuring is understanding !

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OUR STRATEGY

- **Listen to the customer's final needs**
- **Open your eyes !**
- **Open your mind !**
- **Challenge the solution !**
- **Measuring is understanding !**

HOW TO USE WASTE HEAT ?

- **Understanding customer's requirements and priorities**
  - Reduce energy bills (usually always ☺)
  - Reduce energy consumption
  - Reduce environmental footprint and improve ESR image of the company
  - Respond customer new heat requirements
  - Decarbonation
  - Legal, regulatory or internal company policy obligations
- **Assessment of heat requirements**
  - **Power** : min / max / average / profile / monotonic load
  - Temperature level
  - Assess Heat Reduction Potential before sizing

=> **Measurements and recordings !**

HOW TO USE WASTE HEAT ?

- **Assessment of Waste Heat**
  - **Power** : min / max / average / profile / monotonic load
  - Temperature Level and profile if not constant
  - Availability
  - Simultaneity of available waste heat and heat requirements

=> Measurements, recordings and analyse of available data !

- **Evaluation of available technologies according to customer's priority**
  - Opex
  - Capex
  - Decarbonation
  - …

Case 1
Goodyear Operations S.A.

Waste heat recovery from air-cooled compressors recovery loop

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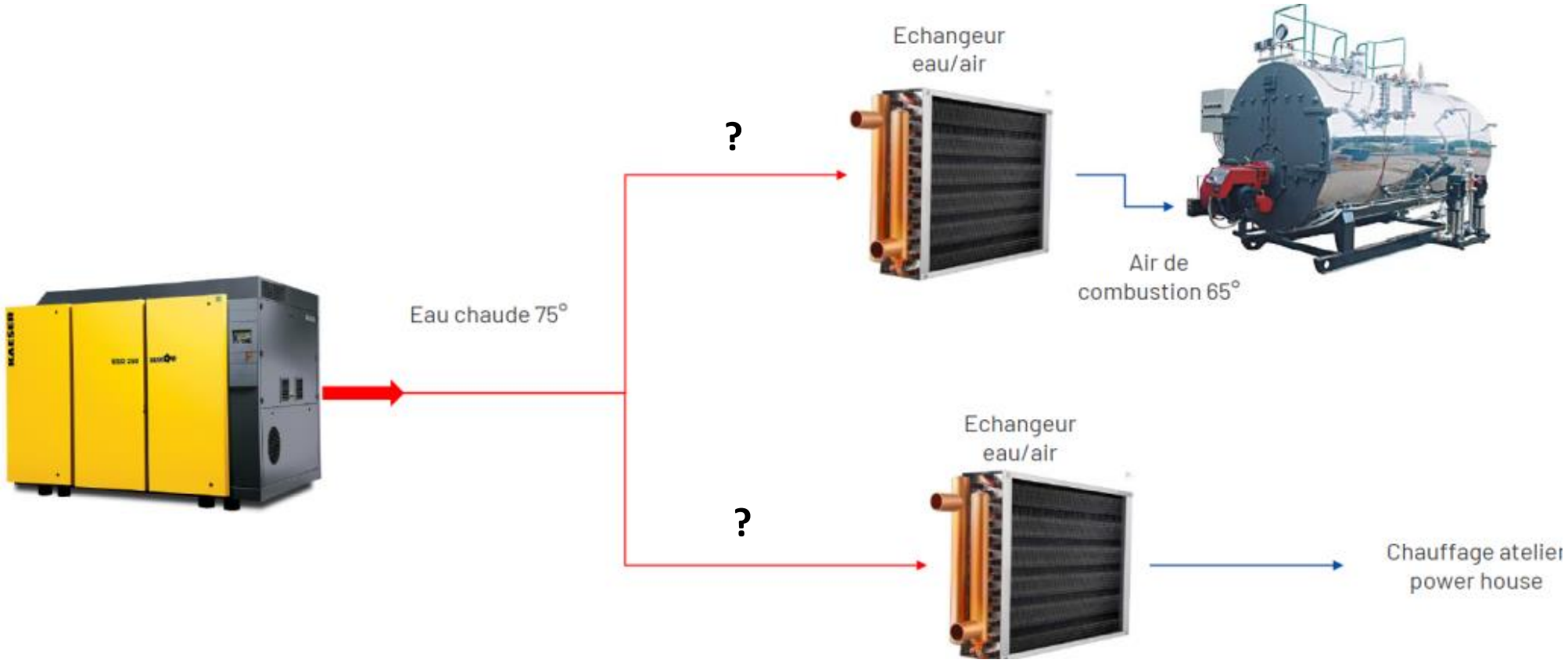
ORIGINAL SITUATION

- **Customer request :**
  - Study the installation of two heat pumps to replace steam/hot water exchangers for heating 2 buildings.
- **Centralised compressed air production plant :**
  - 8 oil-injected rotary screw compressors
  - Installed power : 1,820 kW
  - Pressure : 7.2 bars
  - Heat Recovery loop : hot water 75 °C
    - Preheating combustion air steam boilers (2 boilers 30 T/h)
    - Heating Workshop Power House

ORIGINAL SITUATION



Courtesy of Goodyear

Measuring is understanding !

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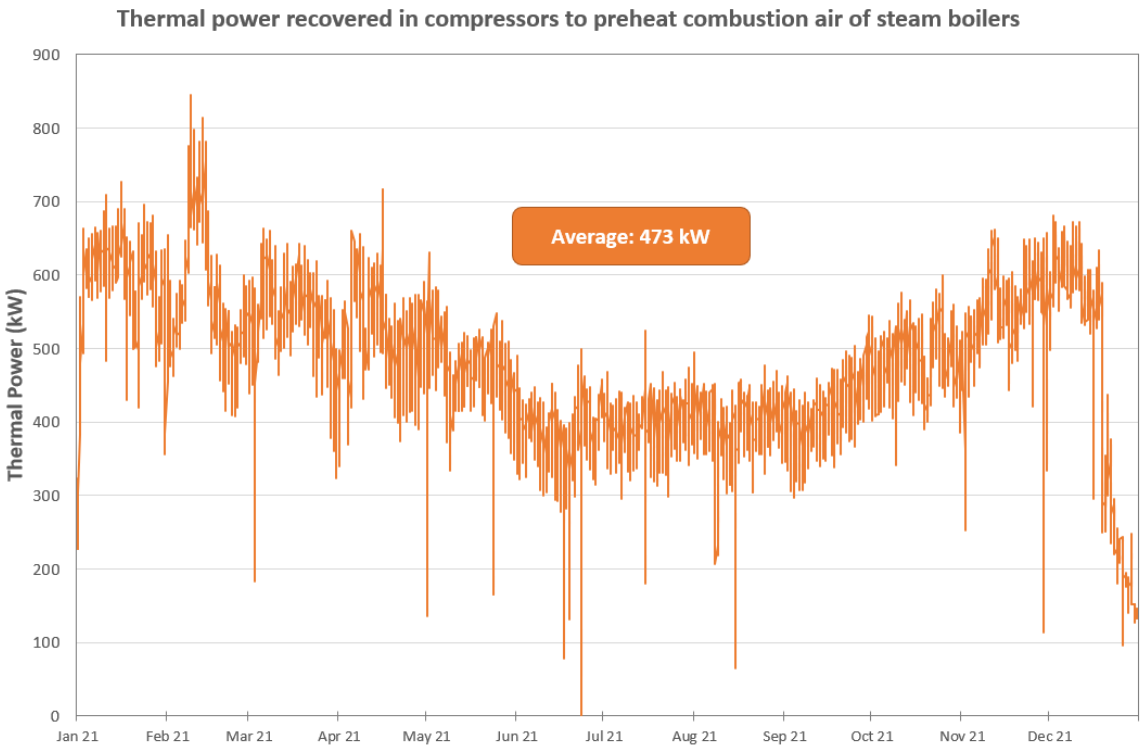
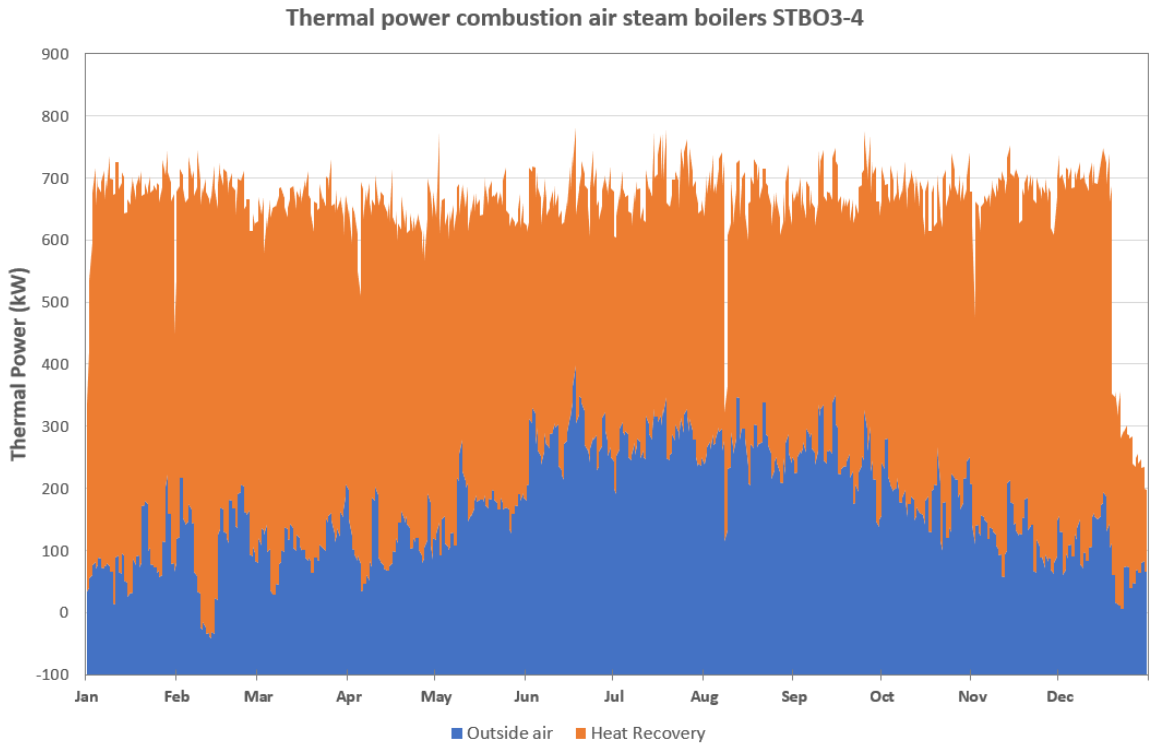
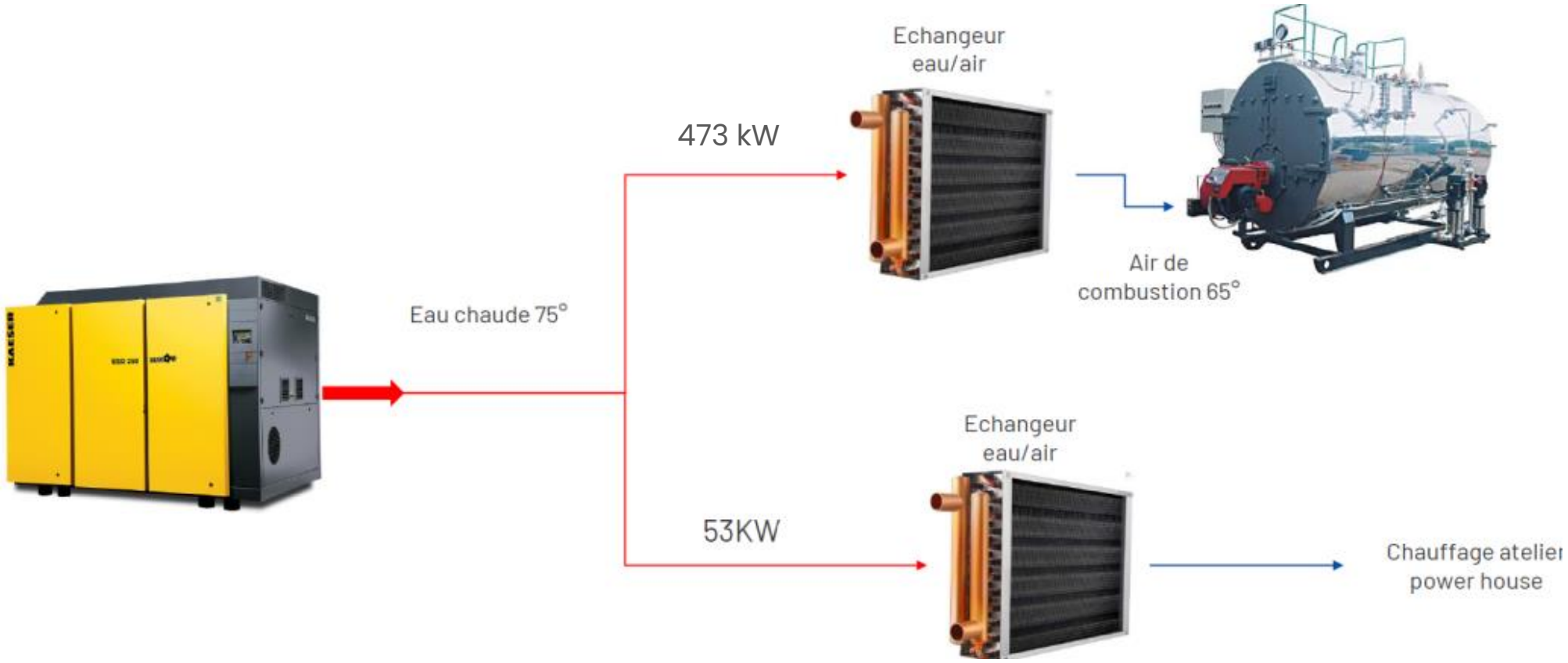
ASSESSMENT OF WASTE HEAT USE

- **Preheating air combustion steam boilers**



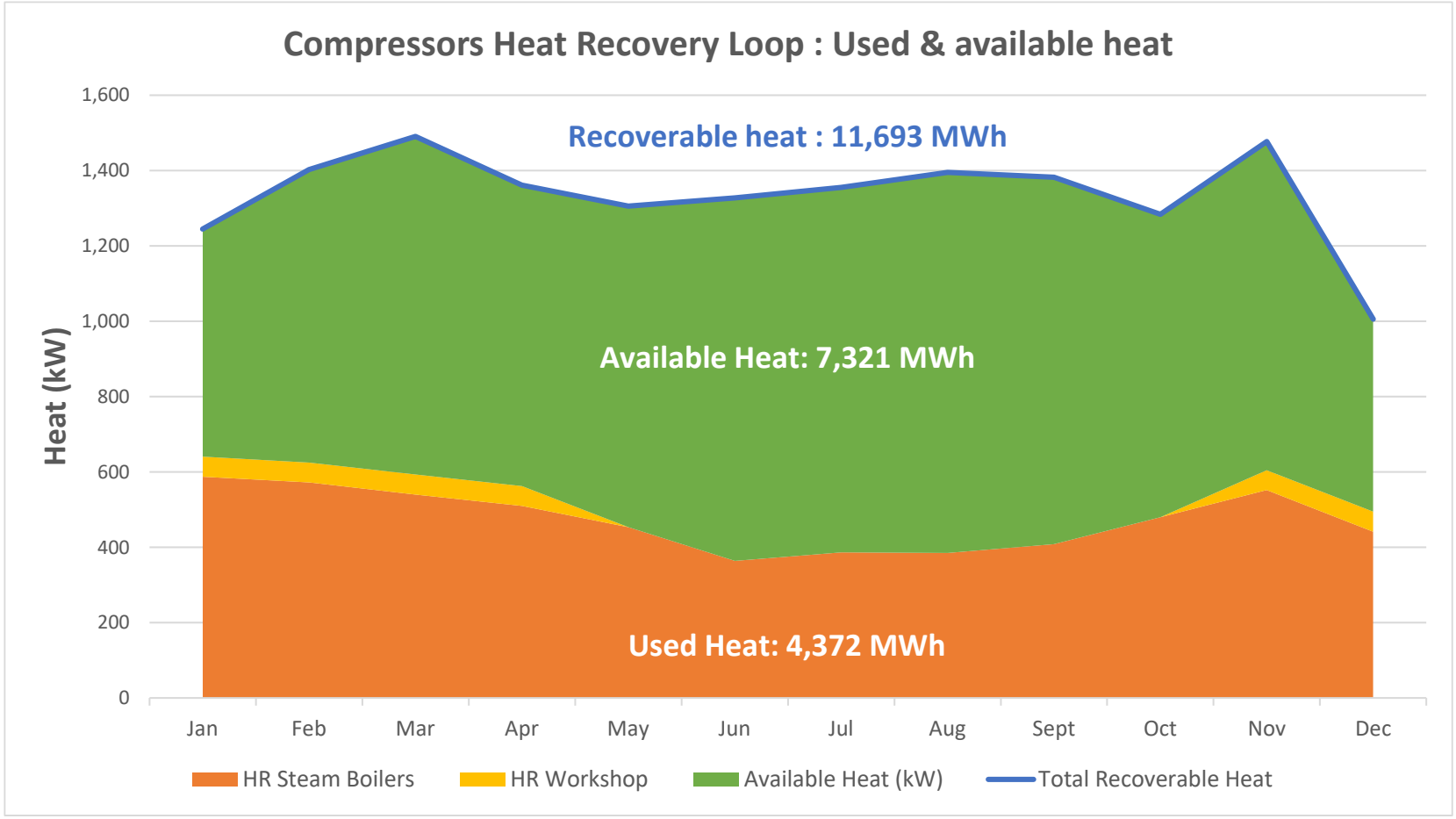


ORIGINAL SITUATION



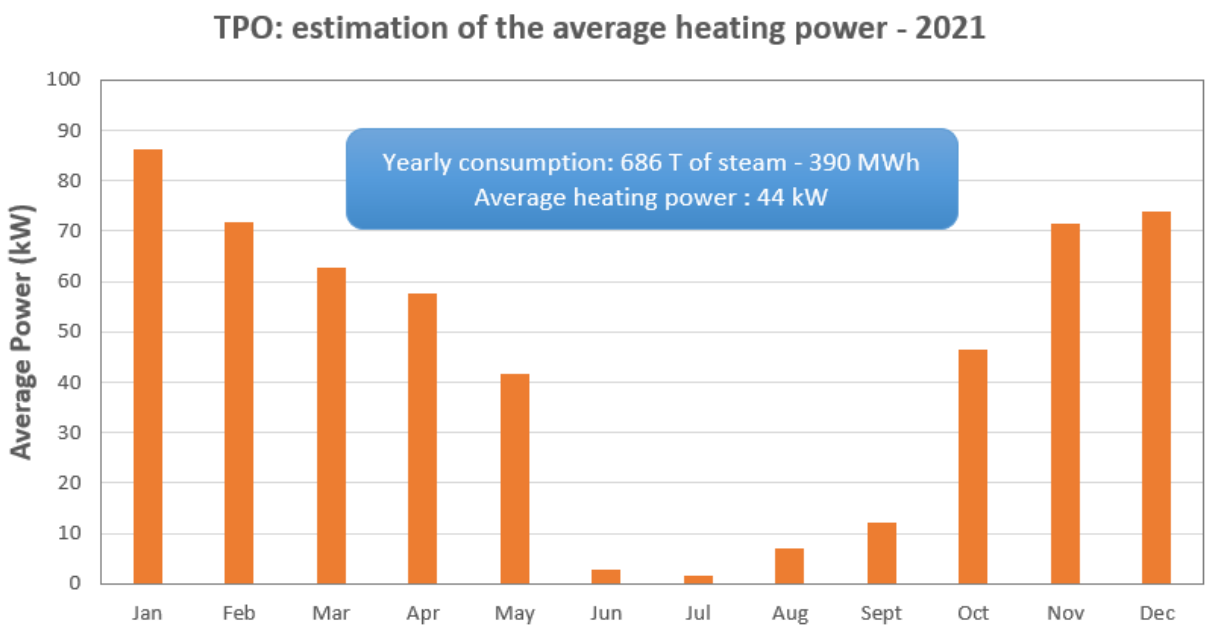
Courtesy of Goodyear

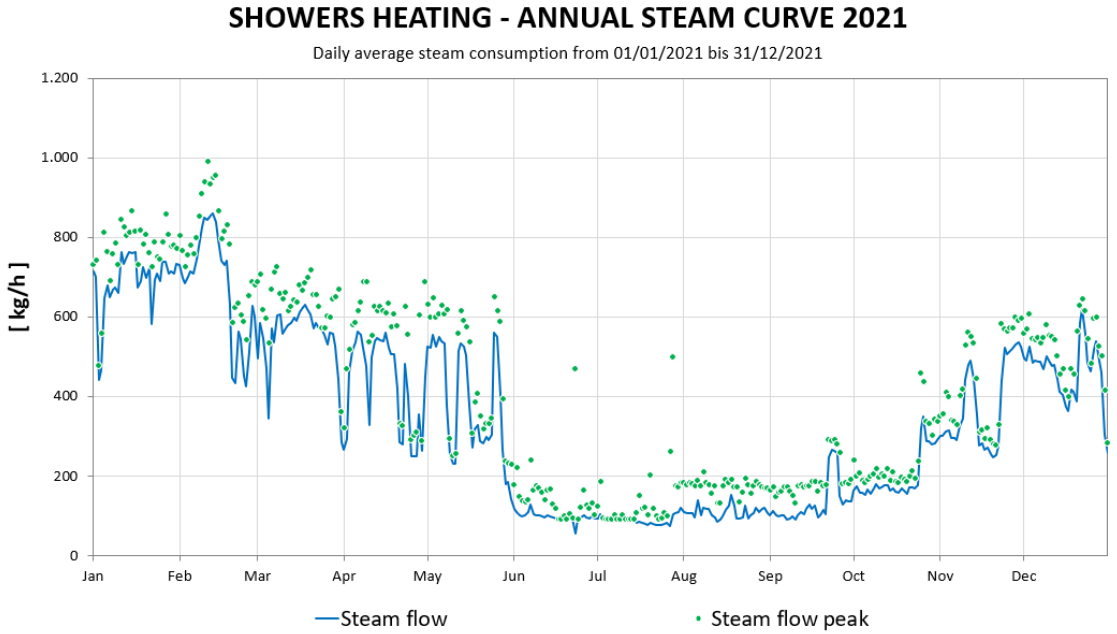
ASSESSMENT OF TOTAL AVAILABLE WASTE HEAT



