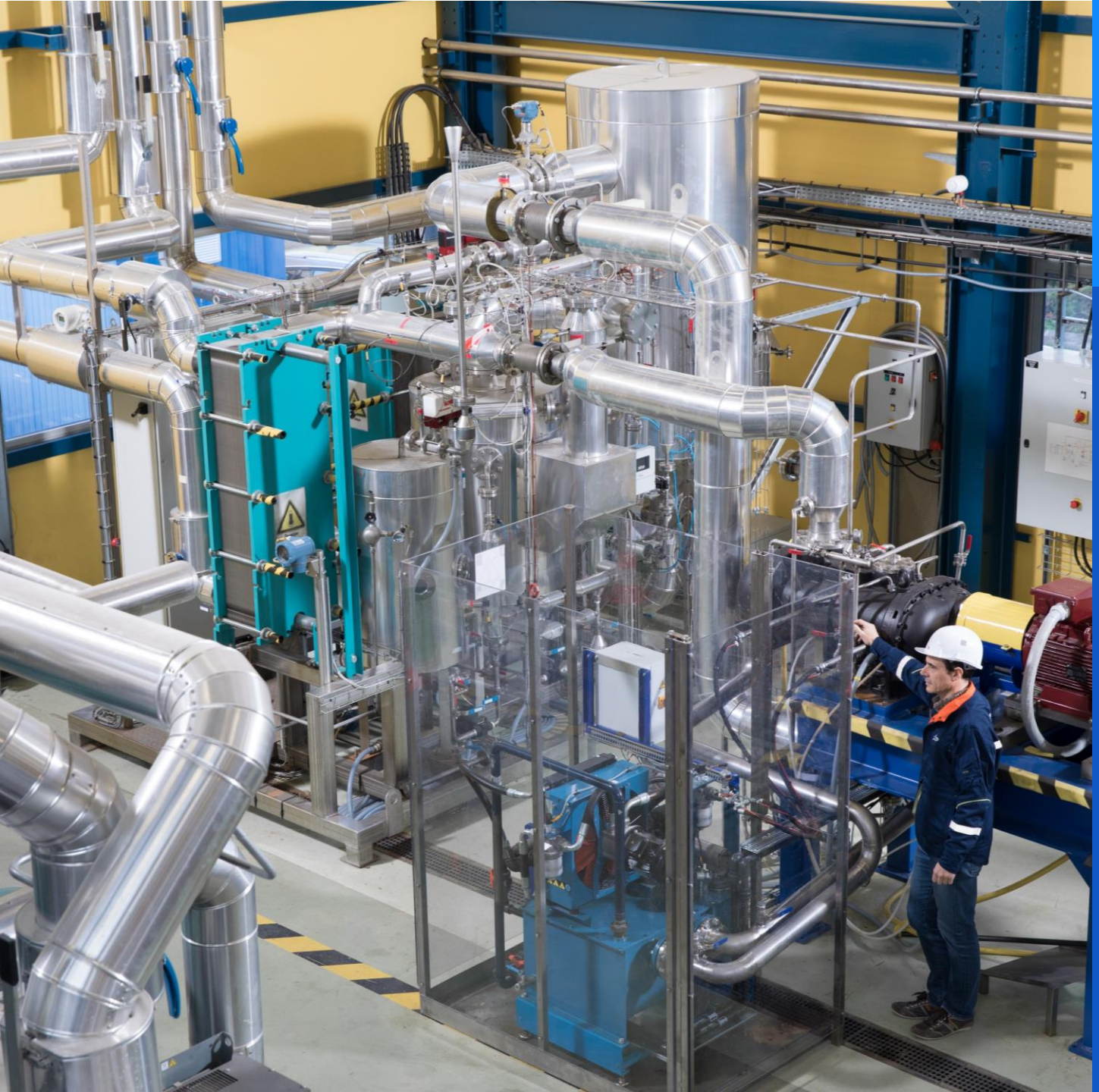


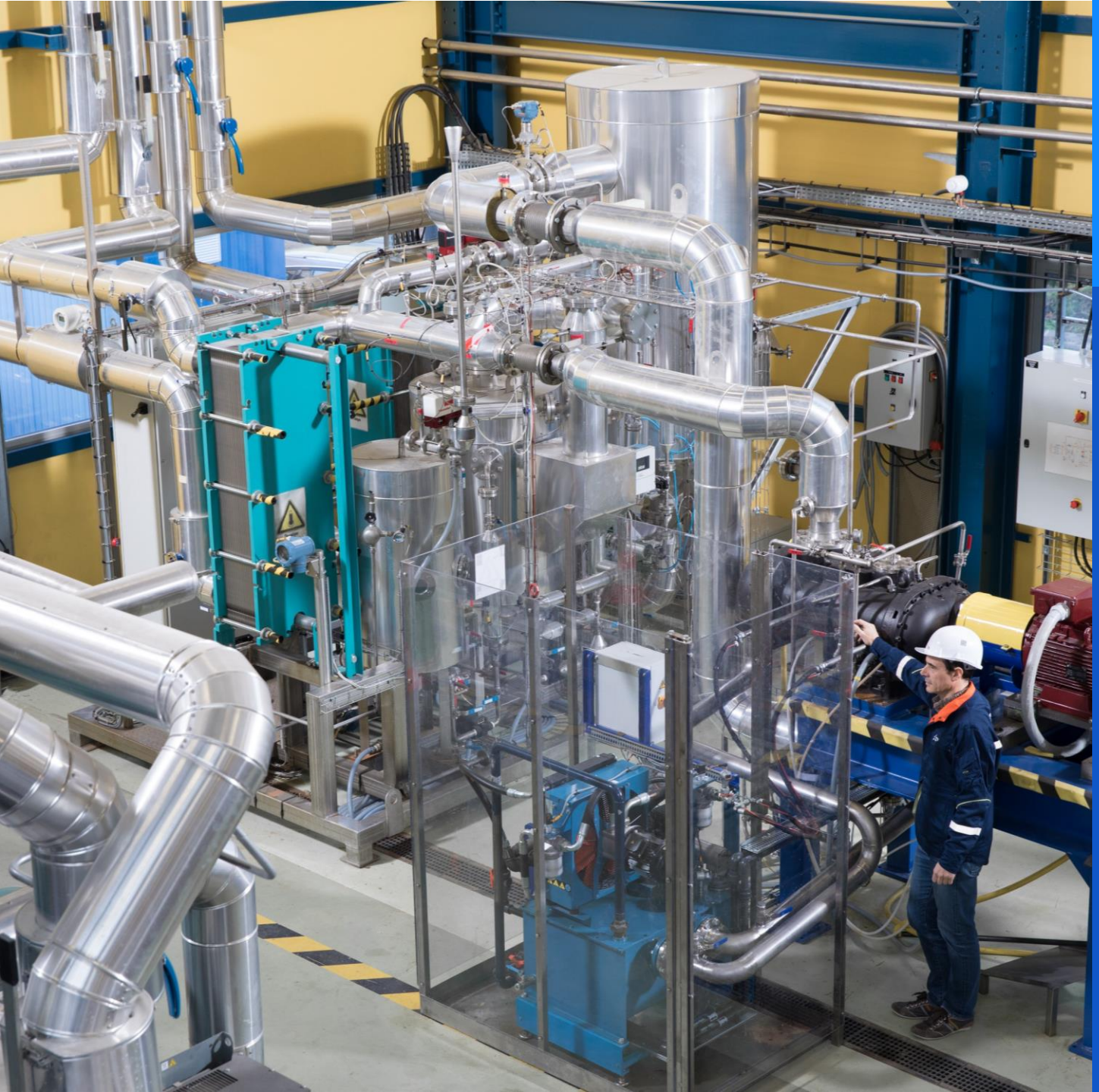
EDF R&D

Technologies and Research for Energy Efficiency

EMAK Workshop 13th of December

Decarbonisation of industry

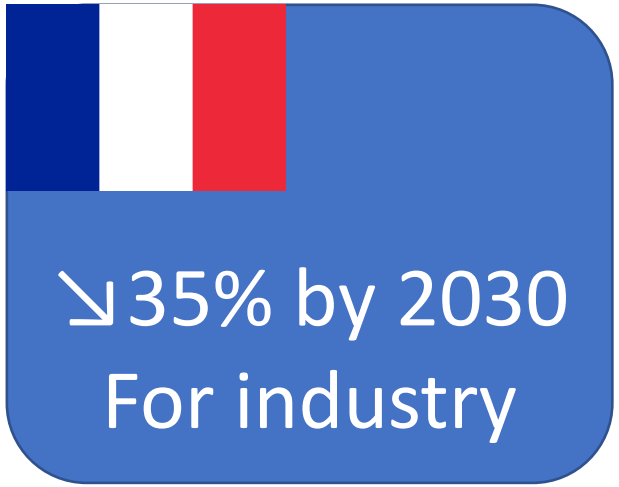
