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

- 55% by 2030 for Global
- 35% by 2030 for industry
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!

Source: Electricity Map
Industry context – focus on France

CO₂ Emission of industry

80 MtCO₂

CO₂ Emission of thermal need in industry

52 MtCO₂

370 TWh

Global consumption of industry 2013 (without energy industries...)

260 TWh

Consumption of industry for thermal uses
Main consumption is heating using fossil fuels

110 TWh

Waste heat
42% of the heat is wasted

Source: Ademe
Industry context – Solutions

2 main leverages could be used in order to significantly lower CO2 emissions

- 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% payant
- ¾ gratuit

Heat need

3 circuits - Closed loop

Source: Chemeng
Heat Pump

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-75 %
Compare to a gas boiler

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**ENR & R**
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**How it works?** (with a COP of 4)

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- Heat need
- ¾ gratuit
- 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
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
The «heat» market in the future

Source: Arpagaus. Al 2023
MVR

How it works?

1 circuit - Open loop

Mechanical vapor compression

Compressed vapor at high temperature
Vapor from process

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

Also drying...

distillation  crystallisation  evaporation

RMV usefull also to make low pressure steam with heat pump

HP + RMV = Low carbone steam

Steam generation

Water
Generated steam at low temperature
Evaporator
Compressed steam at high temperature
Process Waste heat

Electric boiler

Key indicators
• **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

Source: Colombus for EDF (https://colombus-consulting.com/electrifier-la-chaleur-industrielle-pour-decarboner/)
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**
  - Energy Service Companies (ESCOs): 21%
  - Others: 14%
  - Planners/Consultants: 18%
  - Scientists: 18%
  - Industry: 25%
  - HP Manufacturers: 16%

### Knowledge & Information
- Product acceptance: 22%
- Lack of suitable products: 12%
- Lack of knowledge of planners: 10%
- Lack of knowledge about available HPs: 10%
- High OPEX: 16%
- Obstructive electricity taxation: 16%
- Lack of Life Cycle Cost (LCC) analysis: 12%
- Expectation of short payback periods: 3%
- High CAPEX: 19%
- Fuel prices too low: 13%

### Costs
- No suitable temperature levels: 11%
- Insufficient efficiency: 16%
- Unwanted change in production: 7%
- Preferred direct use of waste heat: 1%

### Techno & Process

- 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

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

• 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)
• Commissioning 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...)

IDEA THESIS PATENT TRANSPAC Project Decarbonisation
2010 2012 2015 2017 2023 2030
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

<table>
<thead>
<tr>
<th>IN/OUT</th>
<th>carrier</th>
<th>Max temperature</th>
<th>Max power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat source</td>
<td>water</td>
<td>100°C</td>
<td>~500 kWth</td>
</tr>
<tr>
<td>Heat Needs</td>
<td>Superheated water</td>
<td>145°C</td>
<td>~1000 kWth</td>
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Thank you!

Merci !