ASSESSMENT OF NEW HEAT REQUIREMENTS

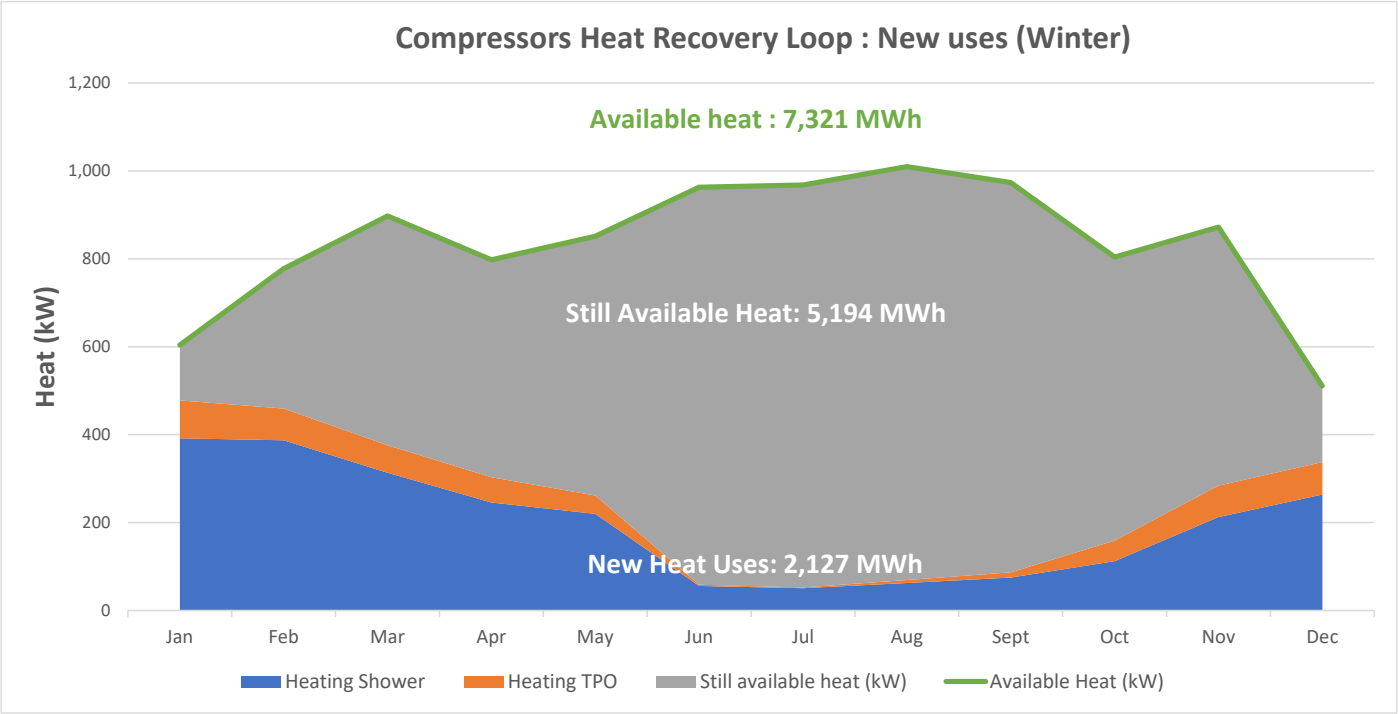
- **New uses of available heat :** Heating Building and Showers heating (currently made with steam/hot water HE and planned to be replaced by heatpumps)



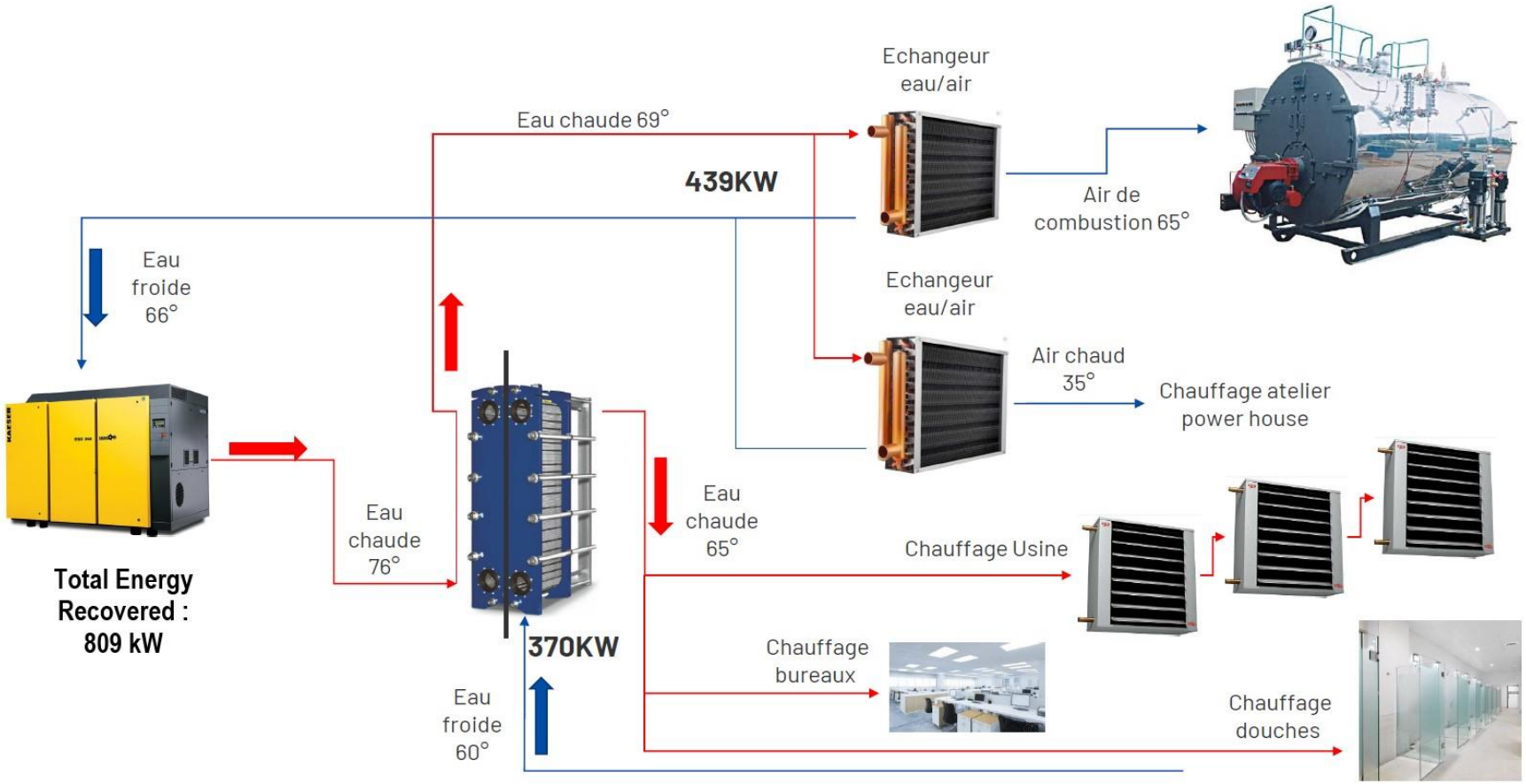


ASSESSMENT OF TOTAL AVAILABLE WASTE HEAT

- **The two new heat requirements can be fully met all year round by the existing heat recovery loop, without adding any new equipment, and there is still heat available for other uses**

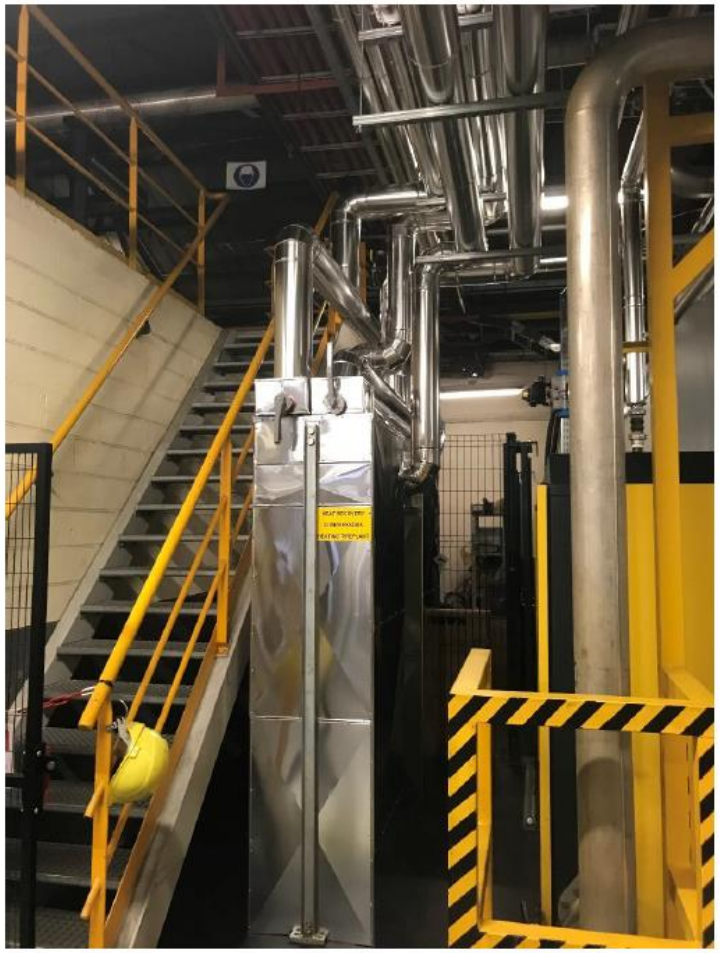


CURRENT SITUATION



Courtesy of Goodyear

CURRENT SITUATION



Courtesy of Goodyear

SAVINGS – INVESTMENTS - SUBSIDIES

- **Savings** (*)**:**
  - Steam : 3,741 T/year => 2.963 MWh Gas GCV
  - CO_2 : 524 T/year
  - 411 k€/year
- **Investments** (*) **:**
  - Heat exchangers and piping : 45 k€
  - Heating offices equipments : 32 k€

  } 77 k€
- **Subsidies** (*) **:**
  - Enoprimes 77 k€ (limited to the investment amount)

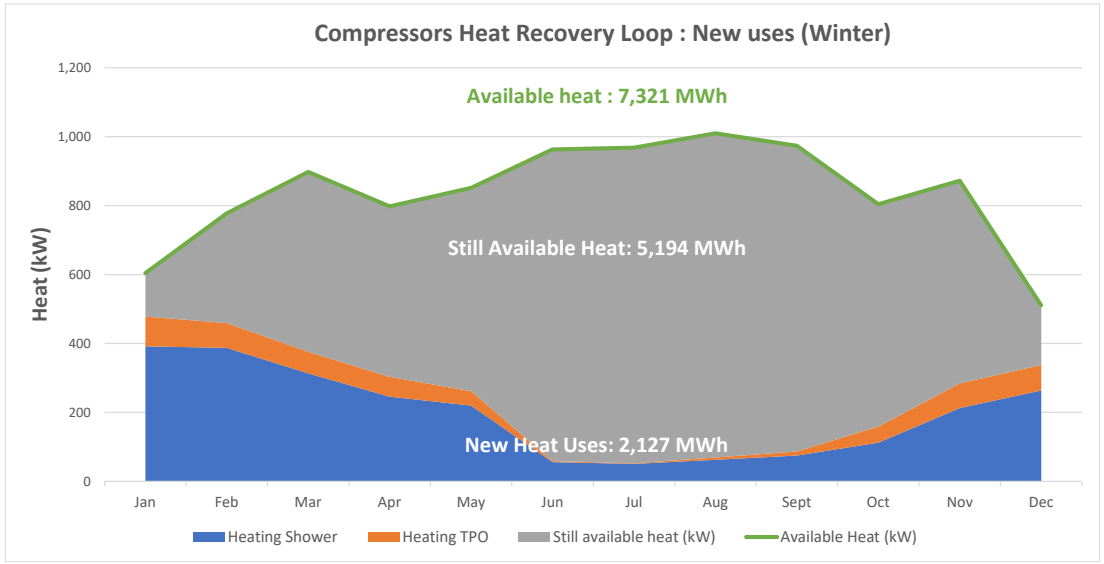
  => Investment fully paid by subsidies !

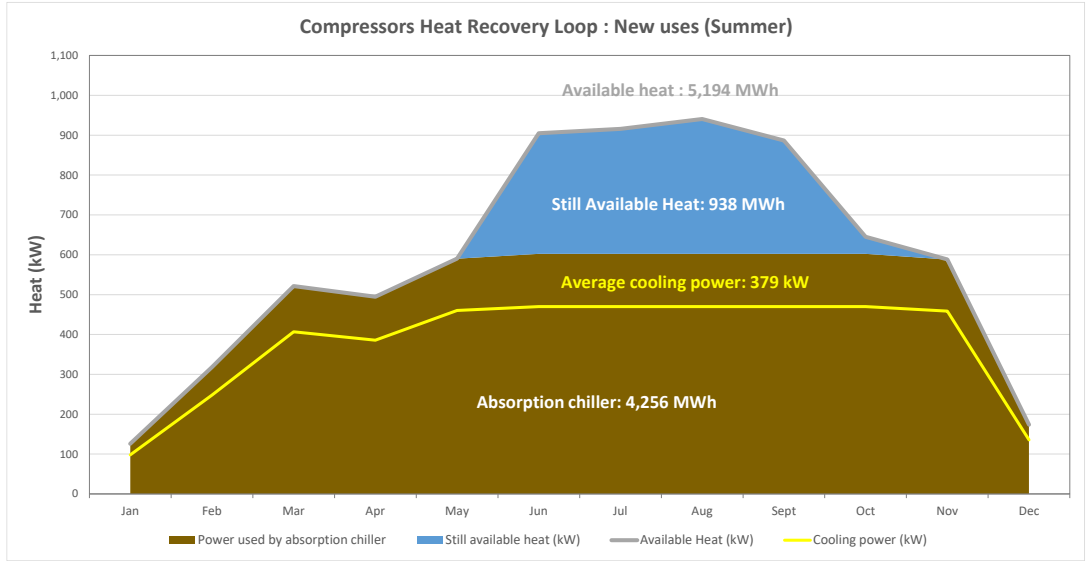
(*) Data kindly provided by Goodyear

PROPOSAL FOR NEW USES : ABSORPTION CHILLER

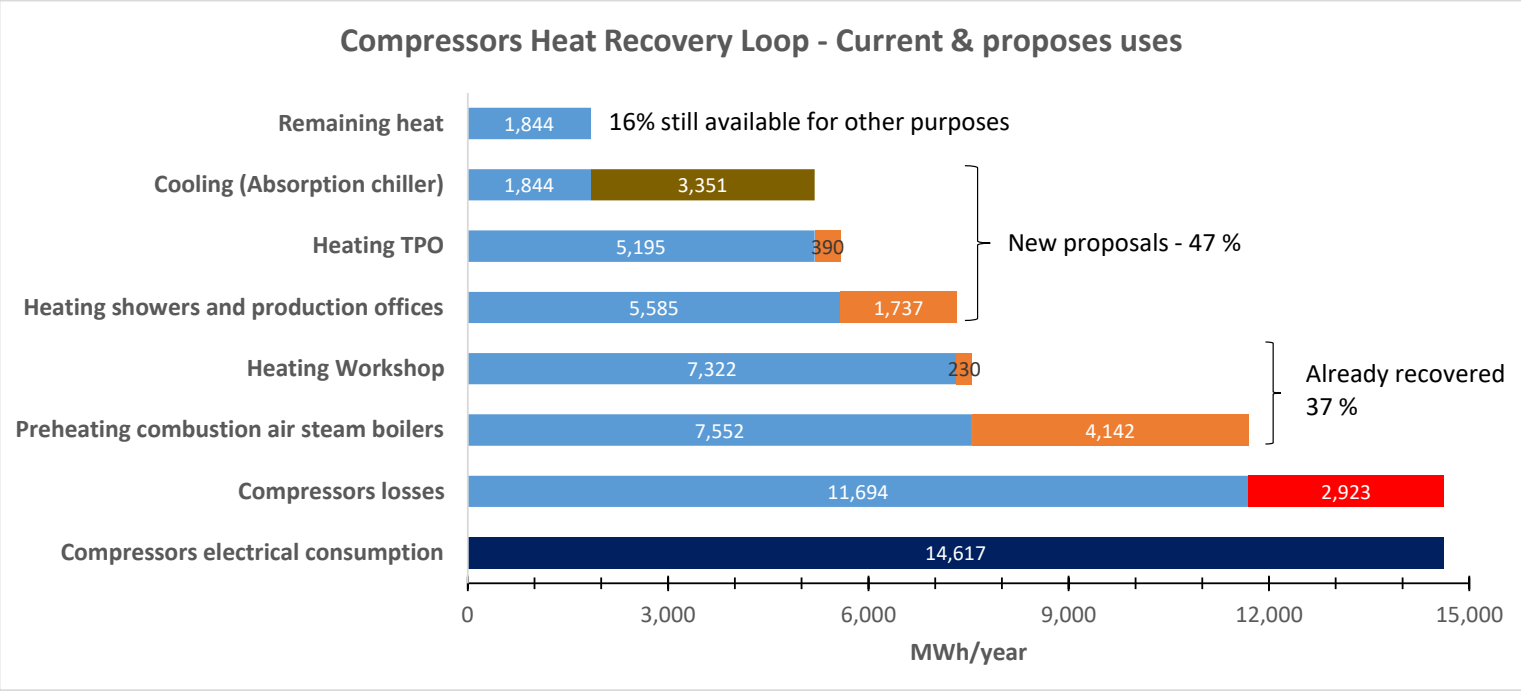
- Despite the two new uses installed on the heat recovery loop, heat is still available for other uses ! Between 150 kW in winter and 850 kW in summer.

=> Proposal to install an absorption chiller to produce chilled water during the summer months, in place of a very expensive rental chiller. This will also reduce the consumption of the current chillers for several months. The chiller has been ordered, delivered and is currently being commissioned. The payback should be short.





SUMMARY



- 37% of waste heat was already recovered
- Additional 47 % has been recovered, almost free of charge (taken subsidies into account), thanks to an in-depth analysis, expertise and open-mindedness.

CIRCUIT FOIL

Case 2
Circuit Foil Luxembourg

Waste heat recovery from process cooling circuit

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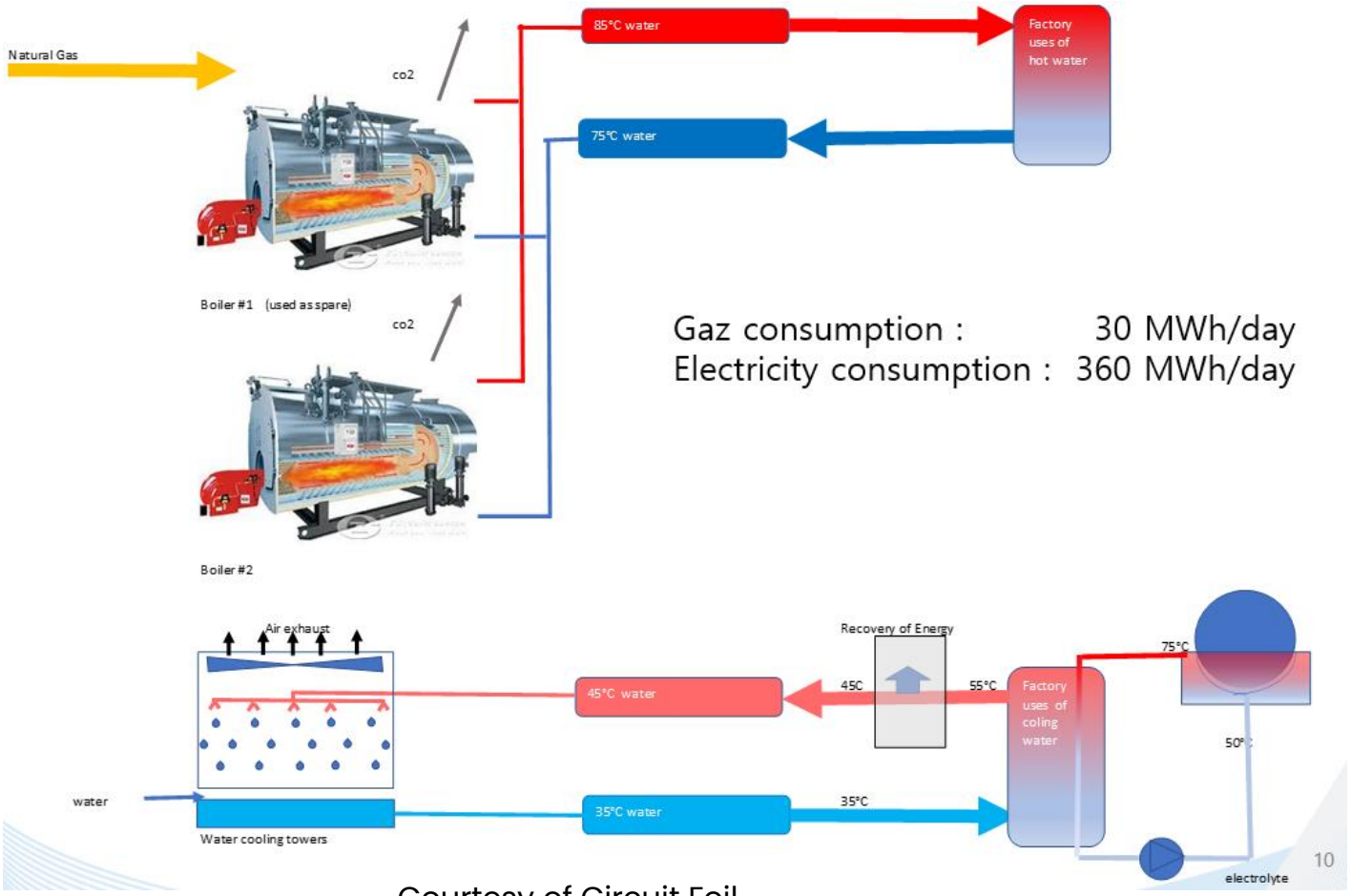
ORIGINAL SITUATION



Courtesy of Circuit Foil

ORIGINAL SITUATION

- A lot of heat generated by process is dissipated in cooling towers
- Hot pool 45 °C / Cold Pool 40°C
- Factory and offices heating requirements and some process needs carried out by two 6 MW gas boilers
- Existing heat recovery loop for process and hot water uses
- Energy audit carried out in 2017 by Energieagence showed potential of replacing gas boiler by heatpump
- In-depth analyses and pre-engineering project, carried out in 2021 by energieagence in the frame of the second energy audit, proved the feasibility and rentability of the project

Measuring is understanding !