Clément Gachot



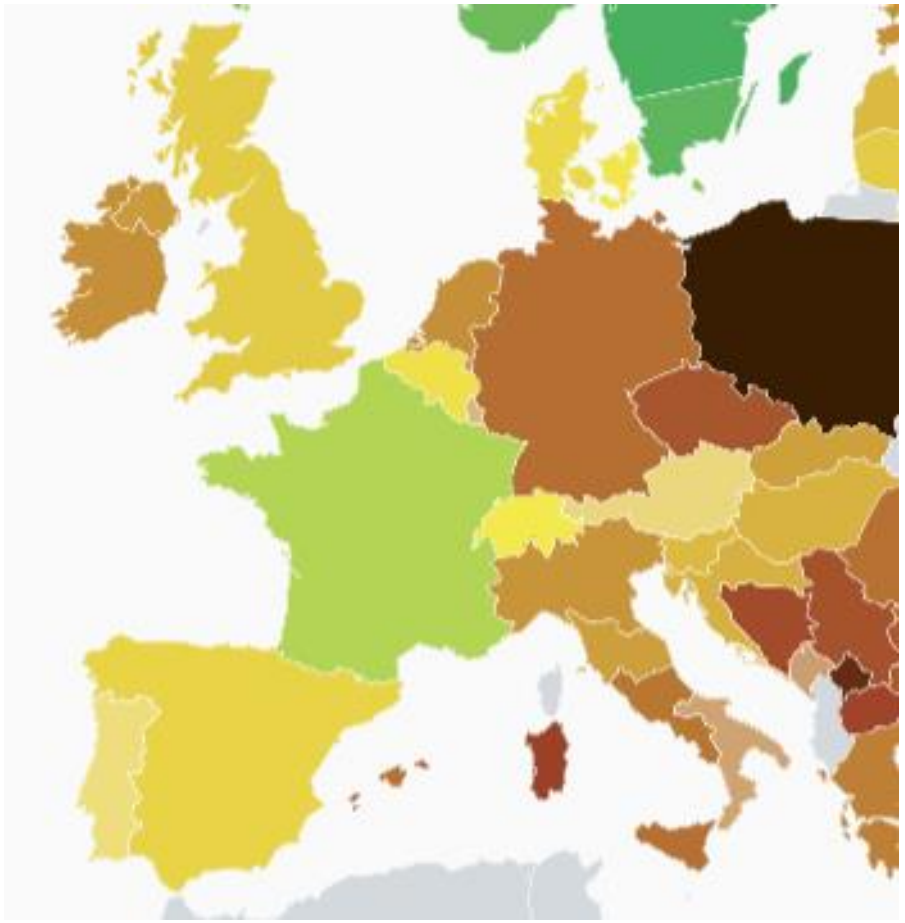
Summary

1. Carbon emission reduction Target for industry EU/FR
2. Heat in French industry context
3. Solutions for decarbonisation by electrification
4. EDF R&D Lab & Innovations

2030’s carbon emission reduction target for industry



Electrification - Disclaimer

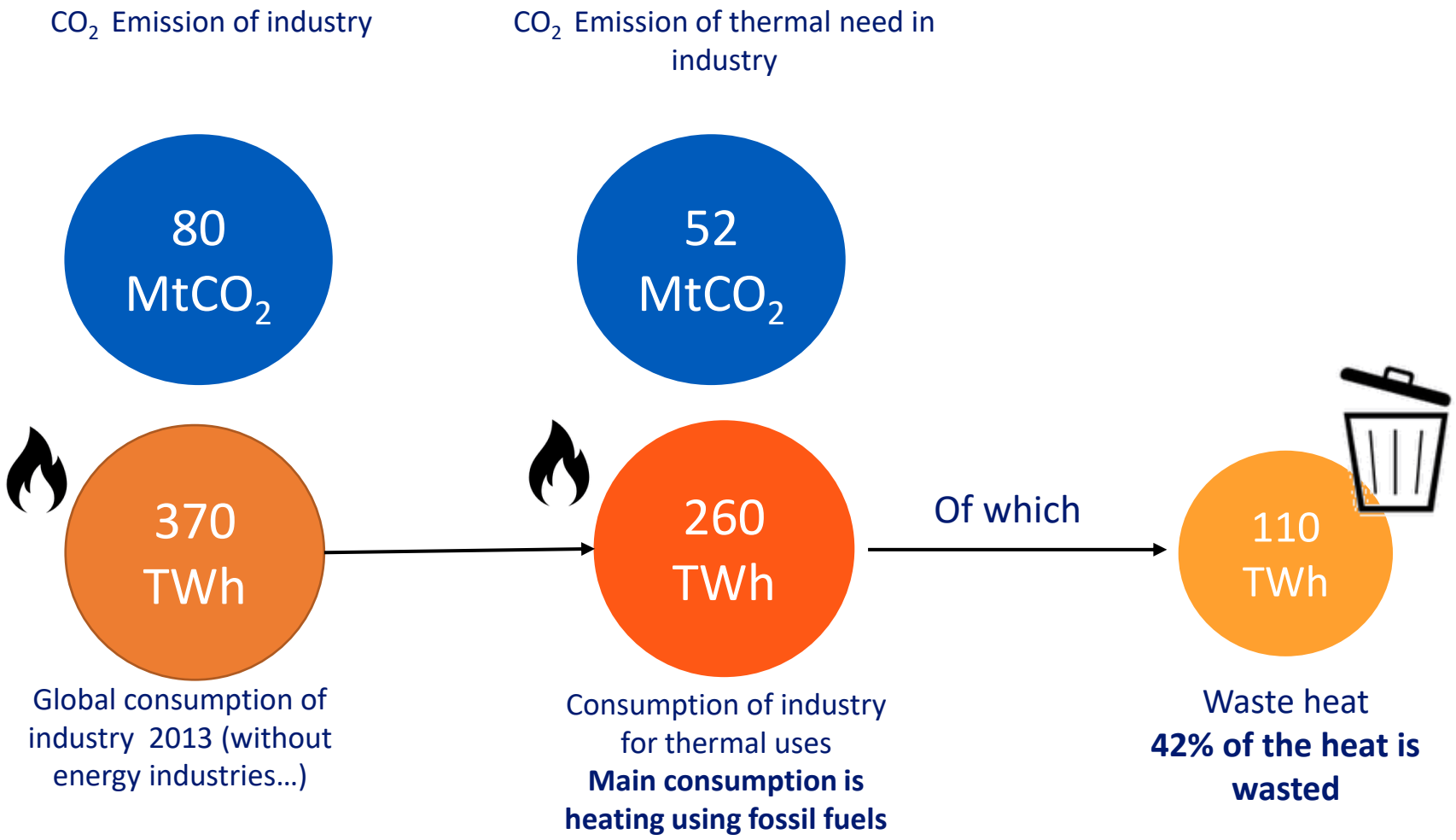


Source : Electricity Map

Using electrification in order to decarbonize industry is the best leverage with available solutions !

In order to really decarbonize with electricity, electricity has to be decarbonized !

Industry context – focus on France



Source : Ademe

Industry context – Solutions

2 main leverages

could be used in ordrer to significantly

lower CO2 émissions

Recovery

+

Substitution

with

Heat Pump, MVR, Electric Boiler or direct electrification of processes

Heat Pump

Energy
-75 %
Compare to a gas boiler

+

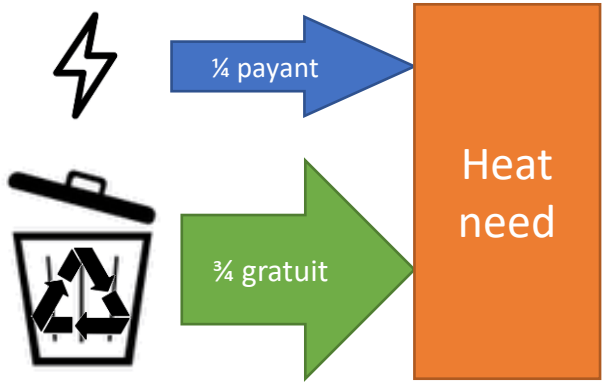
CO2
-93%
Compare to a gas boiler

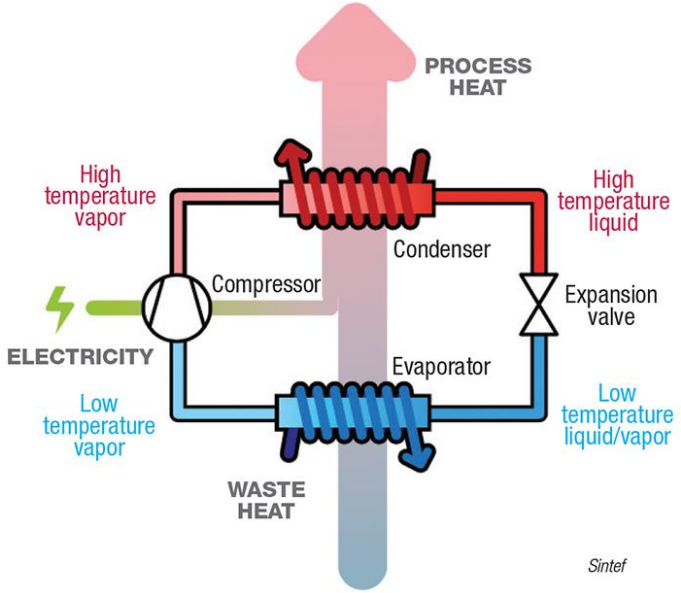
+

ENR & R
Waste heat recovery

*With EF of French gas and electricity mix and with a COP of 4

How it works ? (with a COP of 4)





3 circuits - Closed loop

Source : Chemeng

Heat Pump

Energy
-75 %
Compare to a gas boiler

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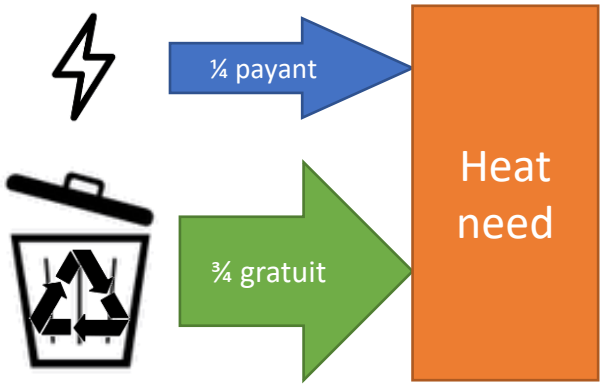


3 circuits - Closed loop

Techno overview :