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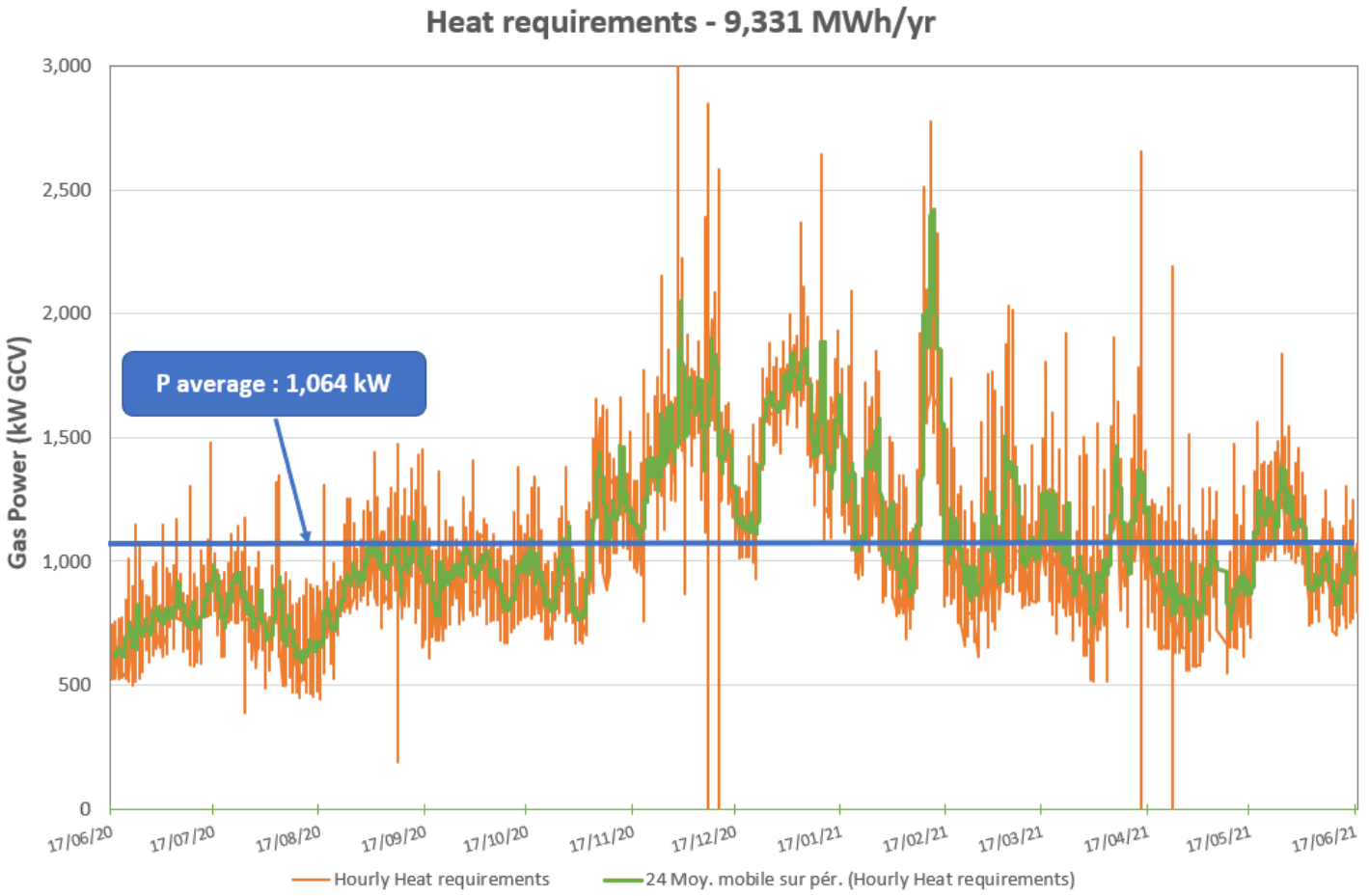
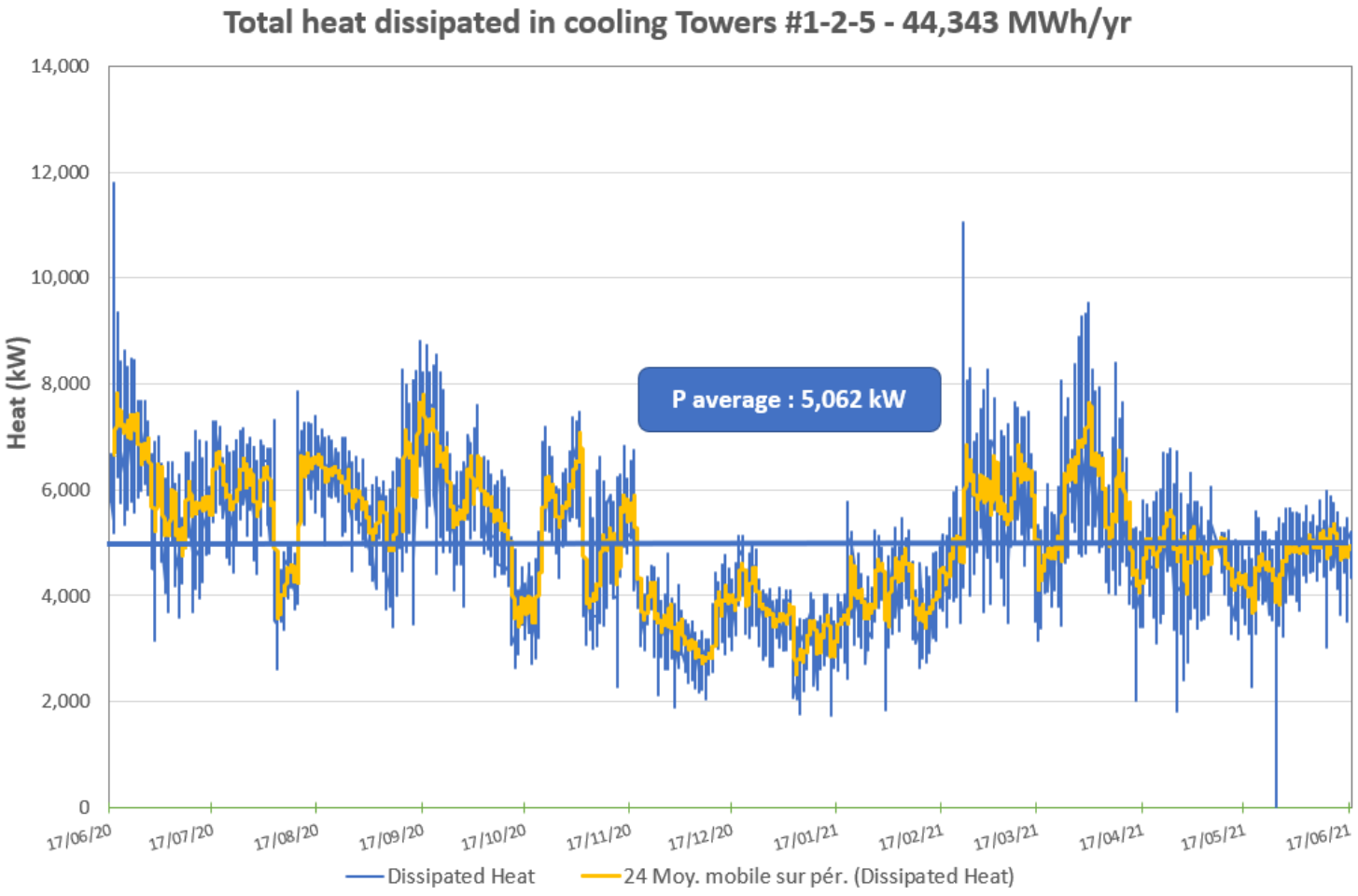
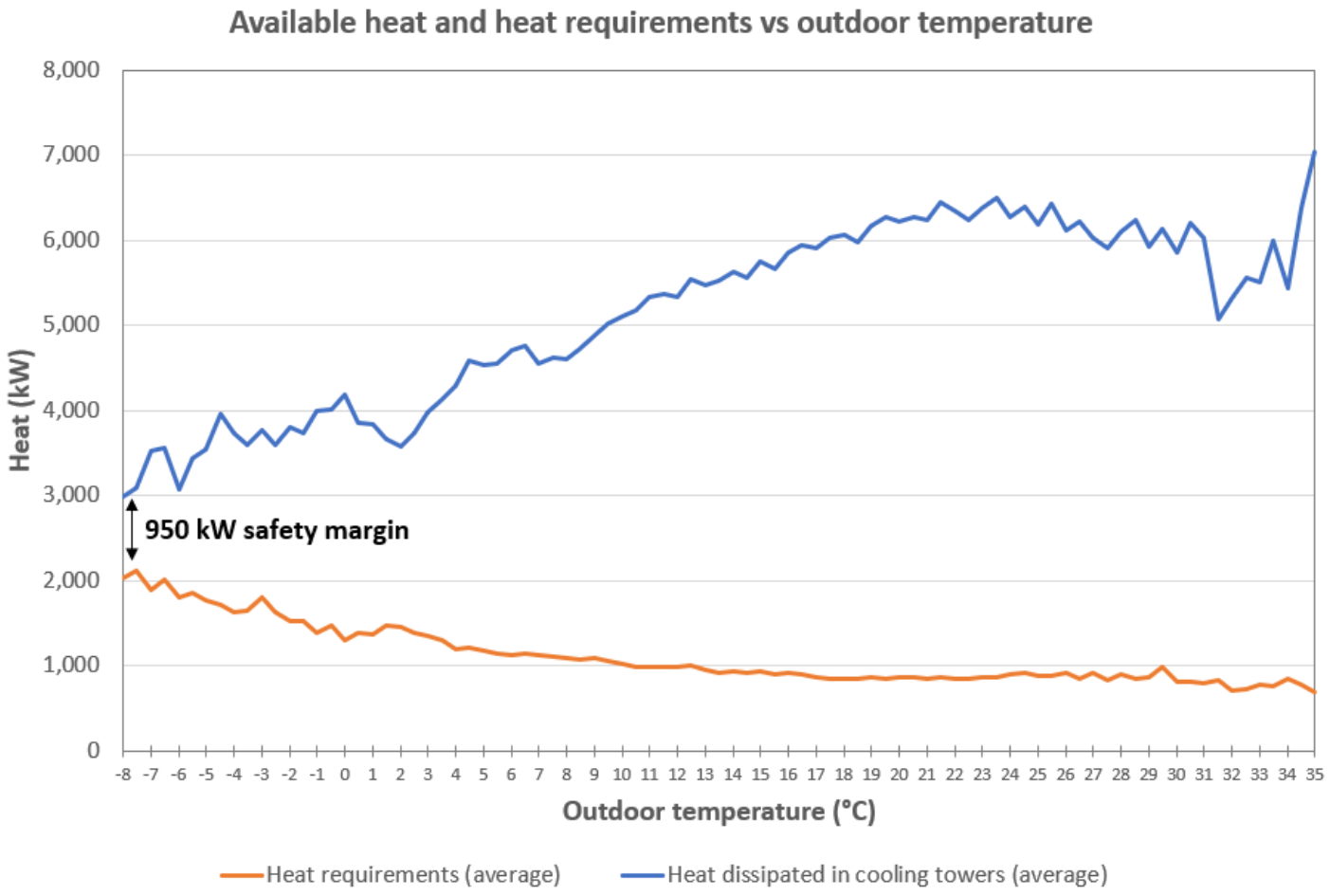
ASSESSMENT OF HEATING REQUIREMENTS



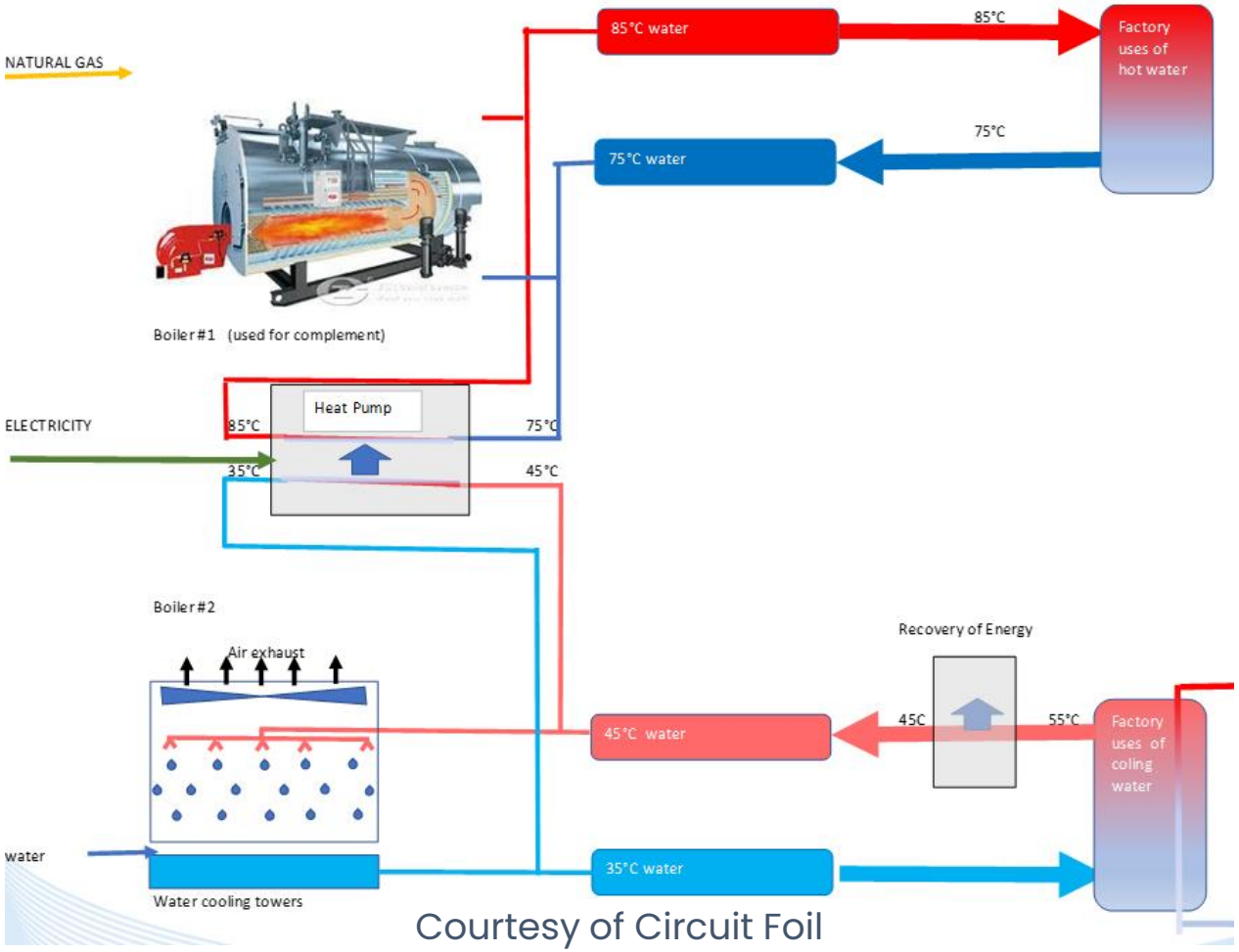
ASSESSMENT OF WASTE HEAT USE



SIMULTANEITY OF HEATING NEEDS AND AVAILABLE HEAT



TECHNICAL SOLUTION



Courtesy of Circuit Foil

PROJECT DATA

- **3 Heat Pumps Ochsner**
  - Refrigerant R1234ze
  - Power : 2 x 820 kW + 1 x 510 kW => Total power : 2,150 kW
  - Evaporating temperature : 43-38 °C
  - Condensing temperature : 80-85 °C (foreseen, probably lower)
  - COP : 3,4 to 4,5 depending on water temperatures
- **Commissioning in February 2024**
  - All needs covered by heat pumps, despite of lower production level
  - Due to heat requirements increase, savings probably bigger than forecast

SAVINGS – INVESTMENTS - SUBSIDIES

- **Estimated Savings :**
  - Gas : 12.3 GWh/year GCV

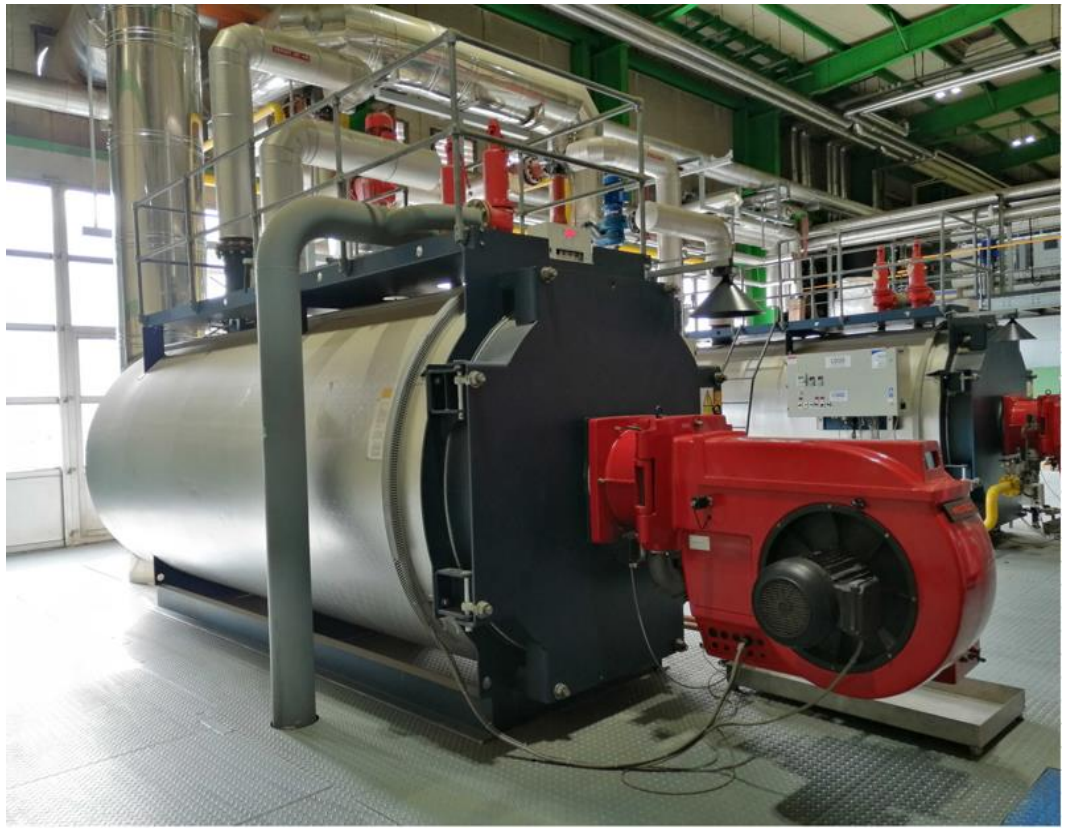
  => Total decarbonation of the site

  => consumption of 400 single-family home in Luxembourg
  - Electricity : -2.8 GWh/year
  - Final Energy Savings : 9.5 GWh/year
  - CO_2 : 2,178 T/year
- **Investments : 1,018 k€** (*)
  - Heat pumps : 426 k€
  - Piping : 380 k€
  - Electricals, automation : 200 k€
  - Civil works, engineering : 12 k€
- **Subsidies : 253 k€** (*)
  - Enoprimes : 117 k€
  - MECO : 136 k€

(*) Data kindly provided by Circuit Foil

PICTURES

Before



After

Cimalux
Ciments & Matériaux

Case 3
Cimalux Rumelange

Waste heat recovery from water-cooled air compressors

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ORIGINAL SITUATION – HEATING REQUIREMENTS

- 2 Hot water boilers with gas burner for heating the administration building
- 3 Gas-fired radiant heaters for the compressor room, generator room and pump room, with separate gas counters

ORIGINAL SITUATION – AIR COMPRESSORS

- 3 oil-injected rotary screw air compressors
- Installed Power : 240 kW
- Water-cooling with cooling towers **=> Energy & water consumption for cooling !**
- **Not used installed** Heat Recovery Exchanger !

Measuring is understanding !

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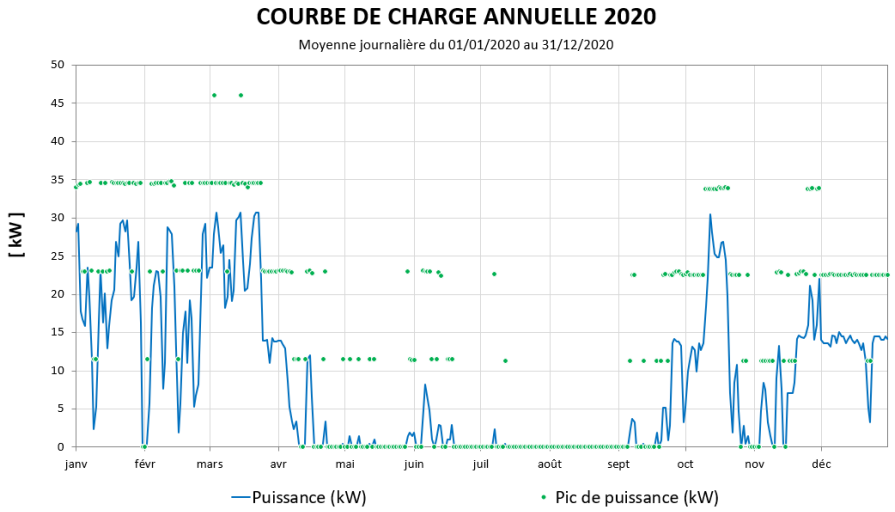
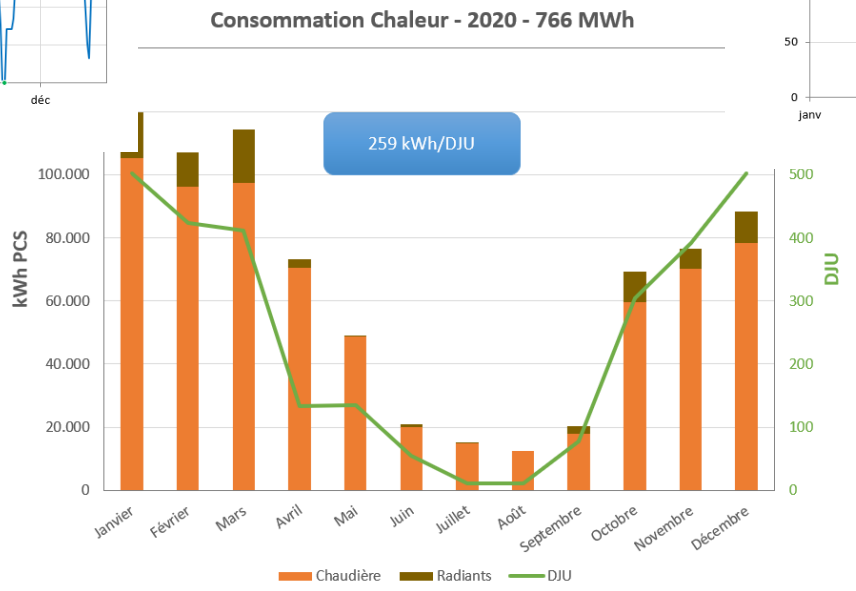
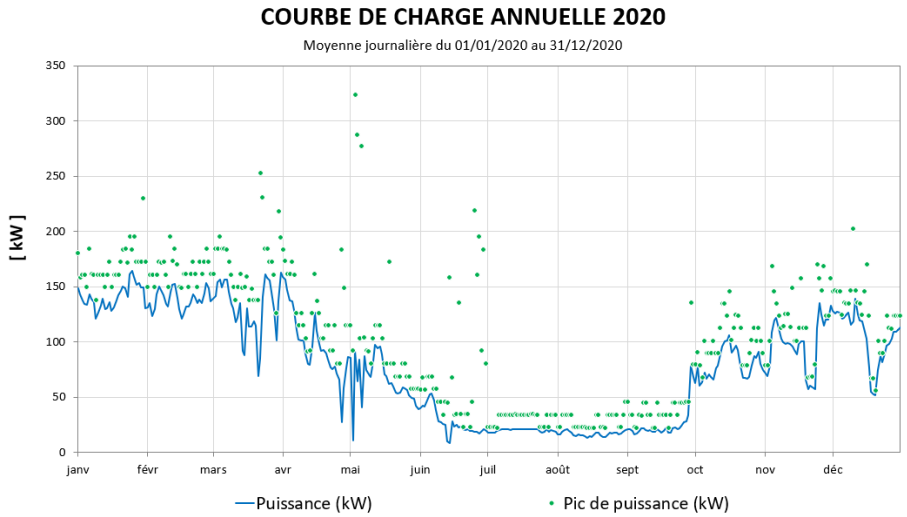
ASSESSMENT OF HEATING REQUIREMENTS



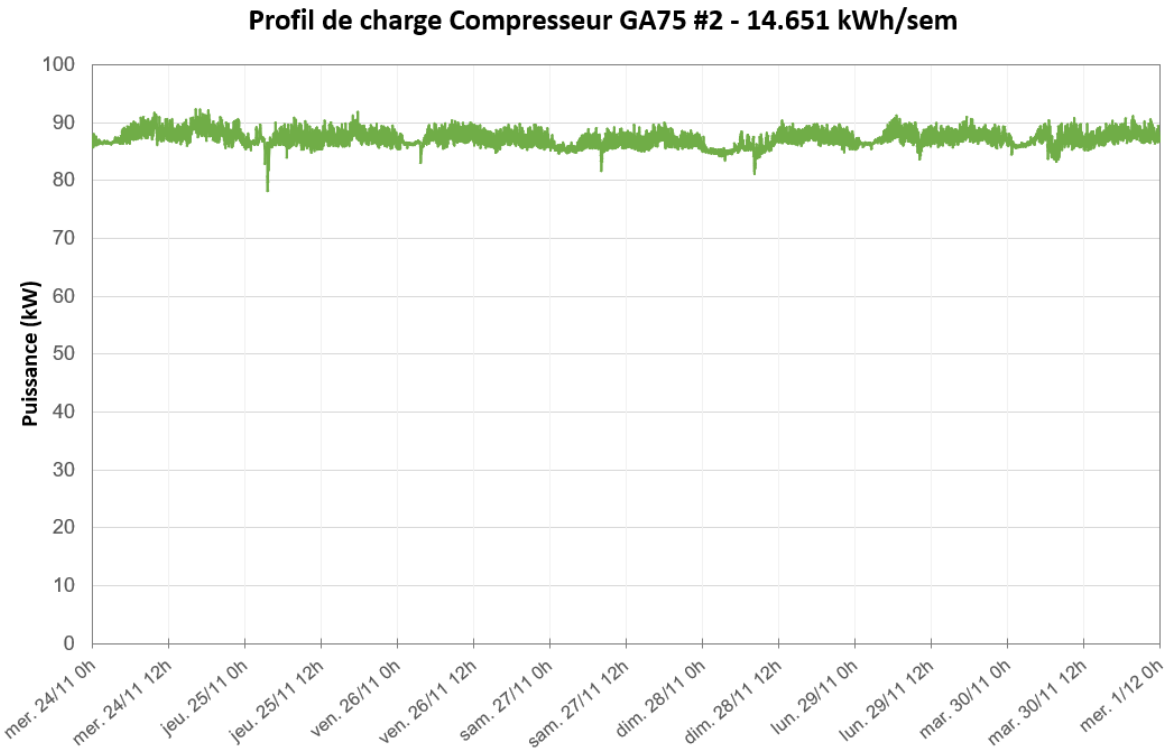
Radiants

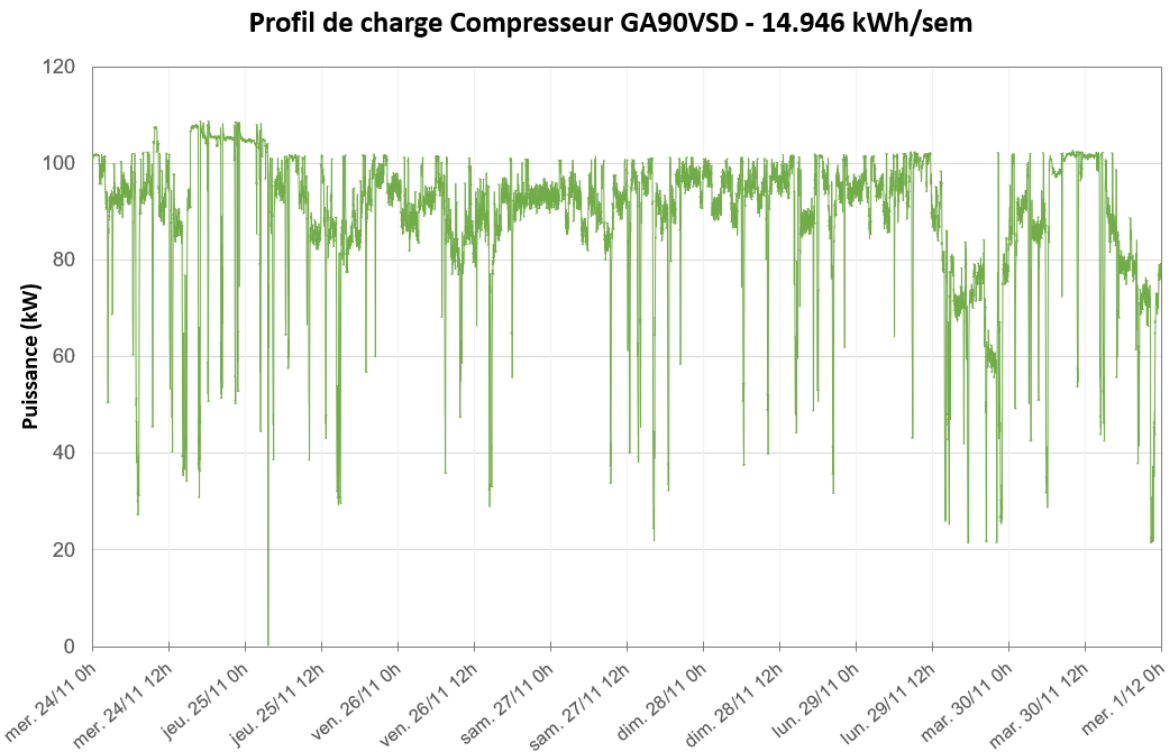




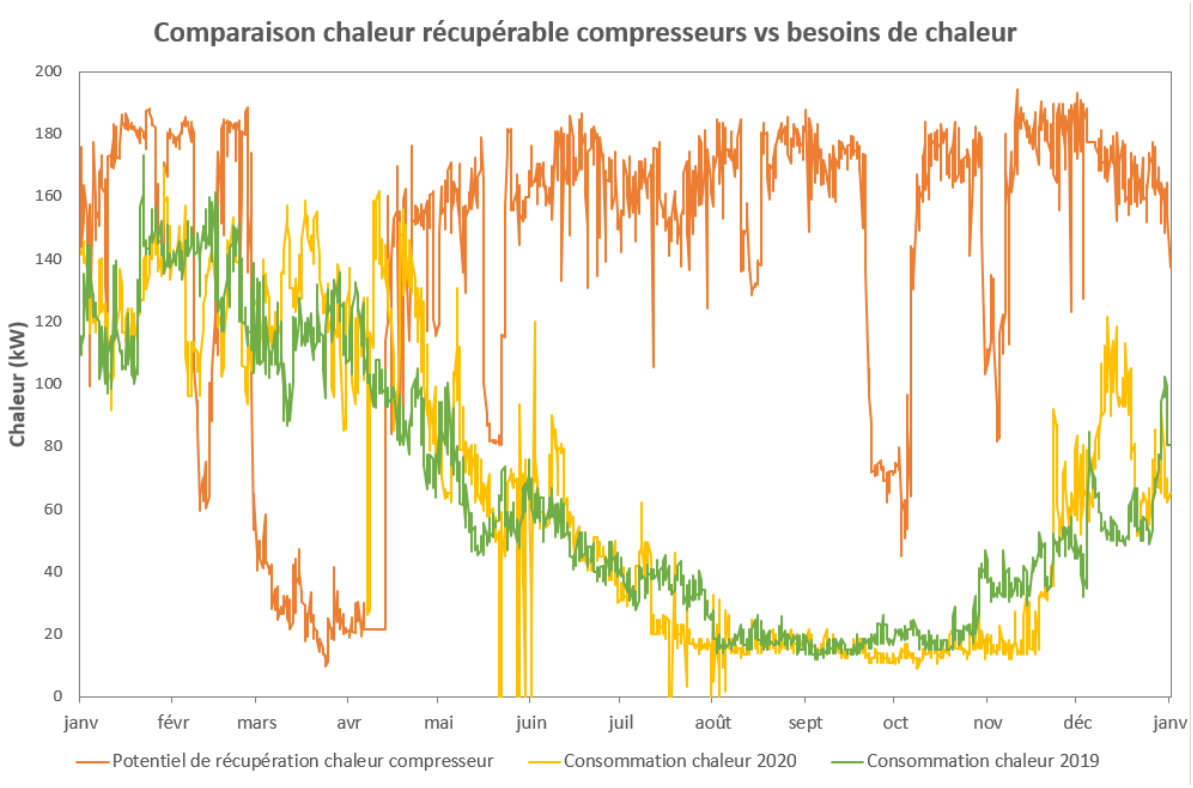
Boilers

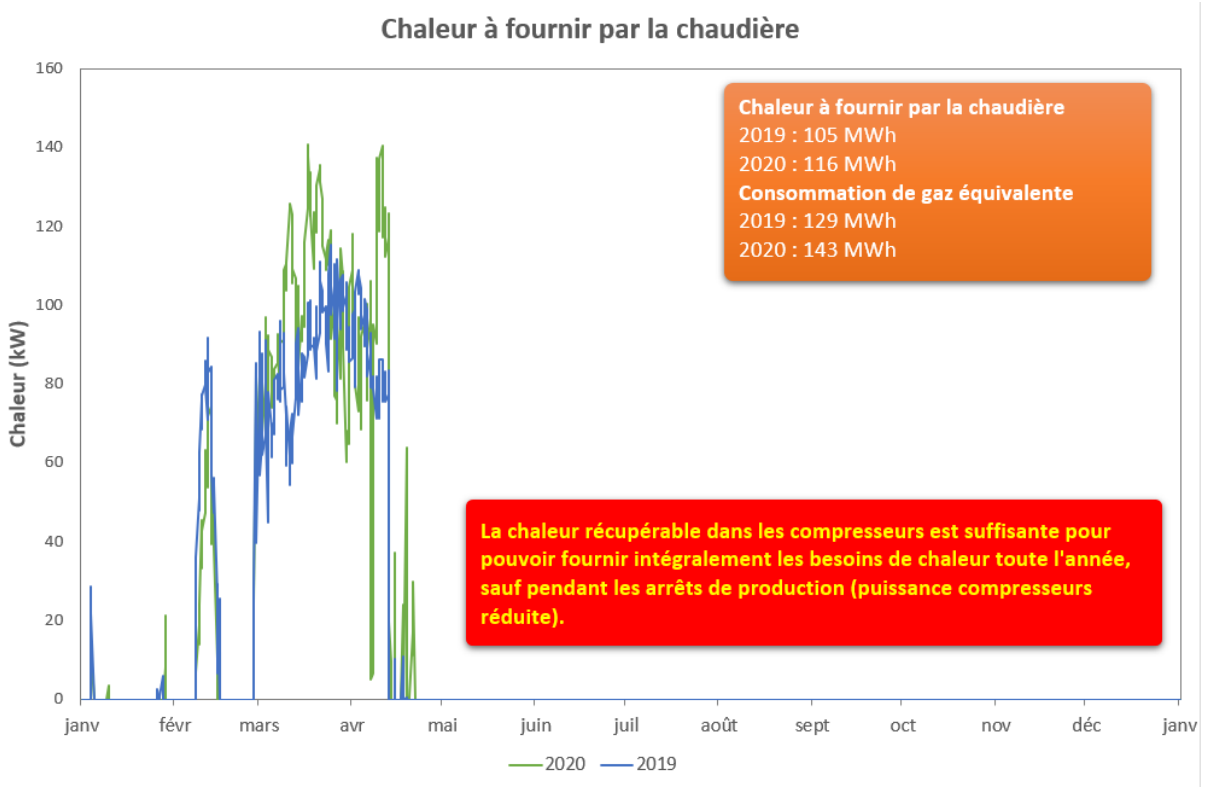
ASSESSMENT OF WASTE HEAT USE





SIMULTANEITY OF HEATING NEEDS AND AVAILABLE HEAT

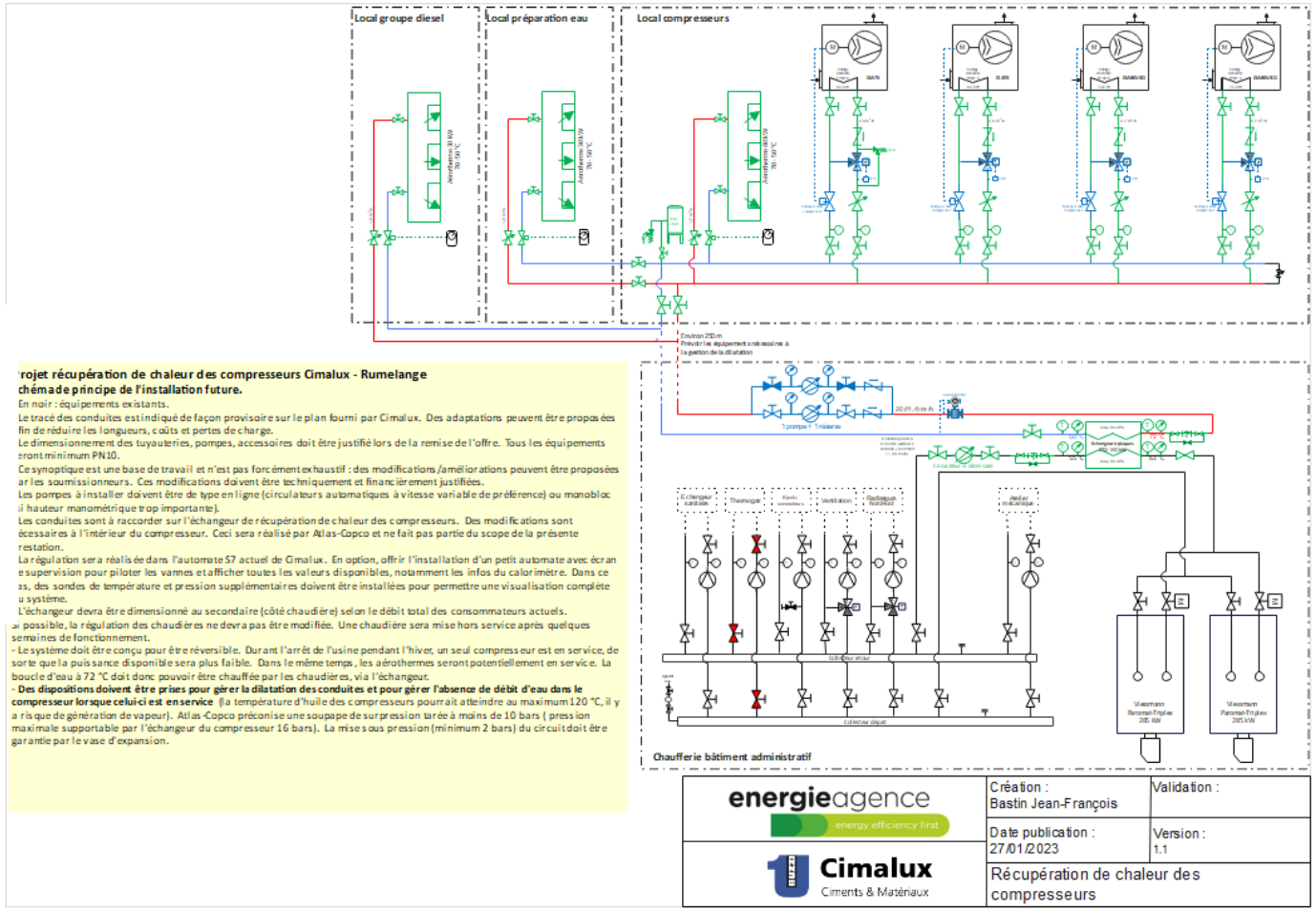




- The heat available in the compressors is sufficient to supply all the heat required during periods of production and part of the requirement when production is stopped.

TECHNICAL SOLUTION

- **Study end 2022 – Early 2023**
- **Work in 2023**
- **Commissioning in December 2023**
- **Optimisation in progress**



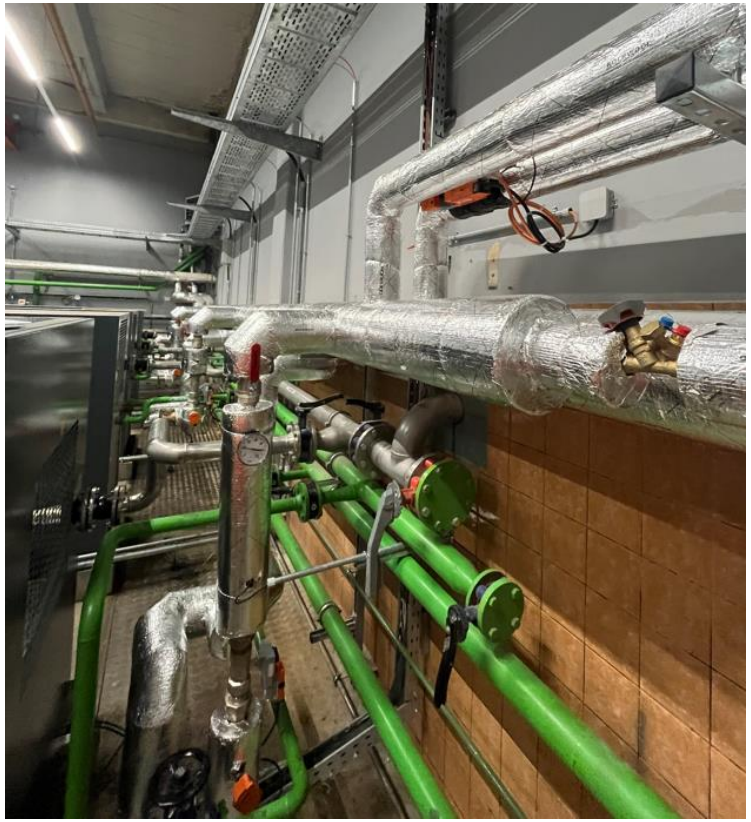
SAVINGS – INVESTMENTS - SUBSIDIES

- **Expected Savings :**
  - Gas : 628 MWh/year GCV
  - CO_2 : 137 T/year
  - Additional savings : elimination of meter rental and capacity term charges
  - Total estimated savings : 68 k€/year
- **Investments : 227 k€** (*)
  - Piping : 145 k€
  - Insulation: 27 k€
  - Electricals, automation : 52 k€
  - Civil works, engineering : 3 k€
- **Subsidies : 15 k€**
  - Enoprimes : 15 k€

(*) Data kindly provided by Cimalux

PICTURES

Compressor room



Boiler house

Special thanks to

Mrs Hupperich (Cimalux)

Mr Huberty (Goodyear)

Mr Thiteux (Circuit Foil)

energieagence

energy efficiency first

Thanks for your attention

More information ?

jean-francois.bastin@energieagence.lu

+352 621 70 52 52

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LUXINNOVATION
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ENERGY STORAGE
Guilhem Dejean

Director Technique and R&D,
Eco-Tech Ceram

LUXEMBOURG MATERIALS & MANUFACTURING CLUSTER

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Eco-Tech Ceram

The carbon free energy

« Industrial waste heat » Workshop,
House of Biohealth, 26.03.24
G. DEJEAN

ETC: decarbonising industry

Climate change

30-50 % of ecosystems under threat

3 billion people at risk

+ 2°C maximum to limit global warming by 2100

*Global figures - IPCC 2022 report

CO2 emissions

78 million tonnes of CO_2 emitted every year in France by industry

20 % of CO_2 emissions come from industries

20 million fewer tonnes of CO_2 emitted by industry by 2032 - a French government requirement

*Haut Conseil pour le Climat figures, Sept. 2022 and Citepa, Secten inventory, ed. 2022 / Speech by E. Macron, Nov. 2022

Lost energy

50 % of energy is consumed as heat

1/3 of the energy consumed is lost as heat

100 TWh of heat is lost in France each year

=

2.4 million French people for their annual consumption

*ADEME figures Dossier waste heat recovery 2020

The ETC solutions

+20 % gains with energy sobriety and efficiency

+20 % gains with heat recovery with or without storage

+30 % gains with the electrification of heat

1000 tonnes of CO_2 avoided each year

*ETC figures based on feedback from infrastructures installed on industrial sites

From R&D to CO_2 savings

2011 — 2013

- Antoine Meffre thesis (CNRS PROMES):

High temperature **energy storage**

- The ETC concept:

Design of a thermal storage unit to recover waste heat from factories.

Design and production of prototypes for public research and higher education.

2014 — 2021

- **Creation of Eco-Tech Ceram**
- Three-time winner of the Global Innovation Contest
- **Prototypes** and industrial sales
- Fundraisings (40 M€)
- Creation of ETC Invest
- **5 patents**
- 50 scientific publications

2024 …

- **6 industrial facilities** in operation, 4 R&D pilots
- **25 employees** experts in sobriety, energy efficiency and energy recovery.
- **Contracts** with **industries and major industrial groups** (5M€)
- **Contracts** with public research **laboratories**
- Active **R&D** thanks to a major scientific network

Our turnkey offer to recover and substitute

1	2	3	4	5	6
Diagnosis	Feasibility study	Study	Funding	Turnkey project	Performance trackings
					
Assessing the potential of heat sources in your plant. The pre-diagnosis is **FREE OF CHARGE.**	B1 - Process analysis with a view to efficient efficient use of energy in in all its forms.	B2 - Development of a solution in order to take expert action on all your processes and infrastructure.	Identify the various financing options: grants, third-party financing, ETC Invest, which buys the infrastructure from ETC, leases the facility and/or sells carbon-free heat.	ETC supports manufacturers from A to Z by delivering a project, followed by an adapted product ready for use.	ETC integrates 100% digital tools performance monitoring tools tools that provide real-time measurements measures of productivity.

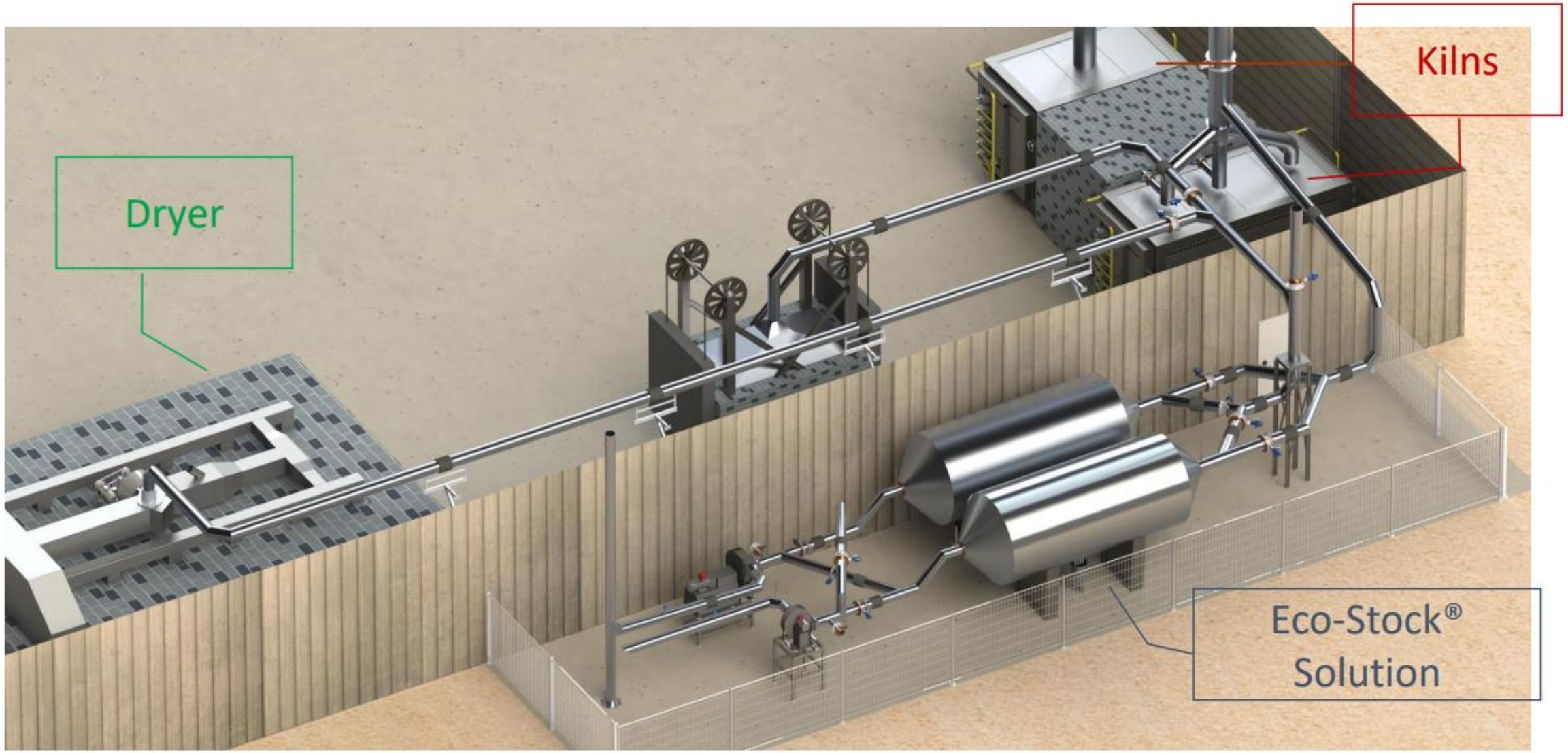
A complete expertise

We understand every stage and every element of **industrial processes**, in ceramics and metallurgy to provide the most cost-effective and sustainable **decarbonised heat** possible.