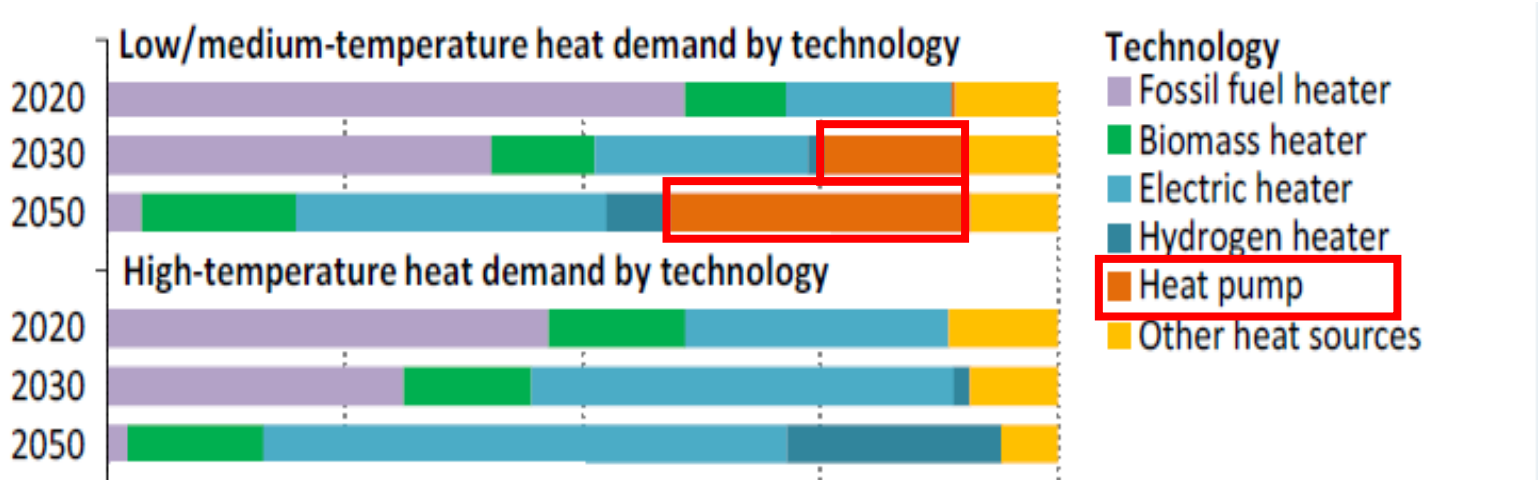
- **Technology already available on the market up to 120°C** and few MW producing mainly hot water
- **Demonstrator level (TRL 7-8)** for more than 120°C **up to 150°C producing water or steam** and lower TRL up to 200°C

Business overview :

- **French market** : **31TWh** of fossil fuel used for heat could be replaced (**20% of total waste heat recovered**) **65% in paper, chemical and food industries**
- **Belgium market** : 8TWh of fossil fuel used for heat could be replaced (Chemycal, F, P)
- **EU market** : from 175 to 750 TWh depending on hypothesis
- **World** : IEA NZE 2050 stated for light industries : 500MW/month during the next 30 years

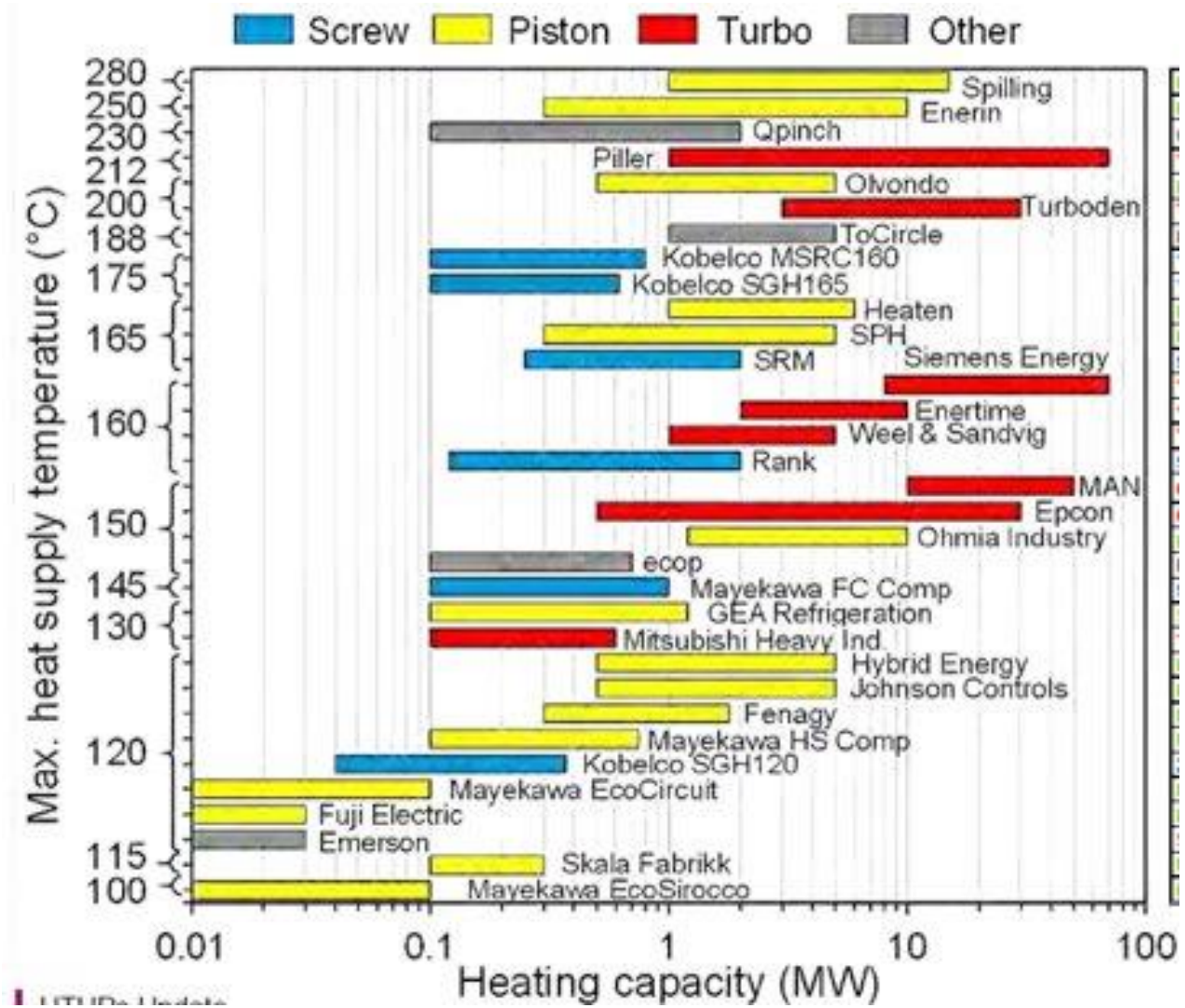
The «heat» market in the future

Electricity accounts for around 40% of heat demand by 2030 and about 65% by 2050. For low- (<100 °C) and some medium- (100-400 °C) temperature heat, electrification includes an important role for heat pumps (accounting for about 30% of total heat demand in 2050). In the NZE, around 500 MW of heat pumps need to be installed every month over



AIE report « net Zero by 2050 »
Light industry – may 2021

The «heat» market in the future

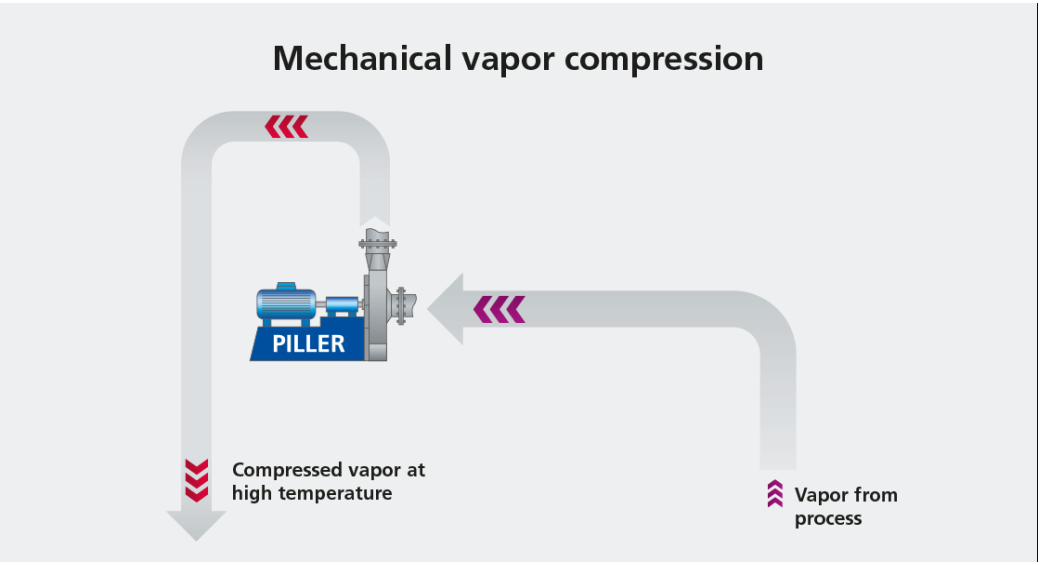


Source : Arpagaus. Al 2023

MVR

How it works ?

1 circuit - Open loop



Key indicators :

- **High Energy Efficiency** ratio : between 3 to 10
- **High CO2 reduction**
- **Market in France : more than 6TWh** of fossil fuel used for thermal applications could be replaced by MVR

RMV for low carbon processes

distillation

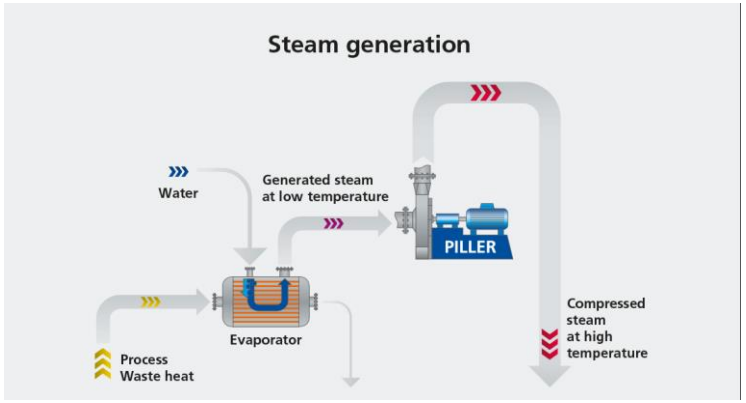
cristallisation

evaporation

Also drying…

RMV usefull also to make low pressure steam with heat pump

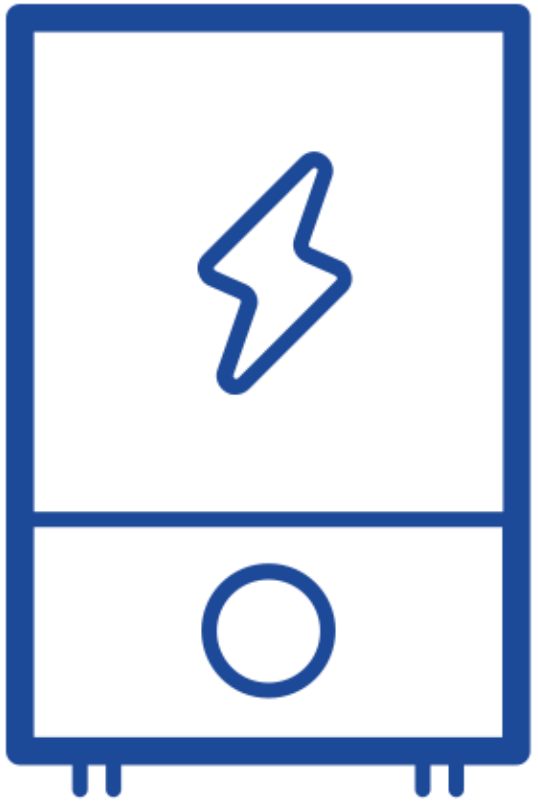
Low carbone steam



Electric boiler

Key indcators

- **High Energy Efficiency** compared to gas boiler (more than 95%)
- **CO2 reduction if low carbon electricity**
- **Lower OPEX on maintenance**
- **Market in France : more than 60TWh** of fossil fuel used for thermal applications could be replaced by electric boiler
- Where heat pump cannot be placed (temperature limit)



Where spread electric boiler? Everywhere :

- Depending on energy prices
- After optimisation of the EE and direct electrification of processes (with HP, MVR or resistor…)
- Replacing fuel boiler
- Not enough ground space available for biomass

Electric furnace/Kiln

Key indicators

- **High Energy Efficiency** compared to gas furnace (more than 95%)
- **CO2 reduction if low carbon electricity**
- **Lower OPEX on maintenance (better impact on security – no explosion)**
- **Market in France : more than 90TWh** of fossil fuel used for thermal applications could be replaced by electric boiler
- **Need on some sectors to invest on R&D** in order to manage the impact by replacing gas furnace by electric furnace on the product

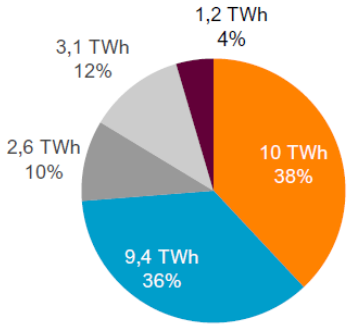
Four à résistances électriques ECM Technologies

Fours à induction EFD Induction

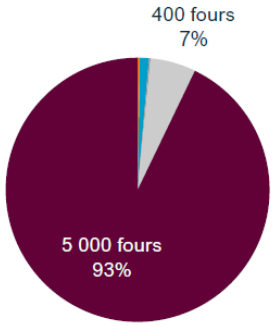
Four à arc électrique Thermomelt

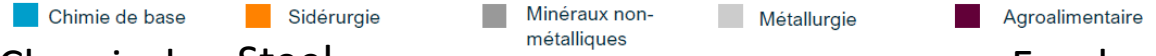
Source : Colombus for EDF (https://colombus-consulting.com/electrifier-la-chaleur-industrielle-pour-decarboner/)