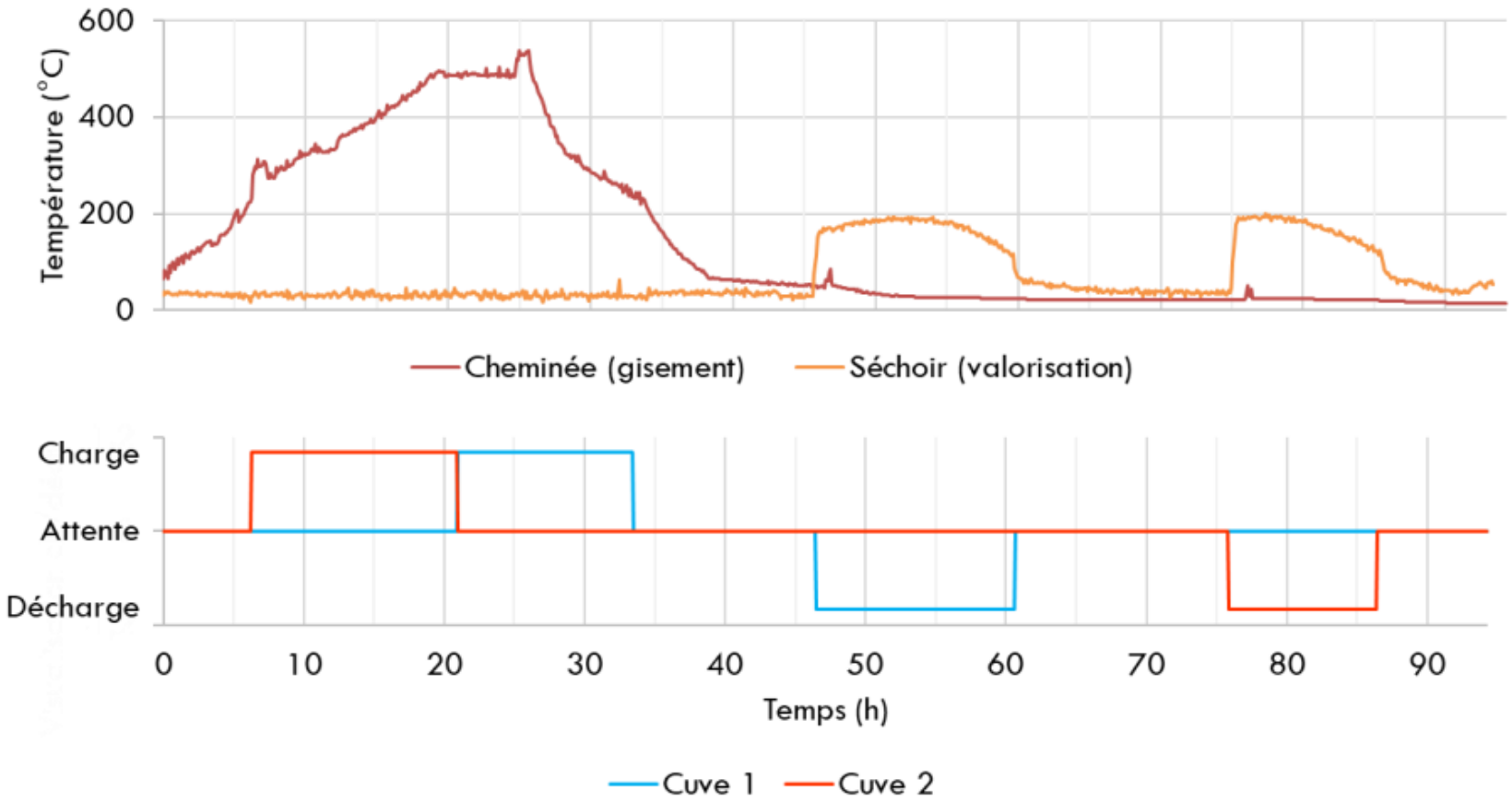
Project management	Materials	Thermics	Process	Mecanics	Automation	Digitalisation	Funding

- From design to implementation
- From experimental laboratory bench to industrial infrastructure: **from TRL2 to TRL9**
- All the necessary scientific and technical skills

Tegulys: First commercial facility



Dryer supply with stored recovered heat



Tegulys: First commercial facility

Tegulys: First commercial facility

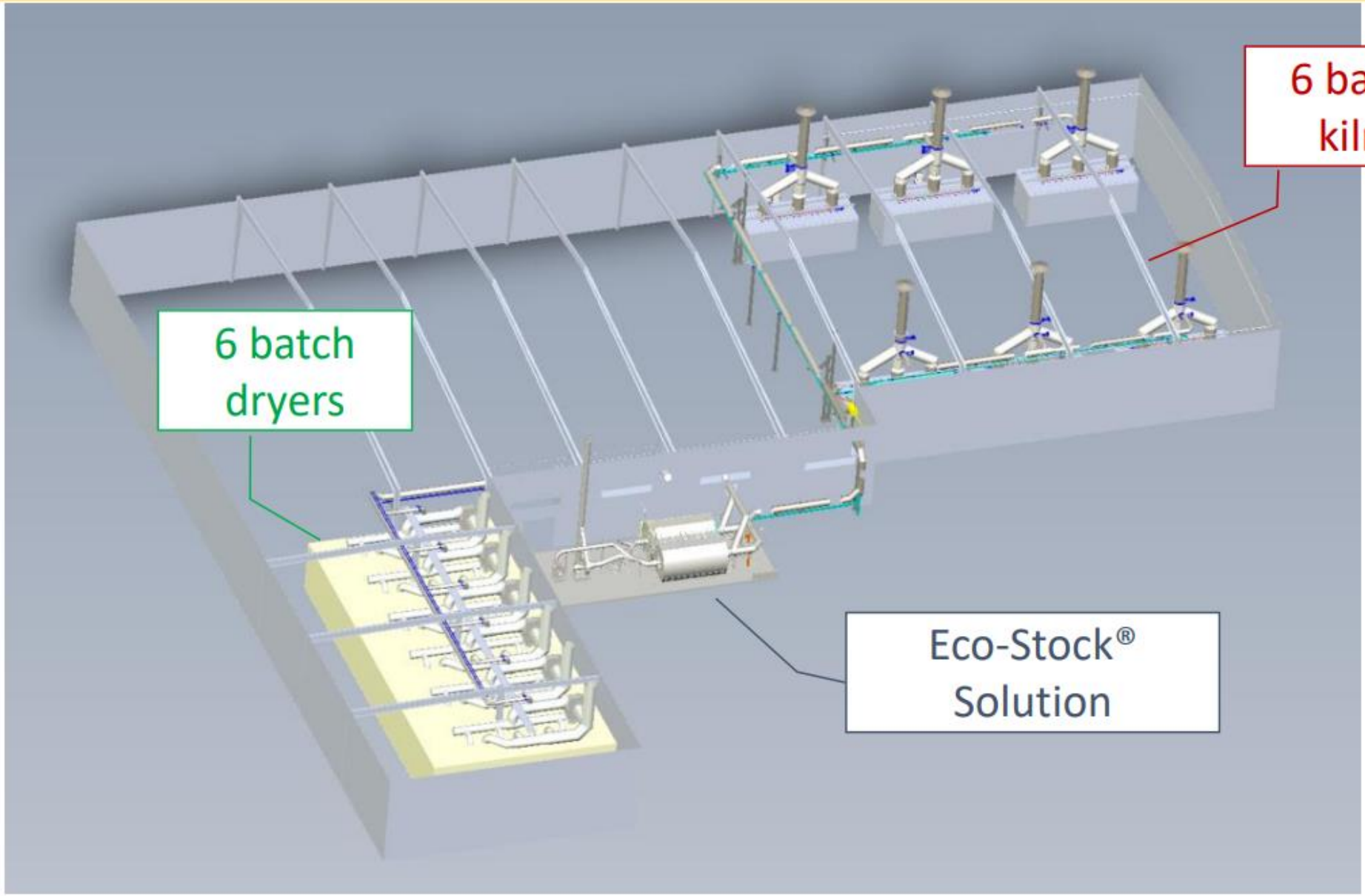
Waste heat recovery through thermal storage

- Recovery of high-temperature (550°C) waste heat from a kiln.
- Heat recovered in the plant's dryer.
- The Eco-Stock® captures and stores waste heat from the kiln so that it can be used in the dryer and pre-cooking chamber when desired.

Industrial plant in operation

- Ceramics
- 700 MWh saved / year
  equivalent to 10%
- 140 tonnes of CO_2 saved / year
- 5% productivity increase
- 1300 kWh storage capacity

Wienerberger case



Wienerberger case

Wienerberger

Exchanger/storage system from 6 kilns to 6 dryers

- Recovery of high-temperature (>500°C) waste heat from 6 kilns.
- Heat recycled to the plant's 6 dryers.
- The Eco-Stock® system captures and stores waste heat from baking ovens so that it can be used in the dryers when required.

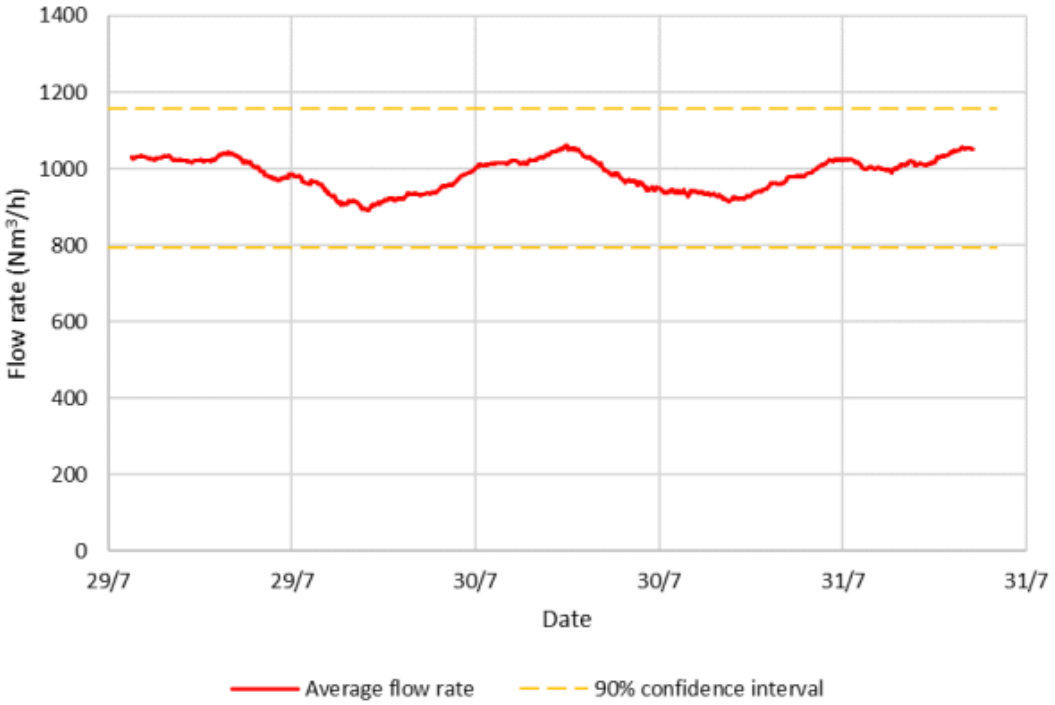
Industrial plant in operation

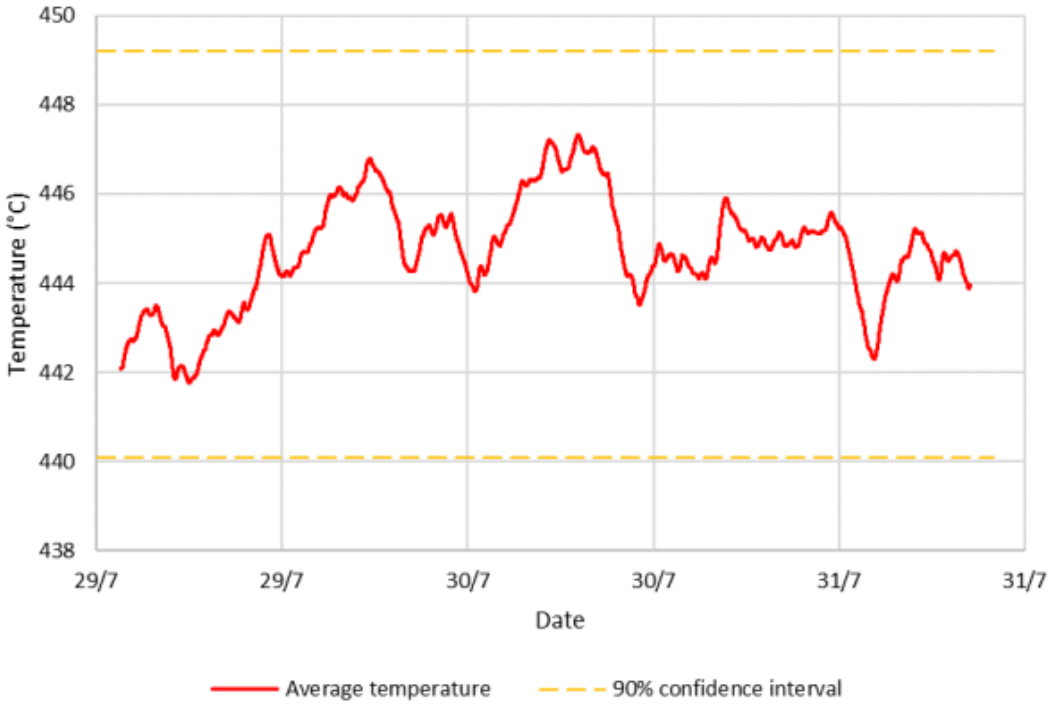
- Ceramics
- 2200 MWh saved / year equivalent to 10%
- 440 tonnes of CO_2 saved / year
- 5% productivity increase
- 4 500 kWh storage capacity

ECOSTOCK European project at V&B plant

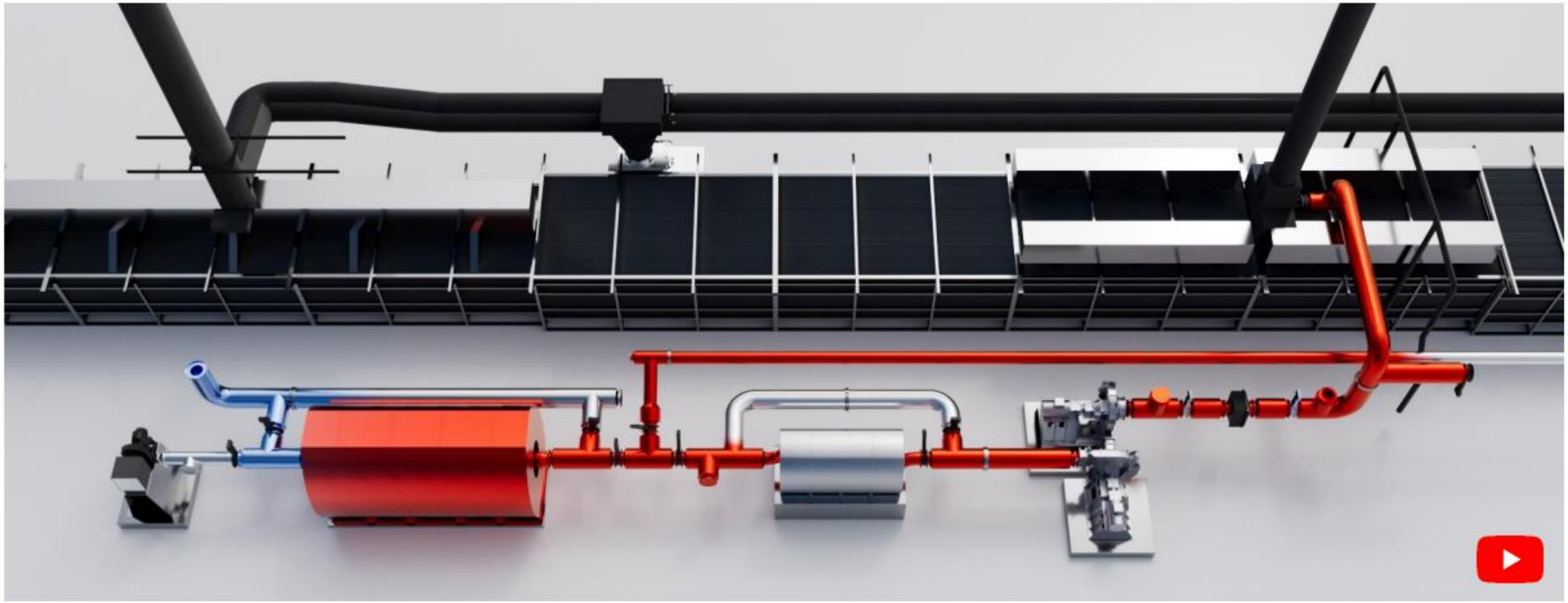
✓Continuous waste heat diposal: **180 kW @ 430°C**
✓Continuous need: **315 kW @ 450°C**

➔ **Insufficient waste heat**

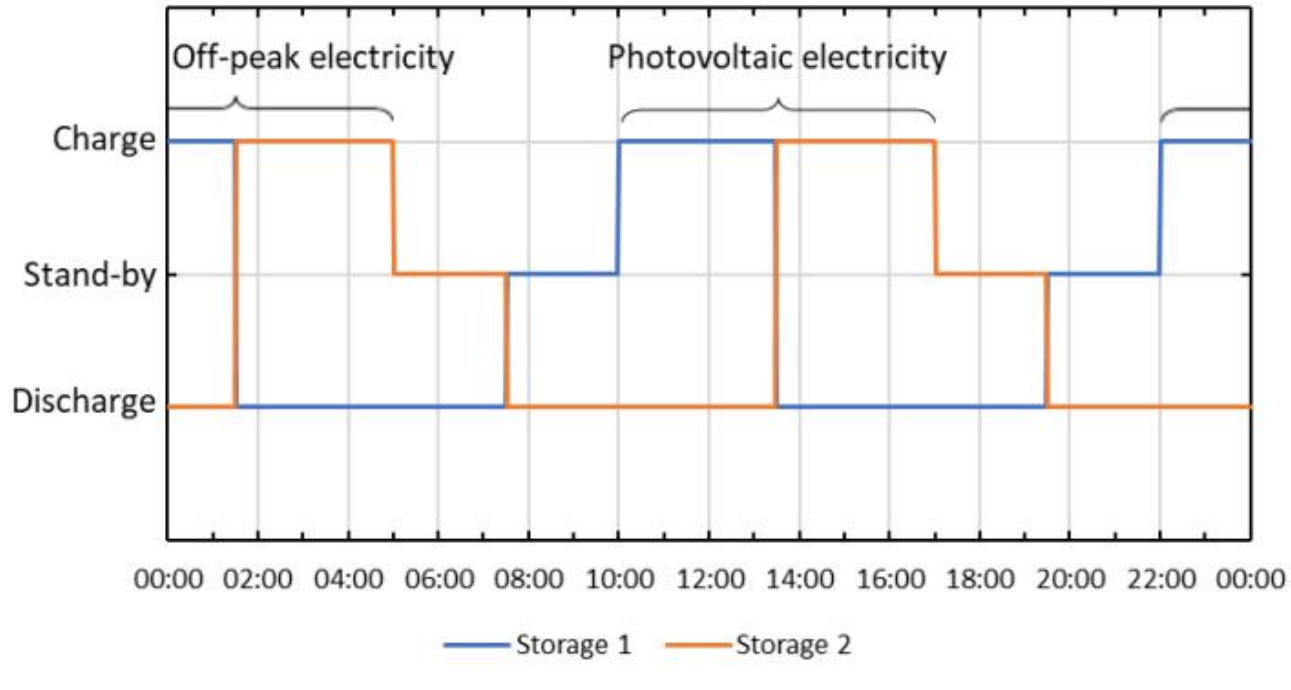




PTH + Eco-Stock® coupled solution

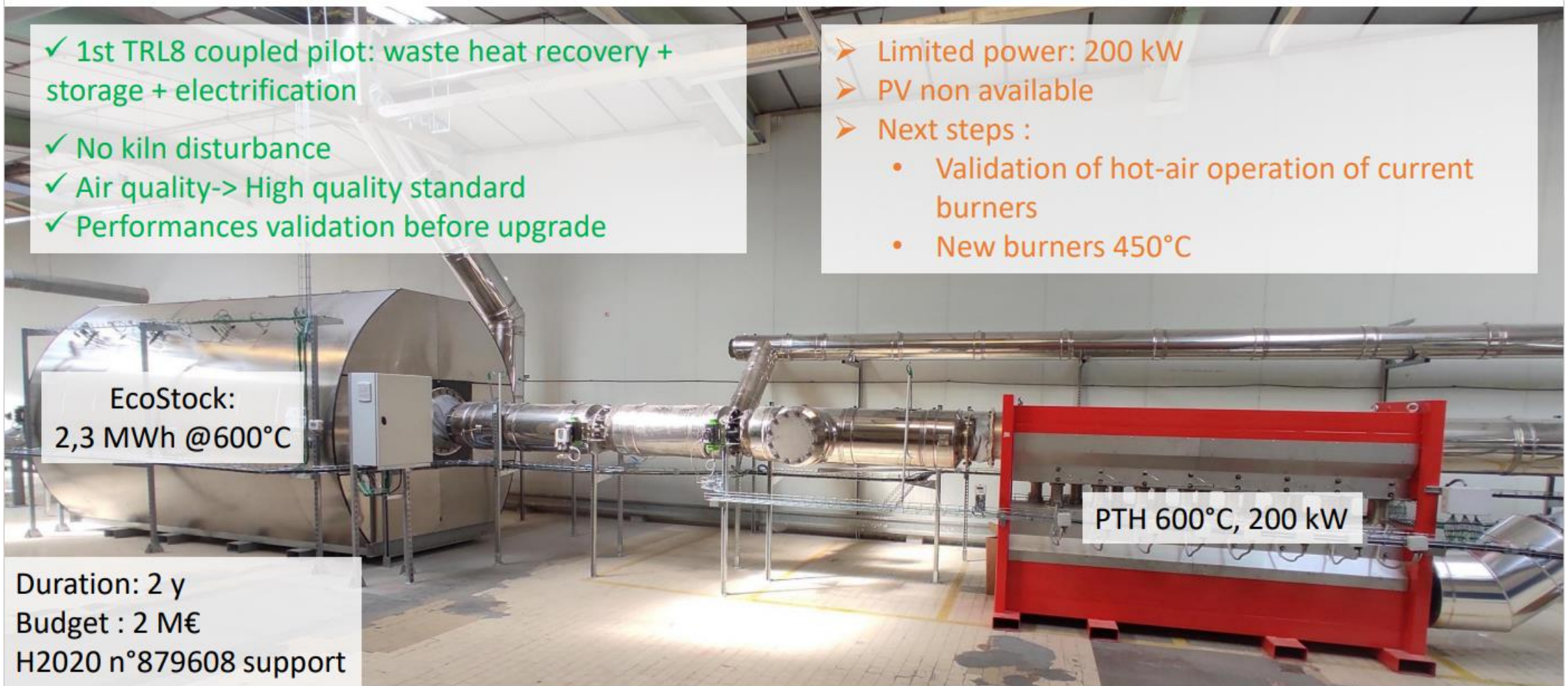


PTH + Eco-Stock® coupled solution



PTH + Eco-Stock® coupled solution

PTH + Eco-Stock® coupled solution



Drying pilot at ArcelorMittal

Pilot plant for drying agglomeration sludge

- Pilot project to avoid using fossil fuels to dry agglomeration sludge.
- Pilot scheme for eliminating the additional cost of transporting wet sludge (20%).
- This pilot plant can be used in a variety of industrial applications: recovery of waste heat from industrial furnaces, drying of materials from all types of industry, pre-heating of materials from all types of industry, production of hot water, production of electricity, recovery of heat from solar power plants.