Consommation d'électricité supplémentaire en cas d'électrification des procédés



Nombre de fours électriques supplémentaires en cas d'électrification des procédés





Chemical industries

Steel industrie

Glass

Mettalurgy

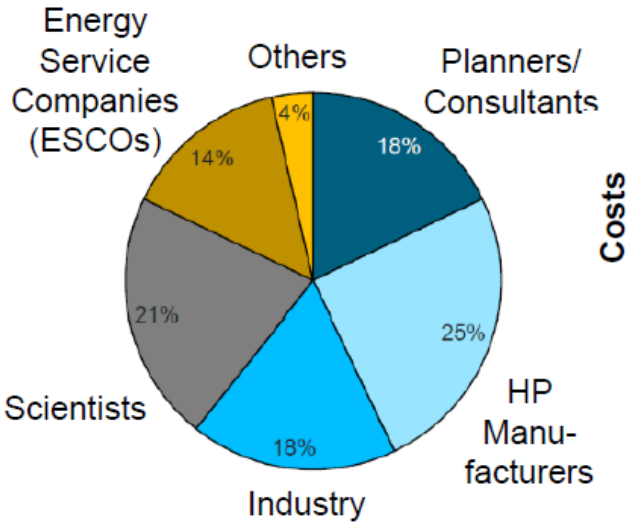
Food

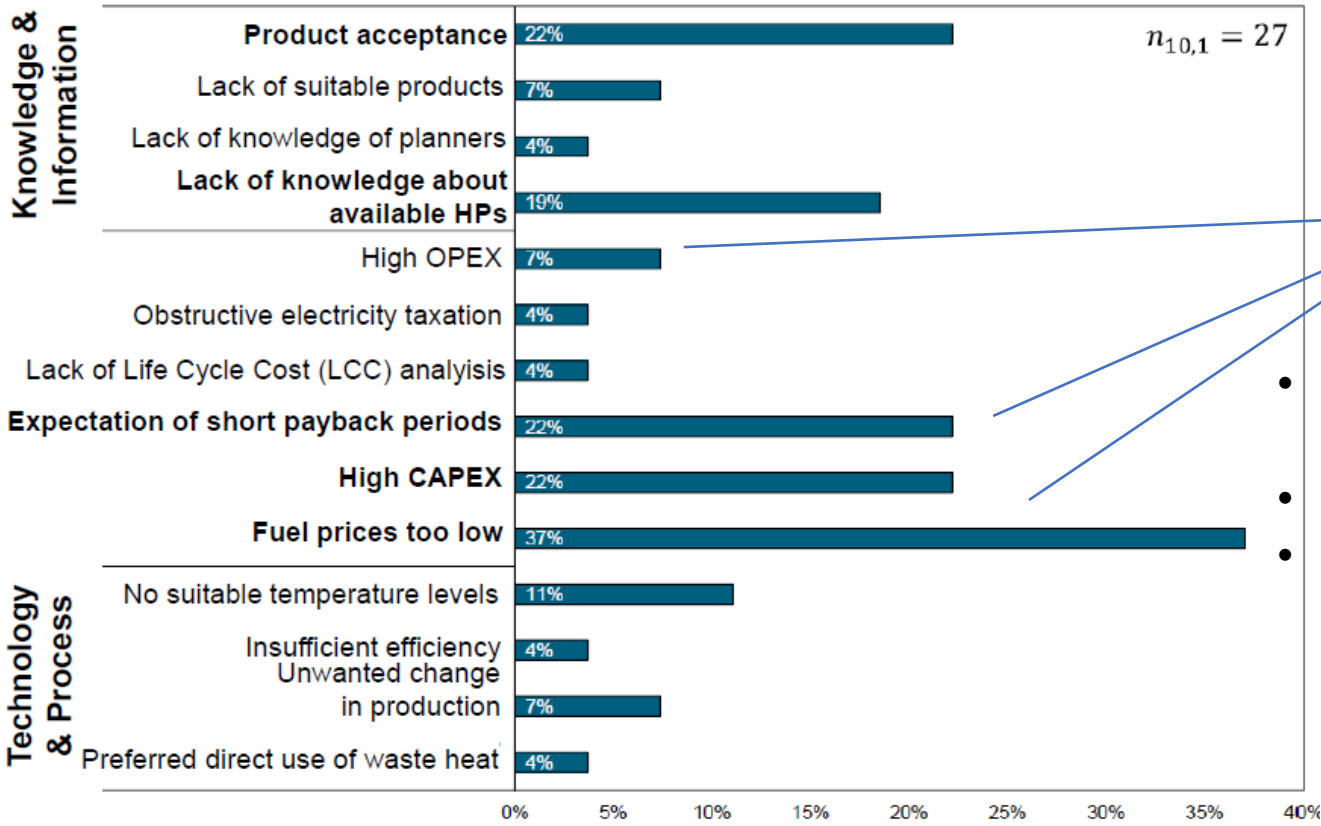
We need to accelerate !

The main solutions in order to decarbonise industrial heat are already available !

Market Barriers for Industrial Heat Pumps

Survey among 27 experts on heat pumps and heat recovery





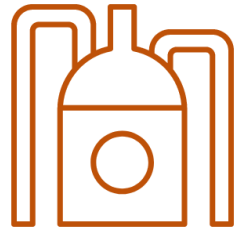
Adapted from Wolf et al. (2017): Systematische Anwendung von Großwärmepumpen in der Schweizer Industrie, Endbericht, 10. Mai 2017 and Wolf (2020): Rahmenbedingungen und Märkte für Industriewärmepumpen, ETV Online Tagung 2020, Industrielle Gross- und Hochtemperaturwärmepumpen im Energiesystem, 22. Juli 2020

- CAPEX sub has to continue
- OPEX sub needed
- Energy Efficiency certificate needs to be fully available for these technologies

One not on the list but not the least : we need more WORK FORCE in these industries in order to install, operates… !

HP Lab in EDF Lab Les Renardières
Innovation !