Completed work

Metallurgy

360 kWh storage capacity at 600°C

ETC
ECO-TECH CERAM

The carbon free energy

Contact-us

guilhem.dejean@ecotechceram.com

5 Rue de Vidailhan 31130 Balma - France

https://www.ecotechceram.com/

25/03/2024

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WASTE HEAT & CIRCULAR THERMAL

Rossen Ivanov

Armstrong International SA
EMEA Managing Director

Jean-Michel Maisson

Armstrong International
Europe Direct Offices Manager

LUXEMBOURG MATERIALS & MANUFACTURING CLUSTER

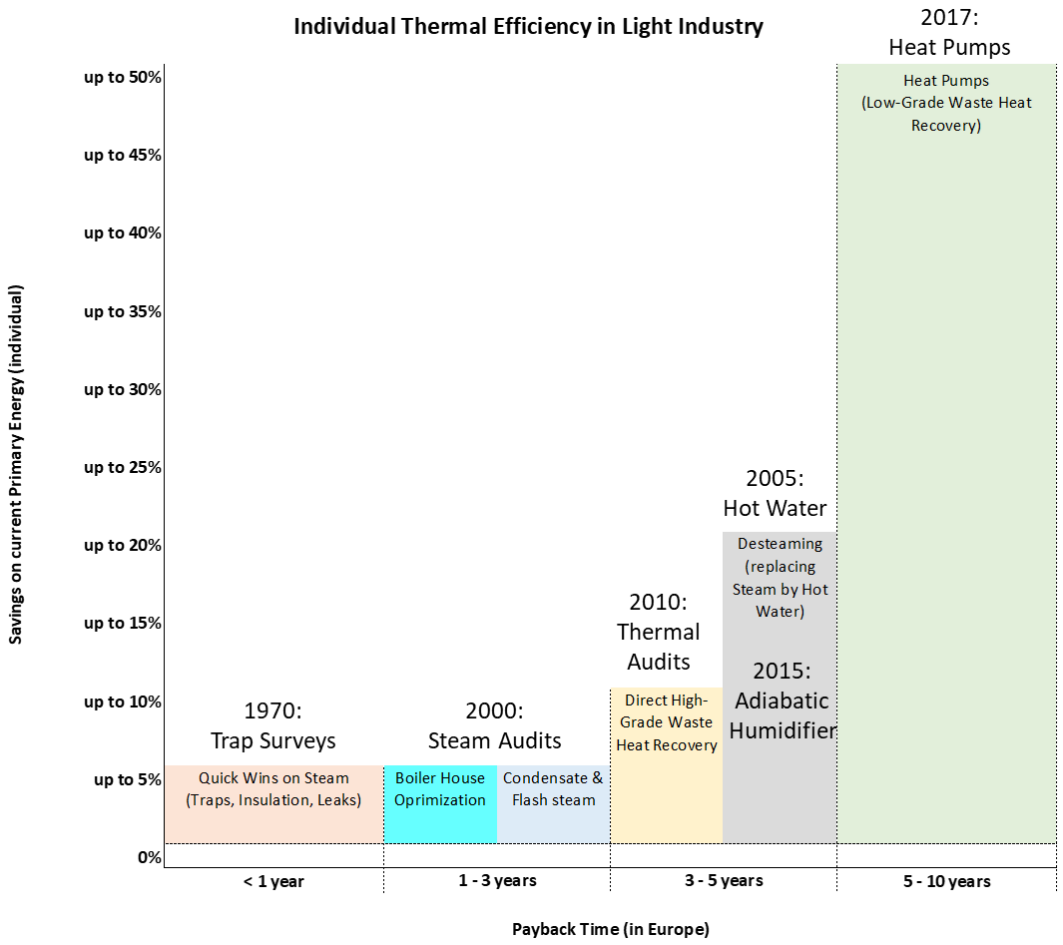
LUXEMBOURG CLEANTECH CLUSTER

The challenge Of Thermal Decarbonization

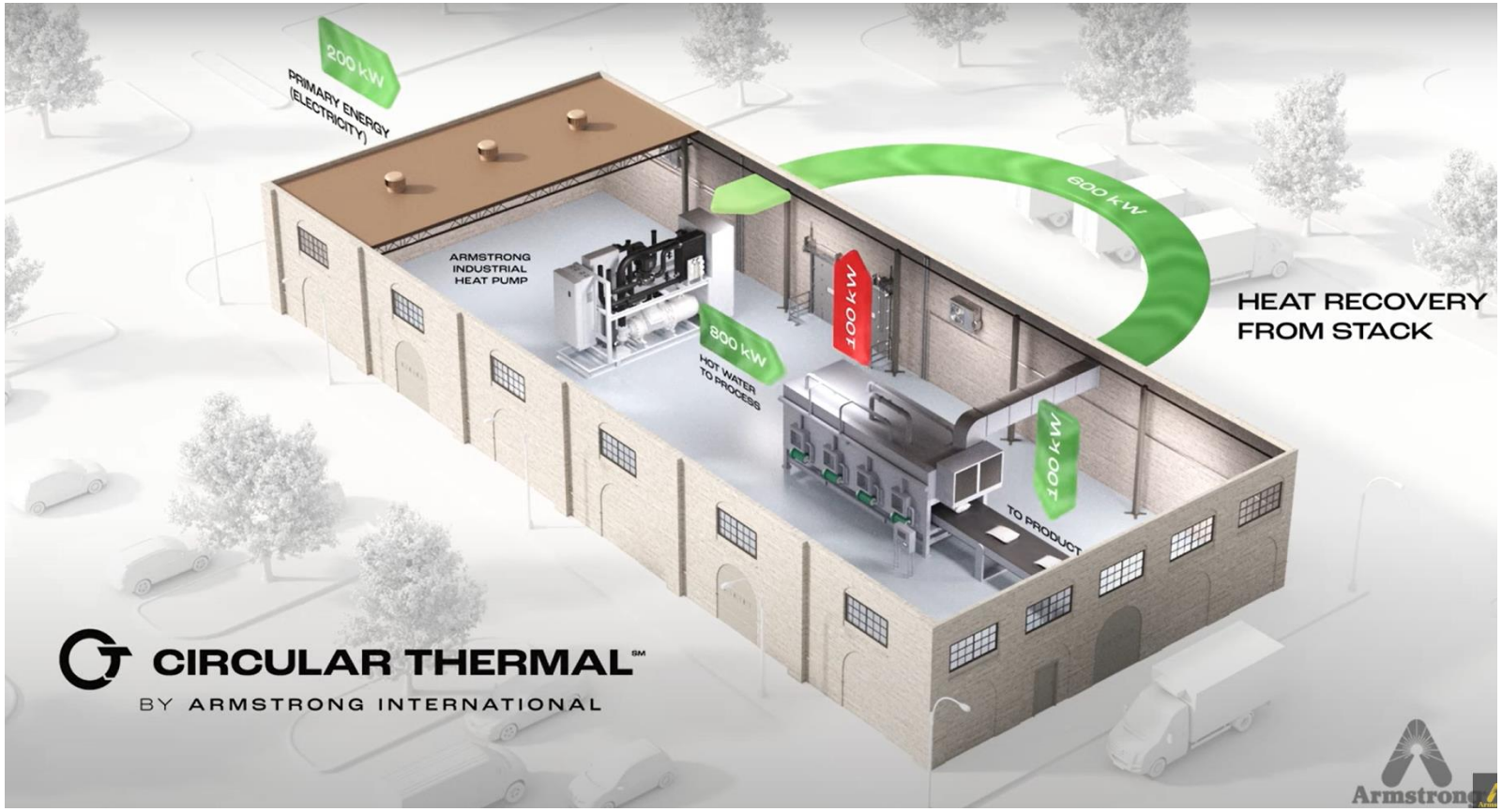
Thermal Efficiency & Decarbonization

Armstrong International Inc.

- Company founded in 1900 in Michigan (USA)
- Managed by the 5th generation of the family
- 15 factories worldwide, > 3000 employees;
- Customer segments: refining, petrochemicals, pharmaceuticals, food and beverages, breweries, etc.
- Supporting large groups in their decarbonisation objectives (Scope 1 and 2)
- Global partnership with Combitherm GmbH (Stuttgart, Germany)
- Heat pump manufacturer since 1972
- Development of industrial heat pump production worldwide
- USA (DoE funding in 2023), Belgium (Hauts-Sarts extension project), India (ongoing), China & Mexico



Circular Thermal[SM] System



"Job to be Done": Evaporate Water from Product using the lowest possible quantity of Renewable Energy (Decarbonization)

50% of Primary Energy in Product

80% reduction in Primary Energy

* the amount of energy remaining in the product will be strongly link to process

Circular Thermal^{SM} System – video

Link: https://www.youtube.com/watch?v=ScfDrhr9n_4&t=4s

Case study: electrified petfood dryer

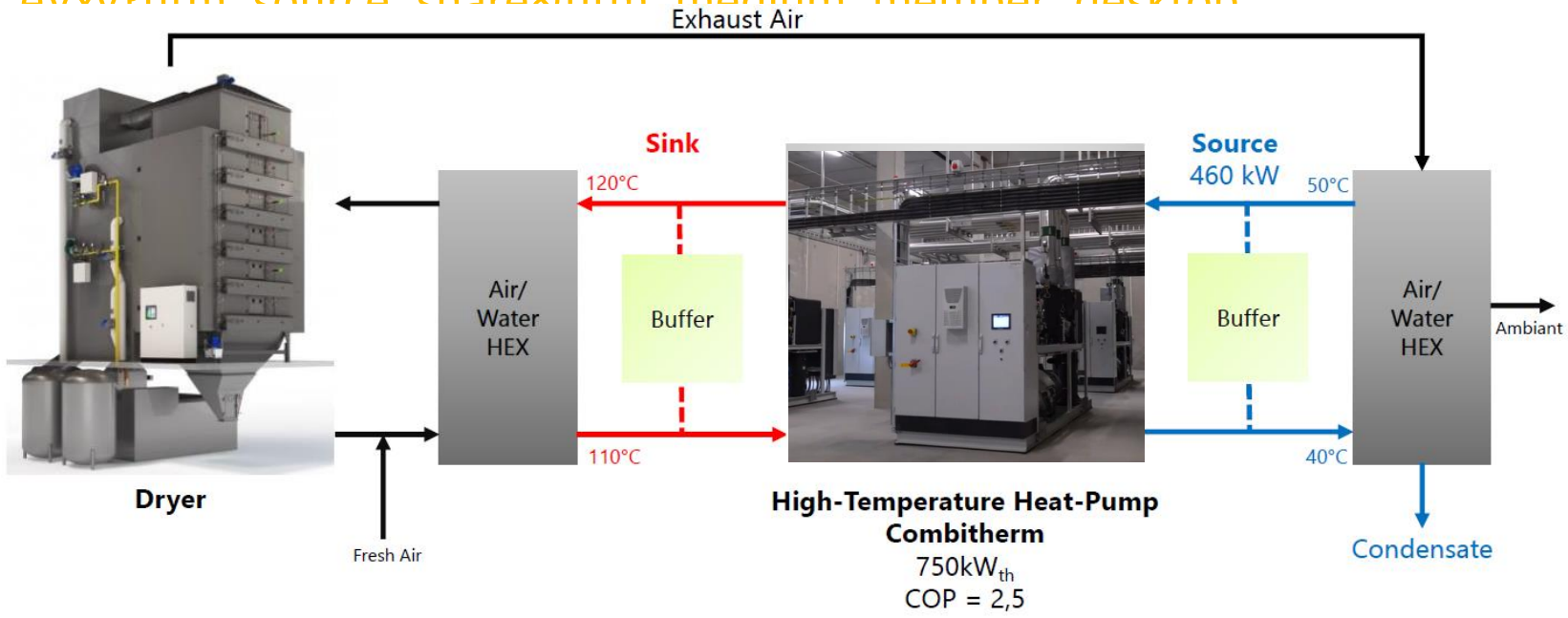
Geelen Counterflow, well-known dryer manufacturer taking advantage from #Combitherm high temperature heat pumps to fully electrify a petfood dryer – **reaching COP of 4** where a conservative 2,5 has been used for ROI calculation (process temperature optimized).

https://www.youtube.com/watch?v=1FIU_kJq81k

https://www.youtube.com/watch?v=keeBW6Y8OeQ

https://www.linkedin.com/posts/activity-6930873655438532608-Ia8B/?utm_source=linkedin_share&utm_medium=member_desktop_web

https://www.linkedin.com/posts/activity-7024279058653839360-eVxv?utm_source=share&utm_medium=member_desktop



Cargill Ewos Bergneset, Norway;
Drying extruded aquafeed, 3.3 MWth
Operational since April 2022.

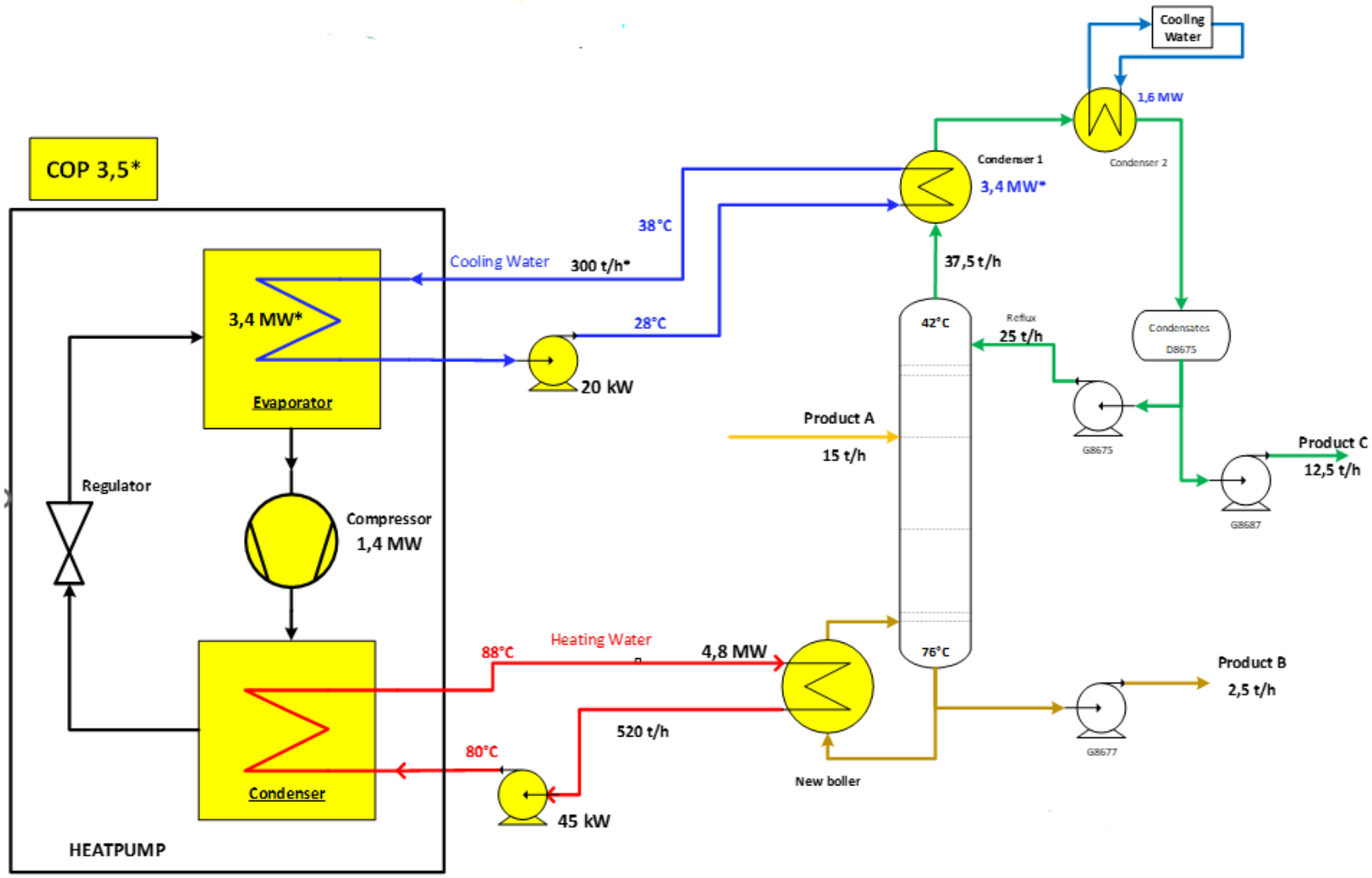
Royal Canin Korea - https://www.linkedin.com/feed/update/urn:li:activity:6967394893937668096/

Case study: electrified petfood dryer

Case study: electrified petfood dryer

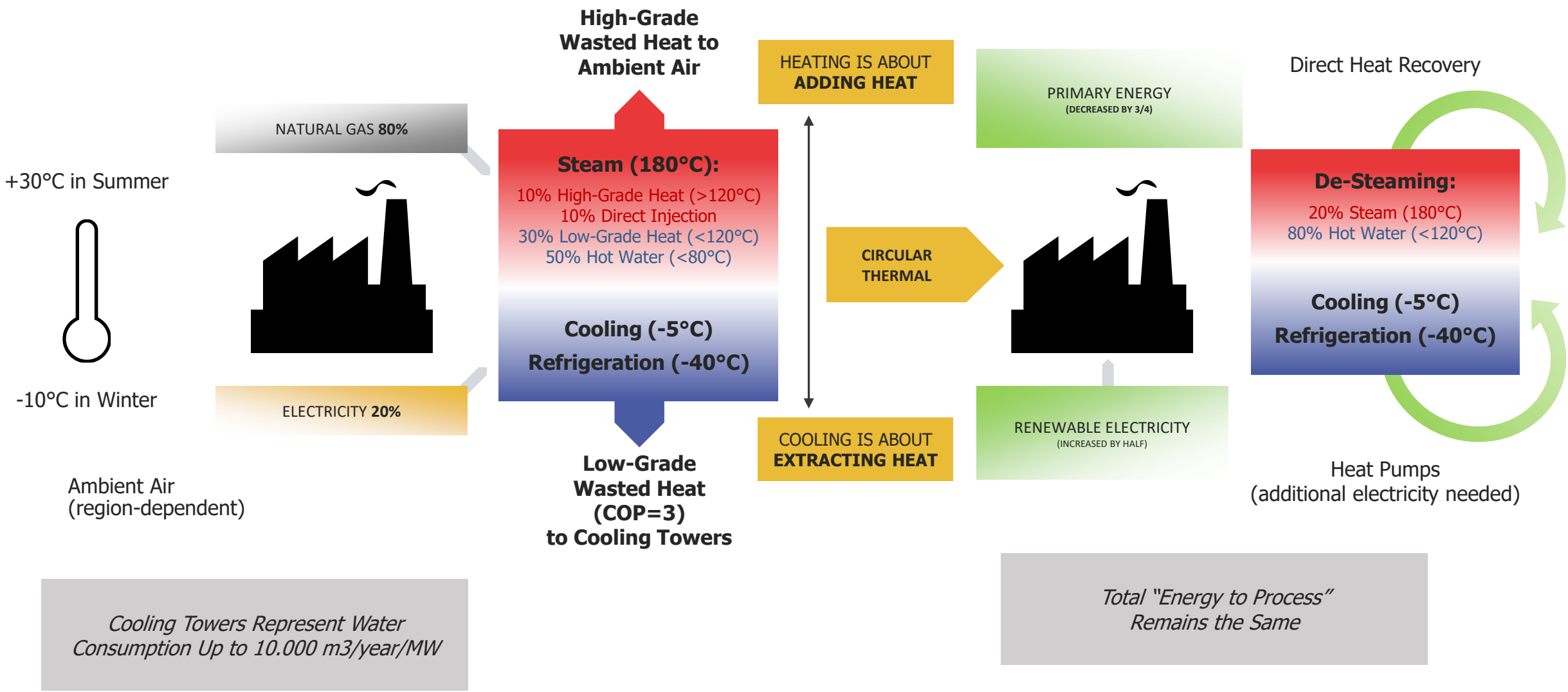
Link: https://www.youtube.com/watch?v=keeBW6Y8OeQ&t=19s

Application highlight: Distillation column



- Heat recovery from distillation column
- Heat sink is the heating of the bottom of the column;
- Heat source is the vapor condensing;
- Close water loop within the heat pump and the column, both condenser and evaporator.

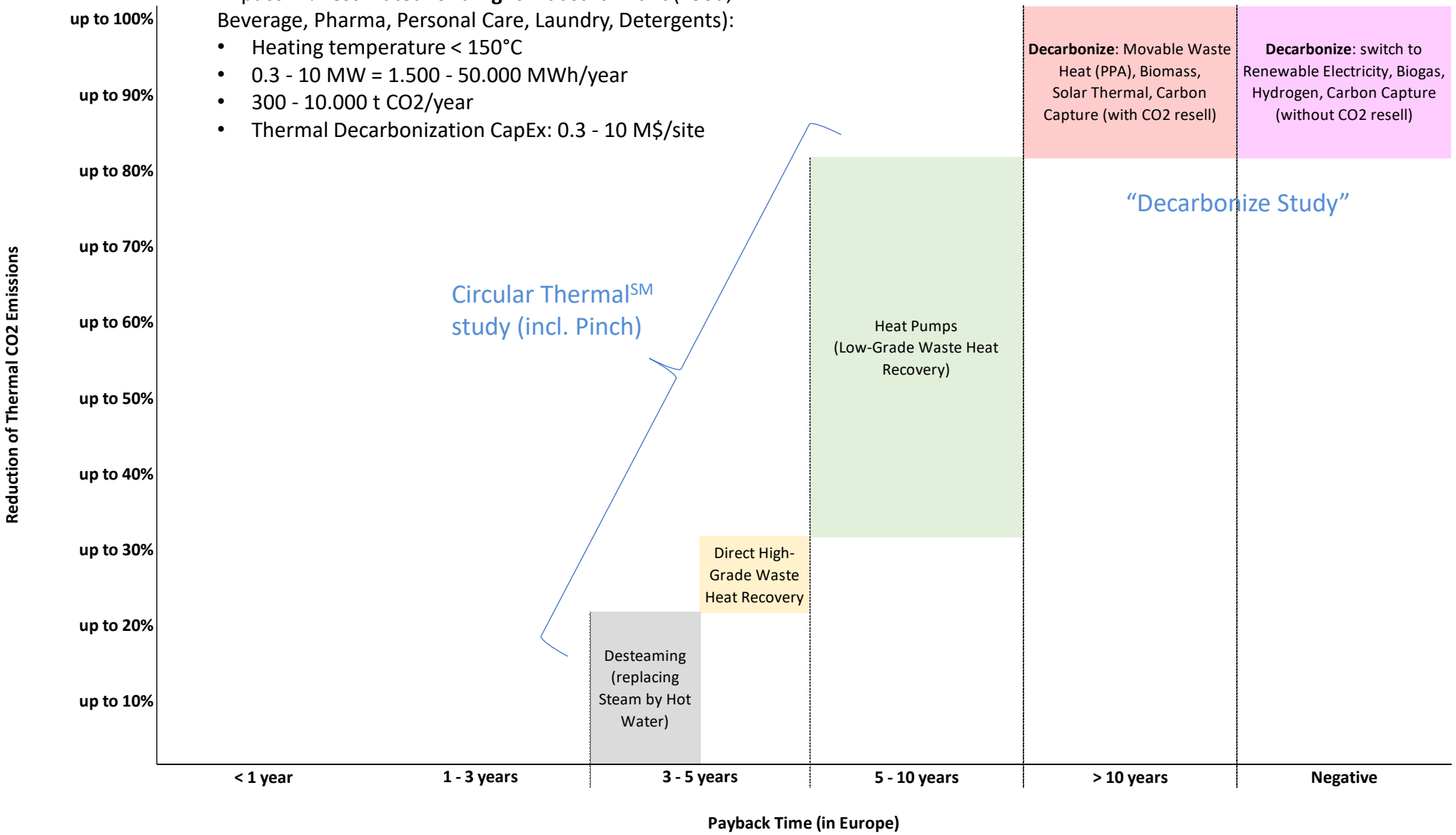
CIRCULAR THERMAL BY ARMSTRONG



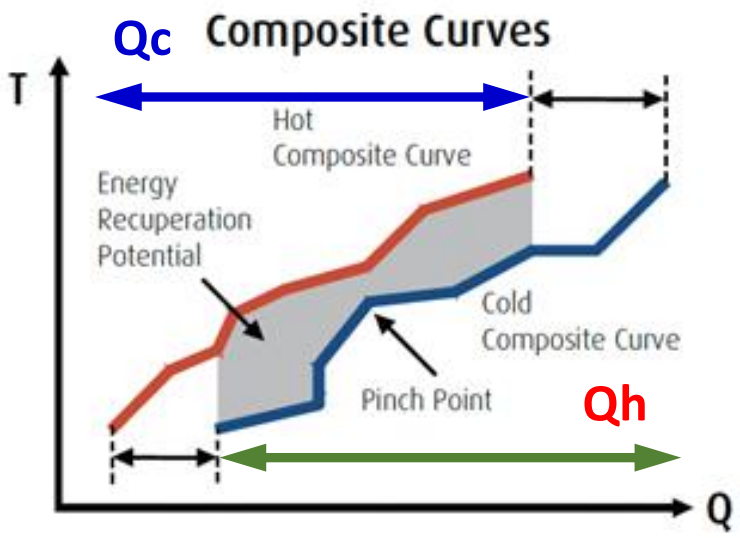
Typical Thermal Decarbonization Journey in Light Industry

Impact in % estimated for a **Light** Industrial Plant (Food, Beverage, Pharma, Personal Care, Laundry, Detergents):

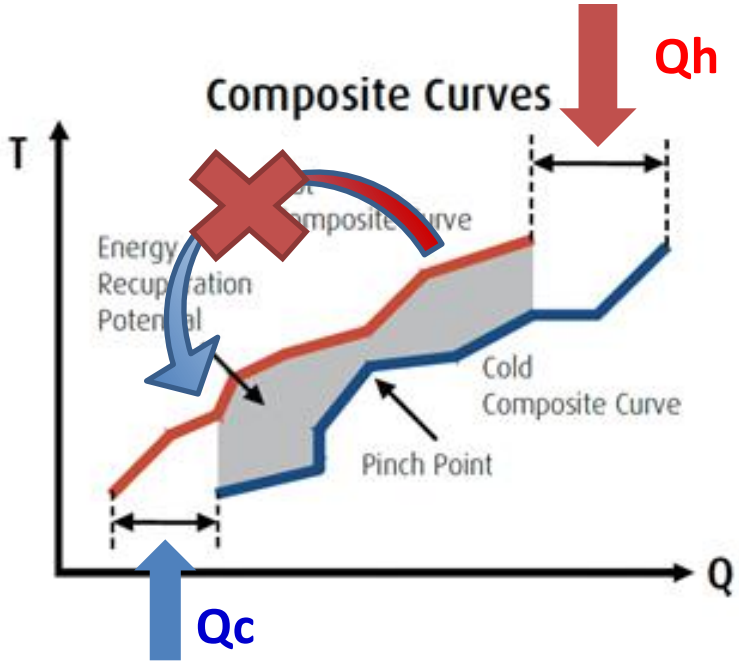
- Heating temperature < 150°C
- 0.3 - 10 MW = 1.500 - 50.000 MWh/year
- 300 - 10.000 t CO2/year
- Thermal Decarbonization CapEx: 0.3 - 10 M$/site



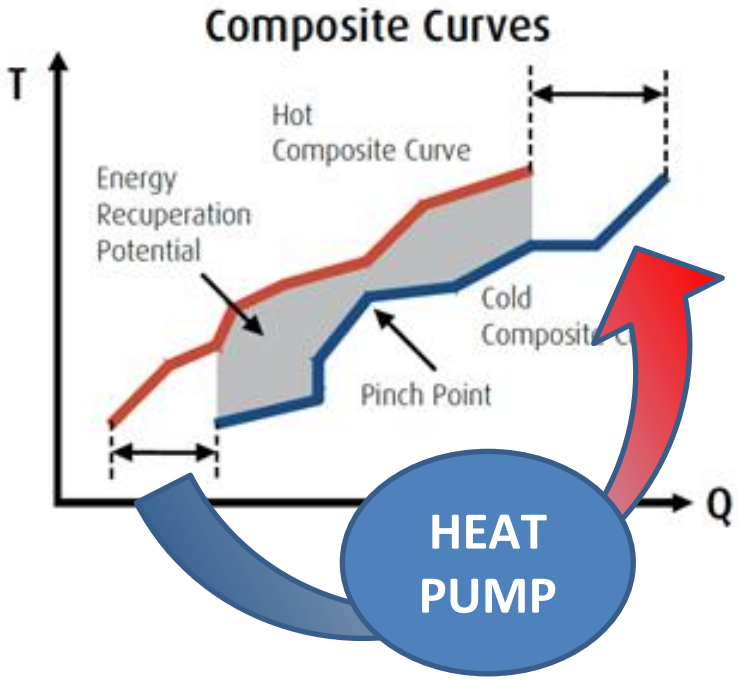
Pinch Methodology



No Heat Recovery



100% Heat Recovery

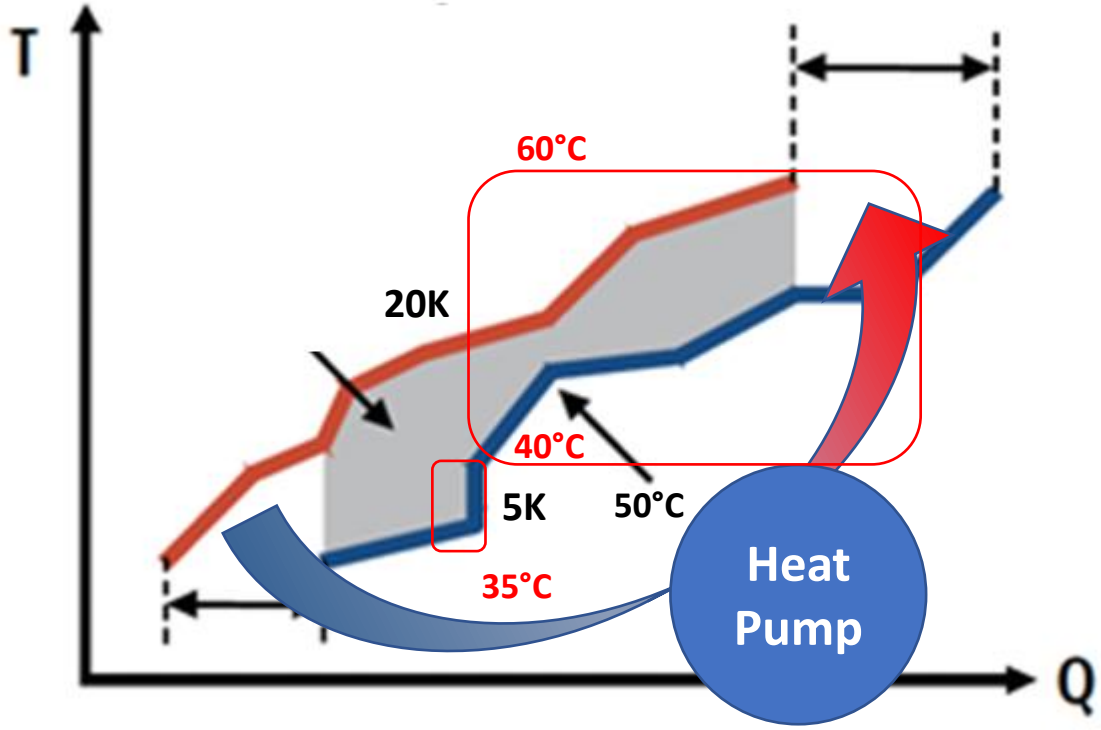


Heat pump can be used to upgrade low grade heat above the Pinch point to further reduce heat demand (Qh)

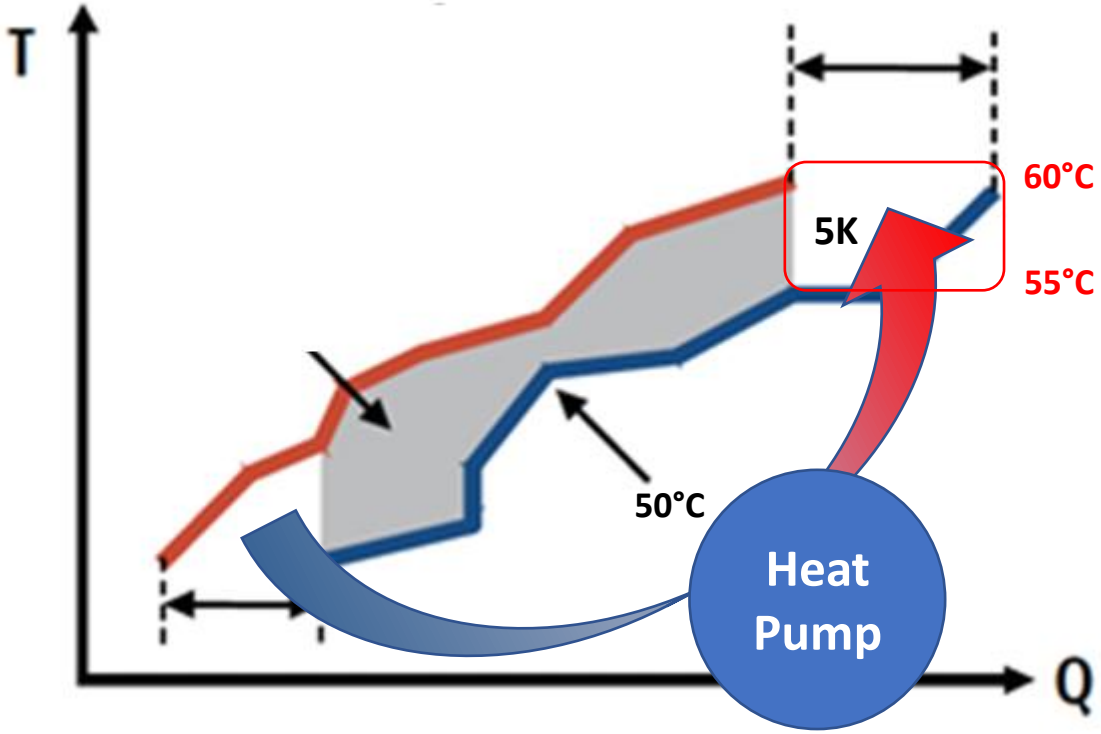
- **Qc**: Energy to be removed from the system through cooling
- **Qh**: Energy to be added to the system through heating

Source: "Pinch Analysis: For the Efficient Use of Energy, Water & Hydrogen", CanmetENERGY, Canada (2003)

Pinch Methodology & Heat Pumps integration



Heat Pump having **20K** temperature difference in heat sinks loop (60°C to 40°C) and low-temperature cooling (40°C to 35°C) of **« open-type compressor »**



Heat Pump having **5K** temperature difference in heat sinks loop (60°C to 55°C) and no external cooling of **« semi-hermetic compressor »**

COP – Coefficient Of Performance

Heating COP = 2.94

$$\frac{\text{Condenser Heating capacity}}{\text{Electrical power to Compressor}}$$

€€€

+

€€

Combined COP = 5.0

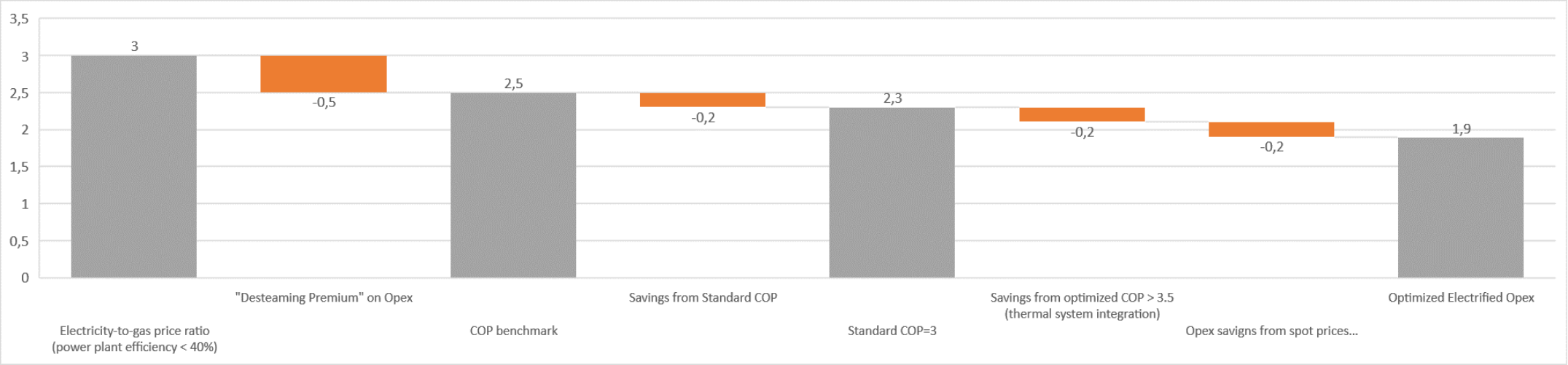
$$\frac{\text{Condenser + Evaporator capacity}}{\text{Electrical power to Compressor}}$$

€

COP Rules of Thumb

- To generate a Payback, COP > Electricity-to-Gas price ratio
- Temperature increase of 50°C, results typically into COP > 3
- Temperature increase of 100°C, results typically into COP > 1.5
- Every 10°C of temperature increase degrade the COP by 0.3
- COP of 1233zdE heat pumps is higher than the ones using 1234zeE / 515B

Price of Natural Gas (€/MWh):	50 €	Heat Pump Thermal Output (in MW):	1,00
Price of Electricity (€/MWh):	150 €	Running Hours per year:	8.000
Electricity-to-Gas Ratio (Spark Spread):	3,00	Heat Pump Thermal Output (in MWh/year):	8.000
CO2 Price (in €/ton):	80 €	Current Steam System Efficiency:	80%
		Avoided CO2 Emissions (in tons/year):	1.600



ARMSTRONG+COMBITHERM

Industrial (200kW - 2000 kW) High-Temperature Heat Pumps (HTHPs) - Working Fluid Characteristics for Screw Compressors

Working Fluid	GWP[1]	Safety Class[2]	Circuit Pressure[3]	Heat Source		Heat Sink		Temperature Ranges (in °C)																						Opex[5]	Capex[6]
				min. t°	max. t°	min. t°	max. t°	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	###	###	###	###	###	###	###	###	###	###		
R134a	1430	A1	< 25 barg			20	65																							Standard	Lower
				-10	40																										
R513A	631	A1	< 25 barg			20	65																							Standard	Lower
				-10	40																										
R515B	293	A1	< 25 barg			20	90																							Standard	Lower
				-10	40																										
R450A	605	A1	< 25 barg			20	65																							Standard	Lower
				-10	40																										
R1234yf	4	A2L	< 25 barg			20	65																							Standard	Lower
				-10	40																										
R1234ze(E)[7]	7	A2L	< 25 barg			20	90																							Standard	Lower
				-10	50																										
R1233zd(E)[7]	5	A1	< 25 barg			40	120																							Lower	Standard
				35	90																										
R1336mzz(Z)[7]	2	A1	< 25 barg			60	140																							Higher	Standard
				50	100																										
R717 (Ammonia)	0	B2L	> 50 barg			0	90																							Higher	Higher
				-40	20																										
R744 (CO_2)	1	A1	> 50 barg			0	90 [4]																							Higher	Higher
				-40	60																										
R290 (Propane)	3	A3	25 - 50 barg			30	80																							Standard	Higher
				-30	40																										
R600a (isobutane)	3	A3	25 - 50 barg			30	100																							Standard	Higher
				5	50																										
R601a (isopentane)	5	A3	25 - 50 barg			60	160																							Standard	Higher
				50	100																										
R718 (Water)[8]	0	A1	-0,95 - 15 barg			50	180																							R&D	R&D
				30	120																										
								-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	###	###	###	###	###	###	###	###	###	###		
								Temperature Ranges (in °C)																							

1 - AR4: according to IPCC IV - time horizon 100 years

2 - as per ISO 817:2014

3 - impacting both Safety and Reliability - EN 378:2017 - heat pumps safety

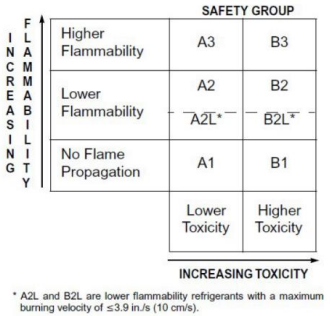
4 - maximum Heat Sink inlet temperature = 45°C

5 - incl. Power and Maintenance / Operation / Repair (MOR)

6 - incl. related Safety costs

7 - TFA degradation of R1234ze(E) and R1233zd(E) < 2%; R1336mzz(Z) < 4%. About 100 liters of working fluid per compressor circuit.

8 - Compressor technology to be confirmed



* A2L and B2L are lower flammability refrigerants with a maximum burning velocity of ≤3.9 in./s (10 cm/s).

Armstrong®

High-Temperature Heat Pump with Steam Evapor

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FUNDING OPPORTUNITIES

Pataki Gabor

Advisor - National Funding,
Luxinnovation

LUXEMBOURG MATERIALS & MANUFACTURING CLUSTER

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State aids for Waste Heat Recovery investments

From the ministry of the Economy
to Luxembourg industries

House of BioHealth

March 26th, 2024

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State aids for Waste Heat Recovery investments

- From the ministry of the Economy to Luxembourg companies

1. Overview of State aids for the protection of the environment
2. Case study on waste heat recovery
3. FIT 4 Sustainability – external expertise to initiate environmental projects
4. How to apply ?

1. Overview

- Of State aids for the protection of the environment

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Law of 15 December 2017

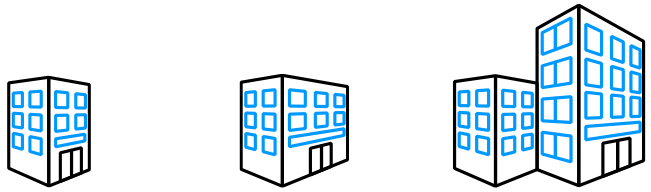
Aid scheme for environmental protection

- 10 different aids for investments enabling:
- **going beyond EU standards**/increasing the level of environmental protection in the absence of EU standards (art. 4)
  - early adaptation to future EU standards (art. 5)
- **energy efficiency** (art. 6)
  - energy efficiency of buildings (art. 7)*;
  - high-efficiency cogeneration (art. 8);
- **energy from renewable sources** (art. 9);
  - remediation of contaminated sites (art. 10);
  - efficient heating and cooling (urban) networks (art. 11);
  - recycling and reuse of waste (Art. 12);
  - energy infrastructure (art. 13);
- **environmental studies** (art. 14)

** Article 7 will come into force once a grand-ducal regulation on the practical implementation of the fund for the promotion of energy efficiency in buildings, necessary for the co-financing of the submitted projects, has been passed.*

4 main aid schemes

- Maximum State aid rate on admissible costs

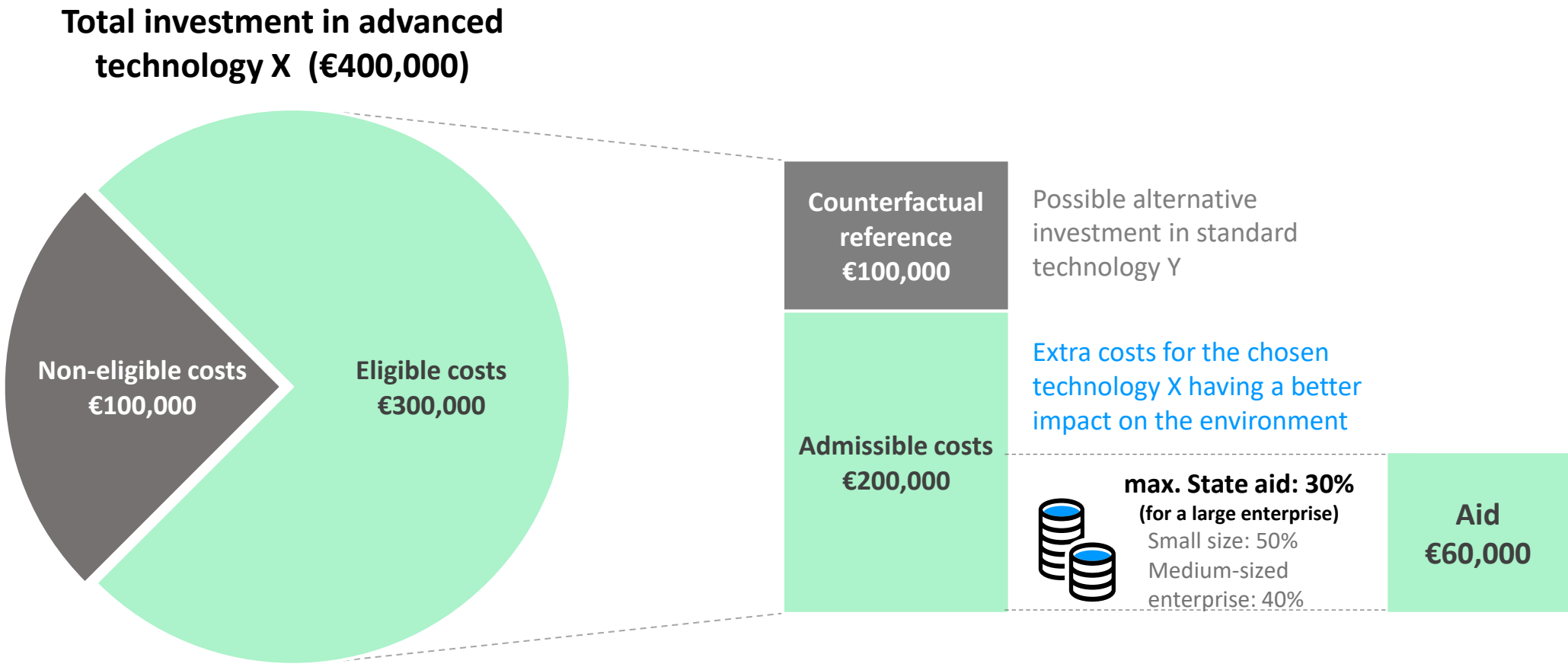


	SMALL ENTREPRISE	MEDIUM ENTREPRISE	LARGE ENTREPRISE
Fit 4 Sustainability and environmental studies *(Art.14)*	70%	60%	50%
Going beyond standard *(Art.4)*	60%	50%	40%
Energy efficiency *(Art.6)*	**50%**	**40%**	**30%**
Renewable energy production *(Art.9)*	65%	55%	45%

- The aid rate varies according to **the size of the company (small, medium or large)**, but also according to the **return on investment** of the supported initiative (demonstration of the incentive effect of the aid).
- The average **effective rate is around 20%** of eligible costs.