EDF R&D is anticipating and preparing demonstrator



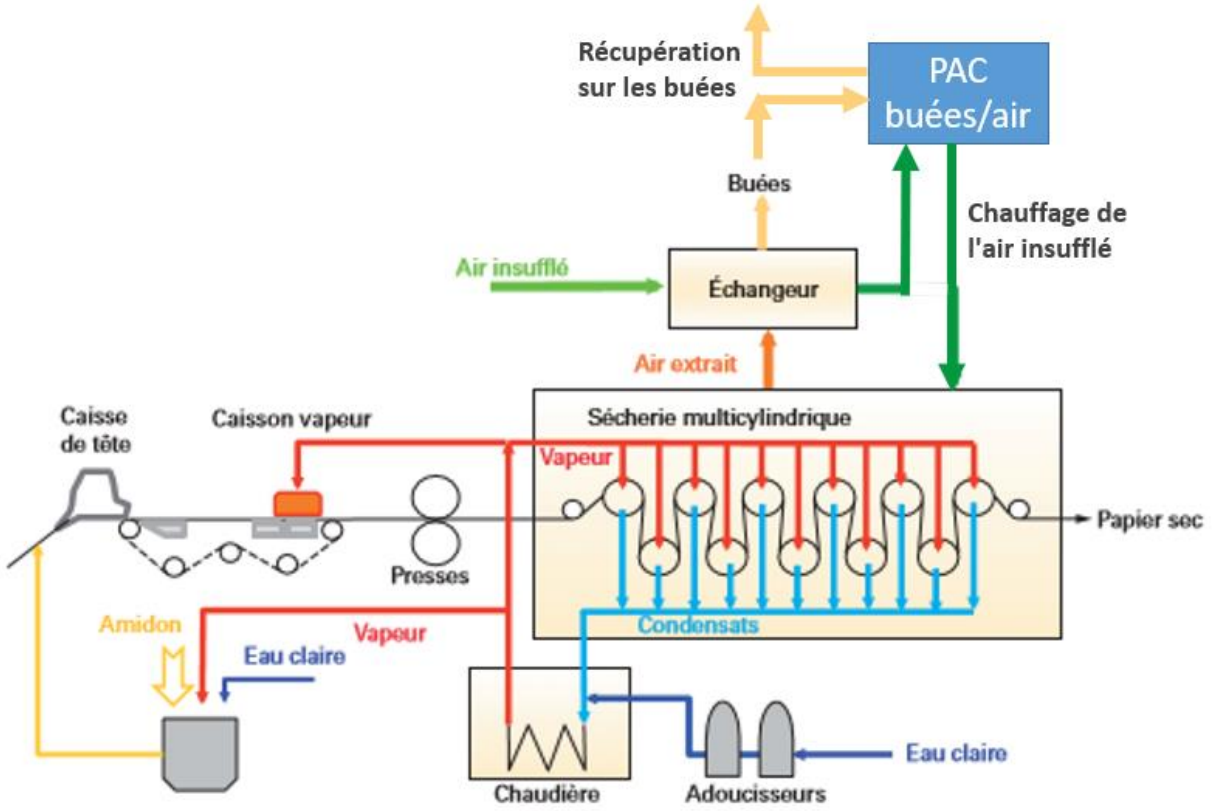
demonstrator	TRANSPAC	BAMBOO / Vapeur	PACO
Technologies	Transcritical HP (COP =4 to 6)	Steam HP	PAC natural fluid (water)
Temperature	120°C to 150°C	152°C	130°C
Industry	Paper and cardboard (dryers)	All industries	food, chemistry (stripping)
Demonstration	2022-2023	2022 (laboratory)	2023
Partners	Wepa, Dalkia, DFS, Armines, Ademe, compressor manufacturer	AIT, Arcelor Mittal, TGE	JCi, Dalkia

Subsidized by

TRANSPAC project

Partners

- **First industrial demonstration of a transcritical HFO heat pump at full scale** (600 kW) on a dryer
- Industrial site : **WEPA Greenfield** (Château-Thierry) factory
- Technical target : **pre-heating the inlet hot air from 97 to 138°C with a COP around 4 using mist at 80°C as a waste heat source**
- Duration of the project : 5 years (2017->2023)
- Commissiong of the demo : spring 2023
- The Demo is running and COP targeted reach since july 2023



Source : EDF

A complete innovation cycle

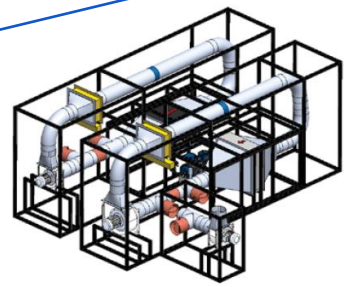
TRL level

1-3

4 – 6

7 - 8

9



A common thesis between research lab and EDF
30kW lab demo
K. Besbes

Patented the innovation

Work on how to go forward with this innovation : found an industrial demo site and a manufacturer
Market study…

Launch of the TRANSPAC project with partners (Dalkia, Wepa, EDF, Armines)

- Consolidate the design
- Derisking the industrial design of the technology (test on small scale compressor in lab)
- Conception (assembling of the components…)
- Integration on site
- Launch (spring 2023)
- Feedbacks

- Operation phase for the first unit
- Commercial action plan
- Tools design for sizing and selling
- Training teams on operation/maintenance
- Target : decarbonization of all compatible dryers!
- Next step to develop the tech (**adapt to new regulation** and use cases…)

↘55% by 2030 Global

↘35% by 2030 For industry

J.L. Peureux
A. Bourig

IDEA | THESIS | PATENT | TRANSPAC Project | Decarbonisation

2010 2012 2015 2017 2023 2030

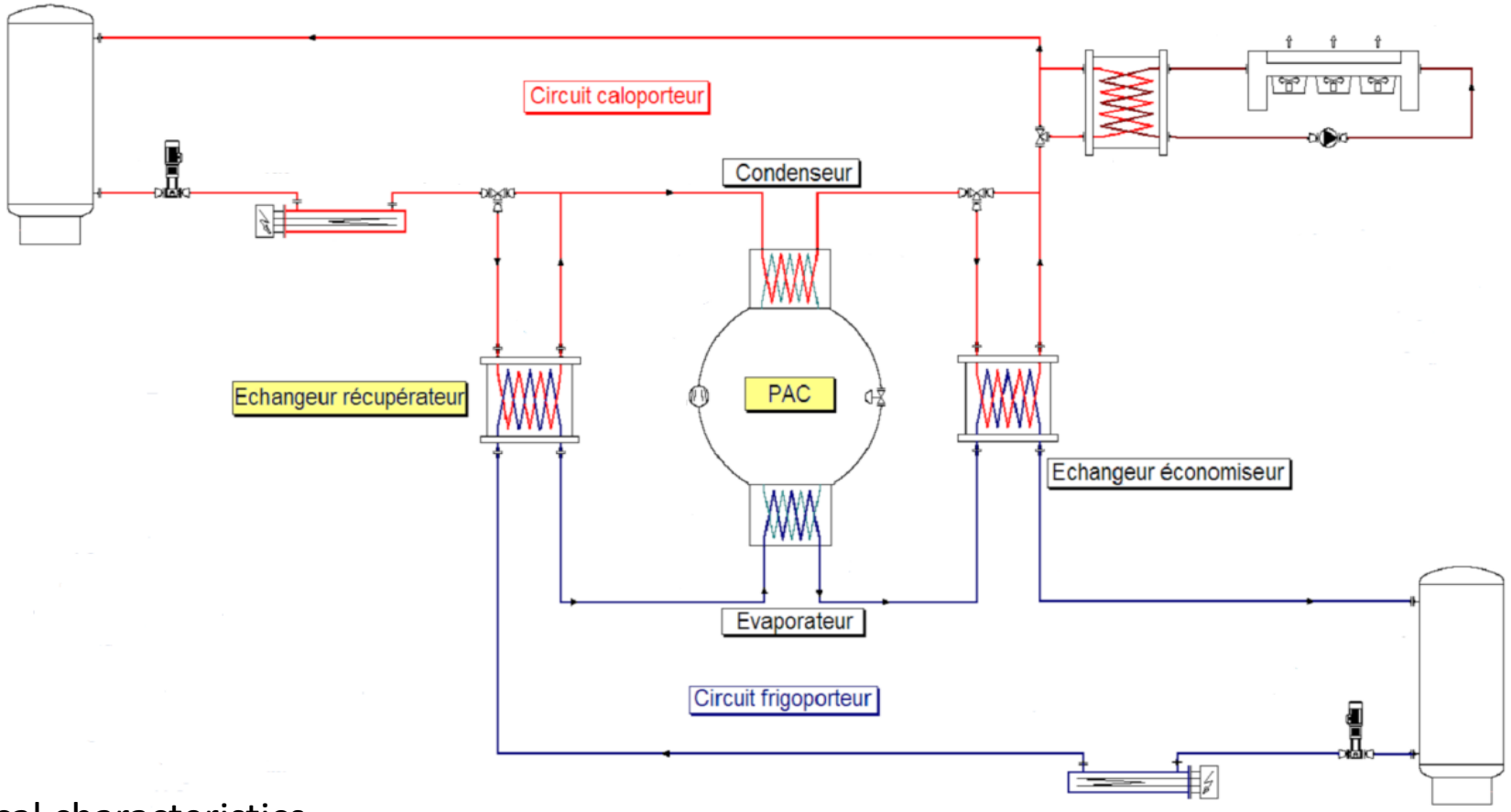
EDF Lab Les Renardières – Industrial heat pump lab

1. **Validate the performance of the HP deployed by EDF Group & its partners in order to reduce the risks of the projects**

2. **Assist our partner manufacturer in their developments of new high-performance products**

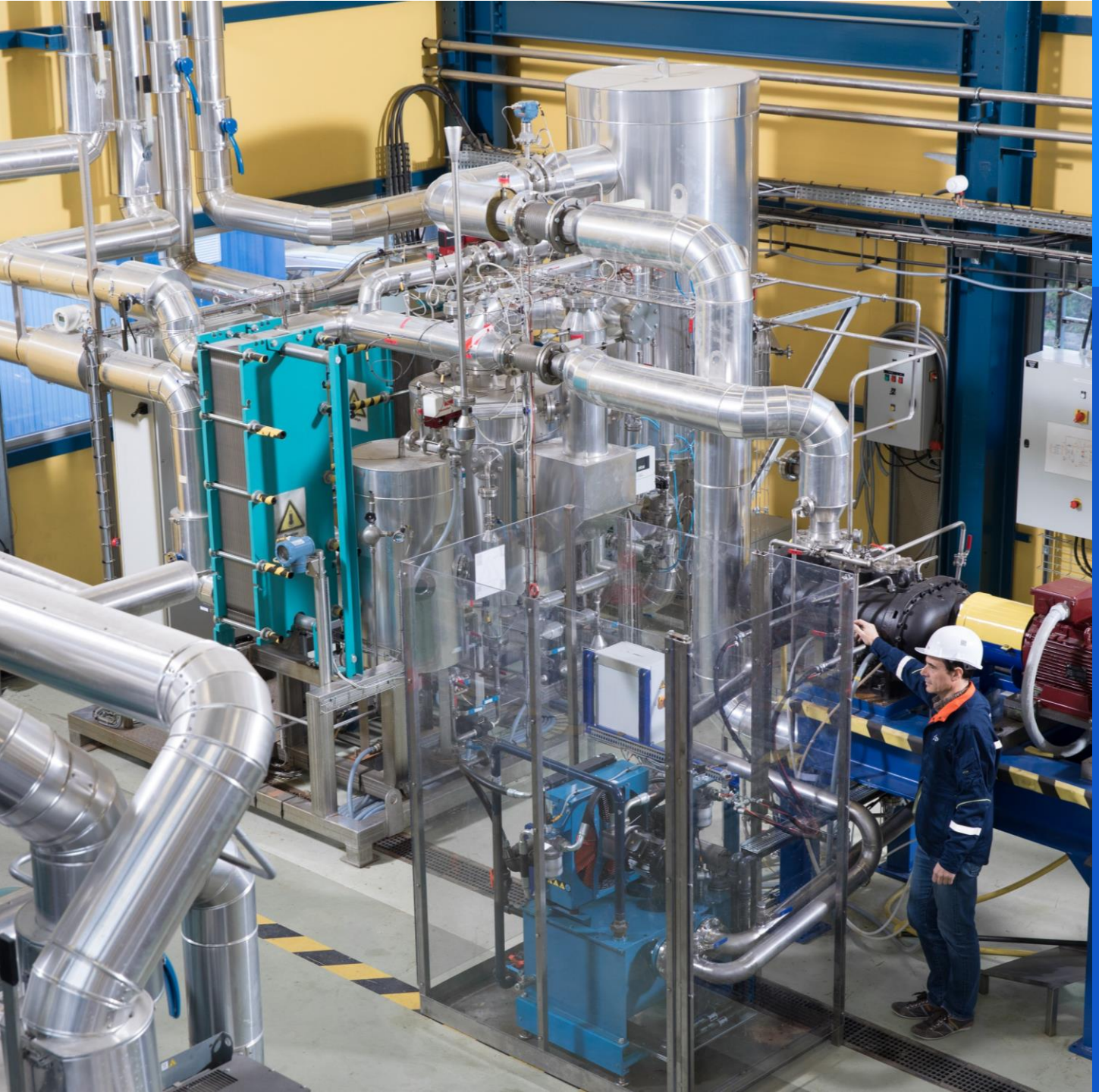
3. **Facilitate the integration of HP within technology mix and test new architectures**

Laboratory's loops



Technical characteristics

IN/OUT	carrier	Max temperature	Max power
Heat source	water	100°C	~500 kWth
Heat Needs	Superheated water	145°C	~1000 kWth



EDF R&D

TREE

Clément Gachot

Thank you !

Merci !