Only extra costs for the environment are aided

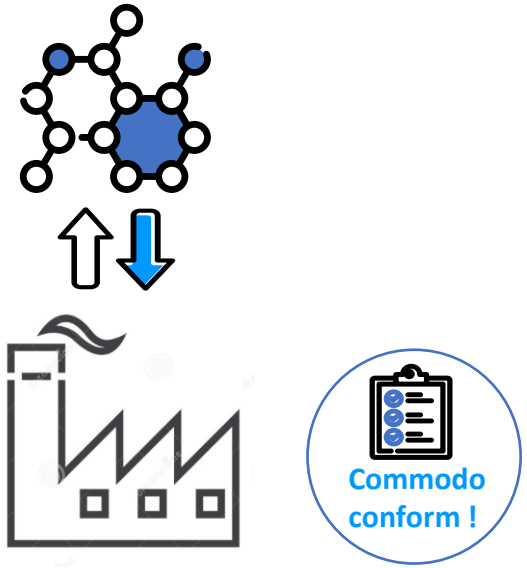
- Counterfactual reference – illustration for an investment in energy efficiency (art.6)

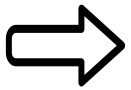


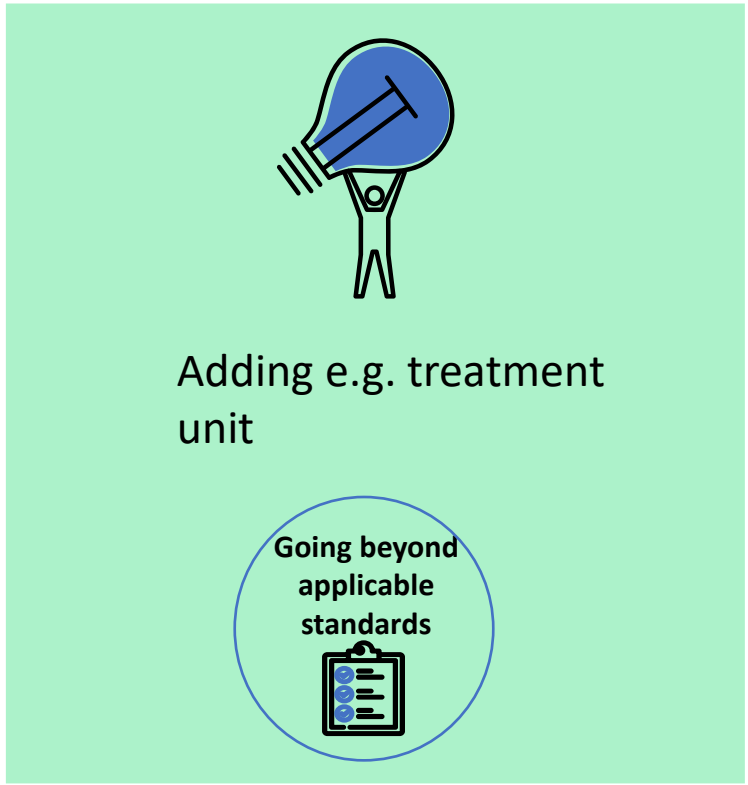
Ineligible costs are costs not directly related to increasing the level of environmental protection: buildings and constructions where the new equipment will be located, related safety equipment, any side cost imposed by regulation, …

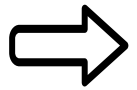
Additionality principle

No counterfactual reference - e.g. investment going beyond standards (art.4)







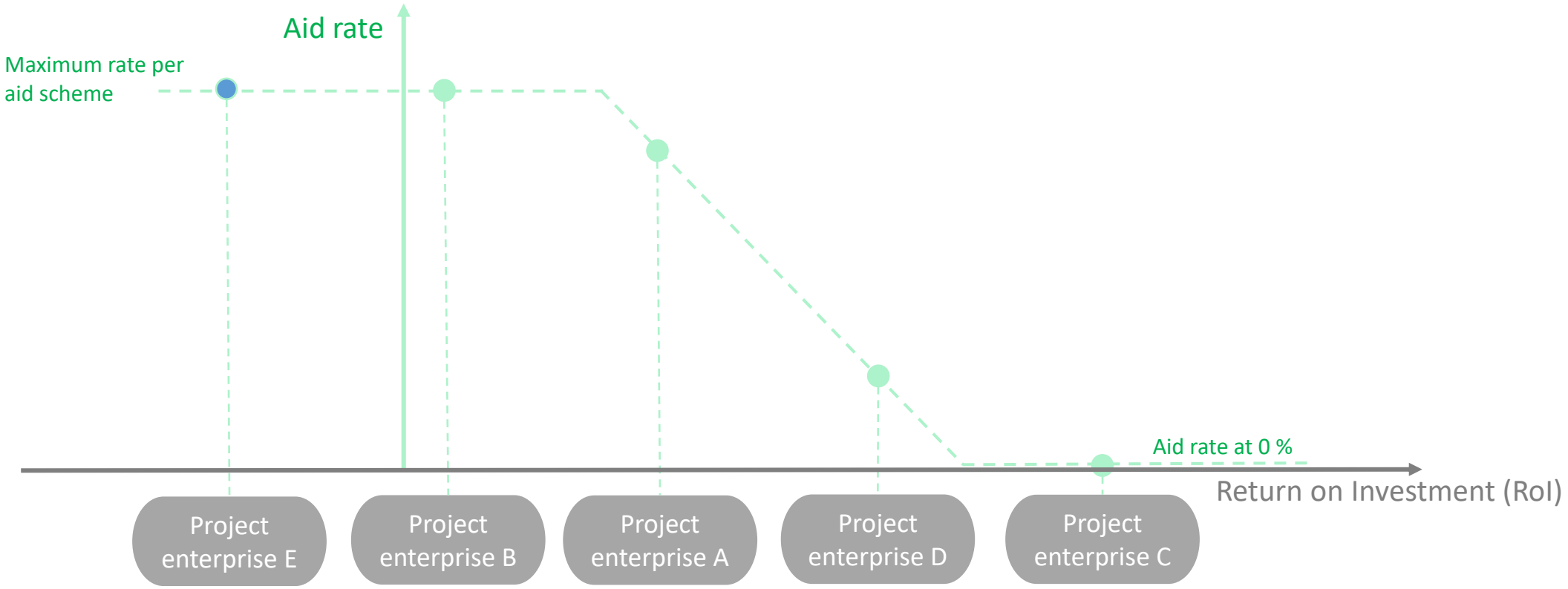


Eligible costs of the **investment** = **Admissible** costs

Max. aid rate 40% - 60%
(depending on the size of the company: SE, ME, LE)

Aid rate is adapted to the Return on Investment

- In order to preserve the incentive effect of the aid



2. Case study

- Waste heat recovery

Case study 4 : waste heat recovery

Business D
Activity: synthetic material
Size: large company

• Energy efficiency (Art. 6)

Current situation: process heat provided by **two gas boilers**, while other parts of the process produce **waste heat**.

Project: replace a gas boiler by **two heat pumps** water-water combined with the recovery of waste heat (45°C waste heat converted to 85°C)

ENVIRONNMENTAL IMPACT

Eq. 13,400 MWh/year GAS SAVING
+ 4,500 MWh/year additional ELECTRICITY
Eq. 1,650 T CO_2 net savings

ECONOMIC IMPACT

Annual net savings on:
COST OF ENERGY
≈ 120 000 €/year

COSTS

TOTAL PROJECT COST
€800,000
Heat pumps and periphery

ELIGIBLE COSTS
€800,000

COUNTERFACTUAL VALUE
€400,000
New gas boiler with identical thermal power

ADMISSIBLE COSTS
€400,000

AID CALCULATION

MAXIMUM AID RATE
30%
Large company, aid for energy efficiency measure, Art.6

AID RATE APPLIED
24%
Adjusted by the ministry to the RoI profile (1/2 technical life), energy balance (COP > 2,5), proportionality with similar aids and projects

AMOUNT OF AID GRANTED
€96,000

i.e. an effective aid rate of:
24% of the admissible costs
12% of the total project cost

3. FIT 4 Sustainability

- External expertise to kick-start environmental projects and subsidies

FIT4 SUSTAINABILITY

- Key benefits
  - Businesses that are looking to boost their competitiveness through sustainability can benefit from this programme.
  - In-depth assessment of your company's environmental impact
  - Personalised recommendations with cost estimates
  - Advice from experienced, neutral experts approved by Luxinnovation
  - Financial support from the Ministry of the Economy
  - Guidance to aid measures for the later investments

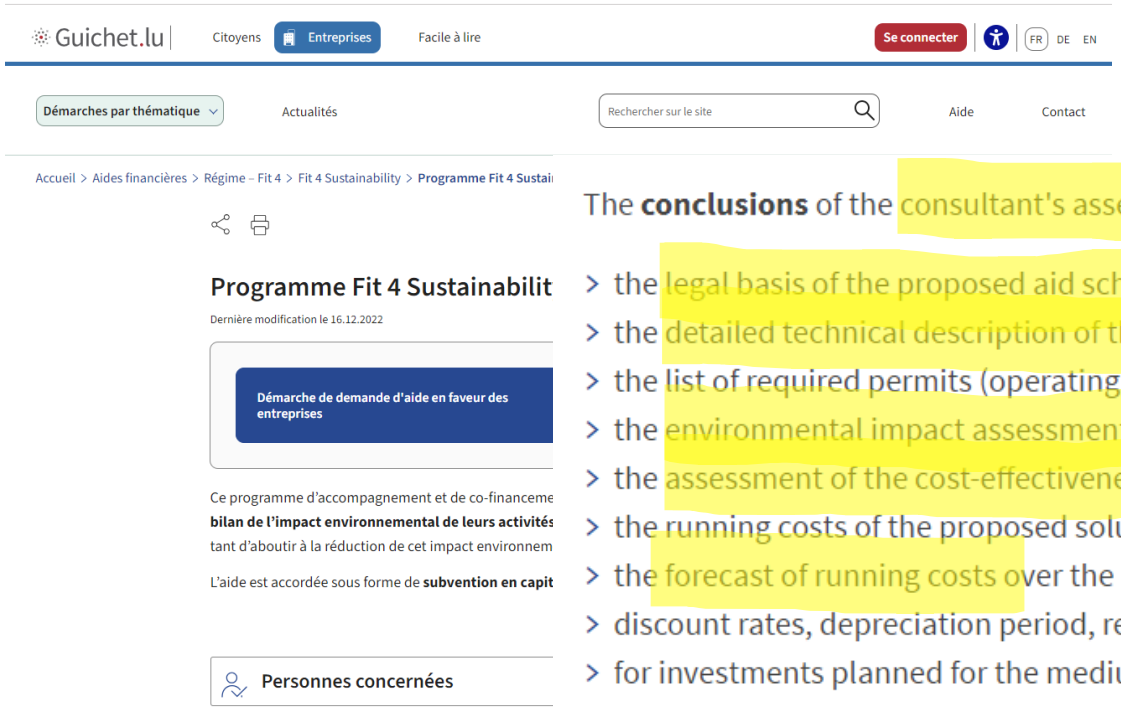
- Key figures

FUNDING RATE	SMALL ENTERPRISE	MEDIUM ENTERPRISE	LARGE ENTERPRISE
F4Sustainability *(Art.14)*	70%	60%	50%

  - 1 environmental study to assess the impact of your business on the environnement and the expected effect of identified measures to reduce this impact (6 months maximum)
  - 1 action & investment plan with technically and economically feasible recommendations
  - Up to 70% of co-funding (small companies), 60% (medium-sized) or 50% (large)

“Fit 4 next application” for environmental subsidy

- Expertise conclusions will feed the next application for investment aid



The **conclusions** of the consultant's assessment must mention:

- the legal basis of the proposed aid scheme;
- the detailed technical description of the proposed solution(s);
- the list of required permits (operating permit, building permit, etc.);
- the environmental impact assessment of the proposed solution;
- the assessment of the cost-effectiveness of the solution over its expected lifetime;
- the running costs of the proposed solution (fuel, annual electricity consumption, annual operating costs, etc.);
- the forecast of running costs over the expected lifetime;
- discount rates, depreciation period, residual values of investments;
- for investments planned for the medium or long term: the costs of a counterfactual investment and the running costs (investmer based on a standard technology that would have been made in the absence of state aid).

Mandatory energy audits for large companies are not supported during the Fit 4 Sustainability diagnostic phase.

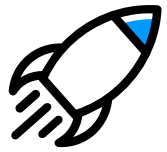
4. How to apply?

- Practical information

How to apply for environmental investment aid ?

What should the company do?

- Estimate its **costs** and **describe the chosen investment** in relation to a **counterfactual reference**
- Explain the **positive environmental impact** of the investment
- Assess the expected **return on investment** (savings, maintenance etc.)
- Apply for the required **authorisations**
- Submit its request for subsidy to the ministry via MyGuichet.lu



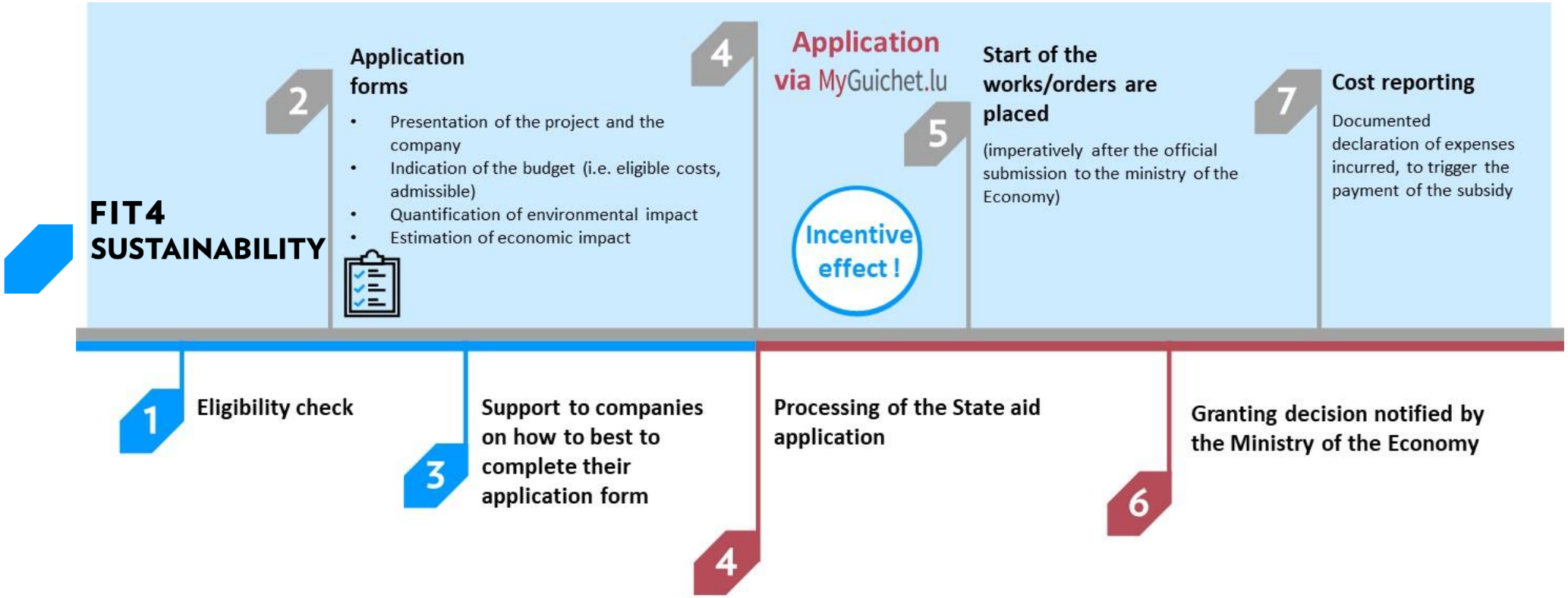
How can Luxinnovation help?

- **Access to experts** through the **Fit 4 Sustainability** program
- **Eligibility check**
- **Methodological support**
  - **"Deciphering"** of regulations / laws / exceptions
  - **Assistance** in the use of the application forms

FIT4 SUSTAINABILITY

State aid application to the ministry of the Economy

- Timeline



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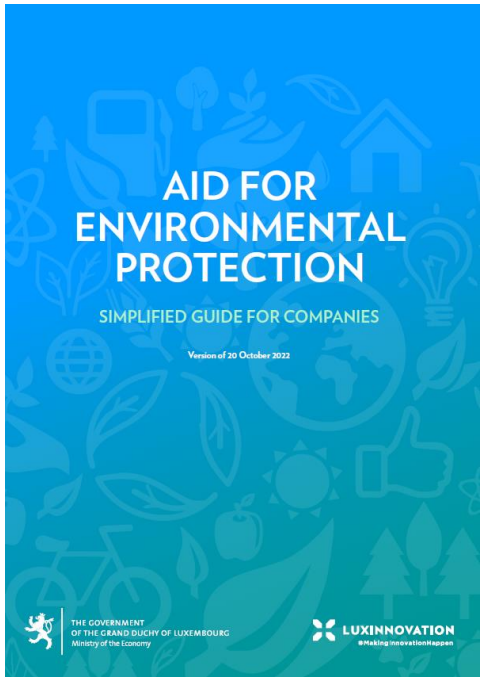
Ministère de l'Économie

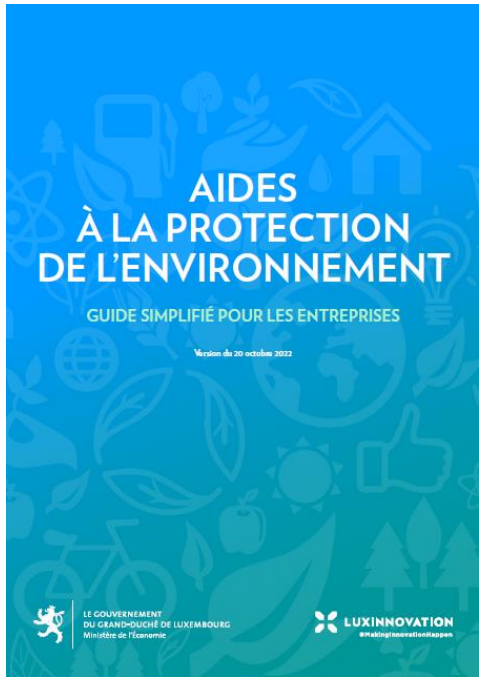
Useful links

- Investment aids for the protection of the environment on Guichet.lu
- Sustainability Innovation Hub
- FIT 4 Sustainability on Guichet.lu
- Submission of the application via MyGuichet.lu

Simplified guide

- to environmental subsidies available here in EN/FR/DE





Merci!

Gabor Pataki

National Funding

LUXINNOVATION GIE
5, avenue des Hauts-Fourneaux
L-4362 Esch-sur-Alzette

aides@luxinnovation.lu

www.luxinnovation.lu

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APPENDICES

Is my project eligible? Is my company eligible?

Main evaluation criteria

Incentive effect: All applications for subsidy must be submitted before the start of the work / the launch of orders (binding act)

Environmental protection effect & innovation

- New installation / component
- Goes beyond the standard
- Saving energy, resources, CO_2 emissions

Co-financing capacity

Return on Investment

Ineligible companies

Undertakings in difficulty

For all companies (excluding SME < 3 years of existence) :

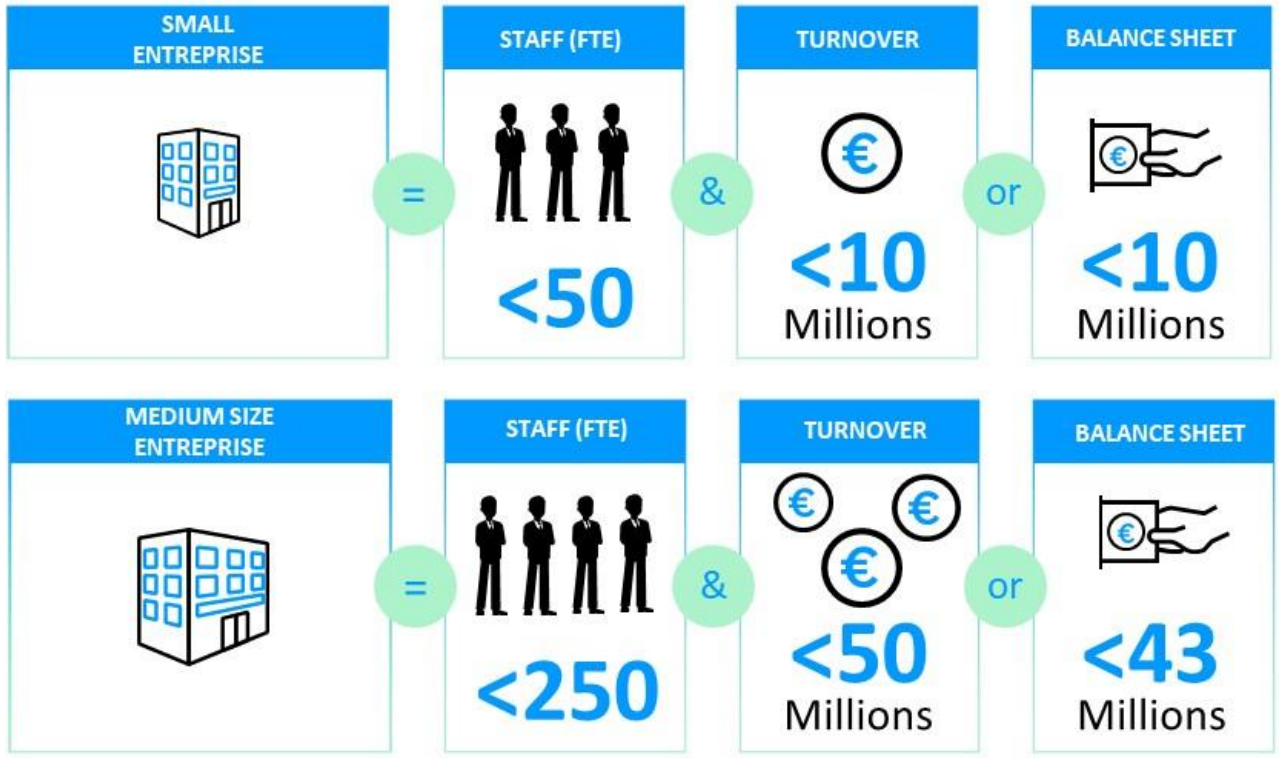
When more than half of subscribed share capital (share premium included) has disappeared as a result of accumulated losses

Example of an undertaking in difficulty:

Own funds of €50k
Share capital of €200k

SME company size

- Thresholds



Click link for tutorial video

- These thresholds are assessed at the perimeter of the **single economic entity**, i.e. the legal entity and its group in the broad sense (shareholding links but also de facto links)
- The rate of aid varies according to the **size of the company** (small, medium or large), but also according to the **return on investment** rate of the supported measure (demonstration of the incentive effect of the aid)

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CLOSING REMARKS

Charles-Albert Florentin

Cluster Manager – CleanTech

LUXEMBOURG MATERIALS & MANUFACTURING CLUSTER

LUXEMBOURG CLEANTECH CLUSTER

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