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Non-electric Applications of Fast Reactors

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CEA/DEN

Heat has always been a major issue for mankind

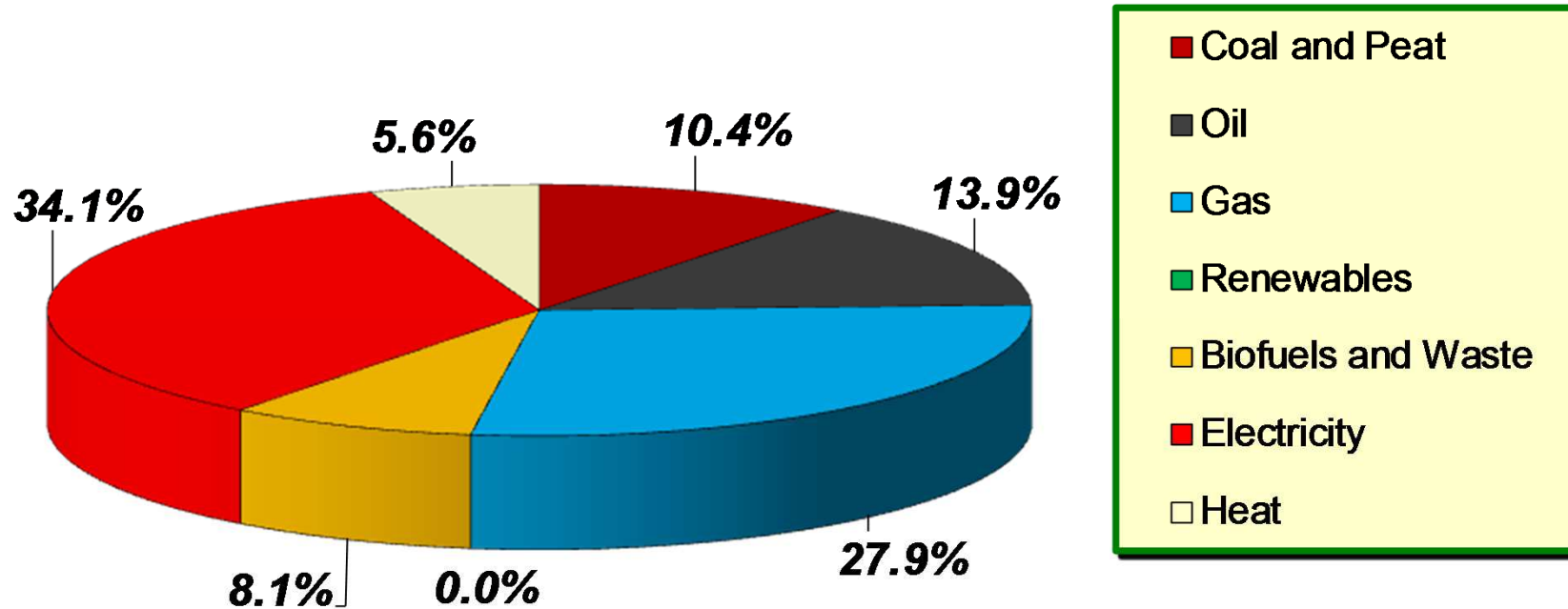In 2011, total world energy consumption amount to **13500 Mtoe**

About 40% of this energy (**5300 Mtoe**) was directly used to produce **heat.**

50% of this heat was for residential homes, commercial businesses and public services and **50%** for industrial applications

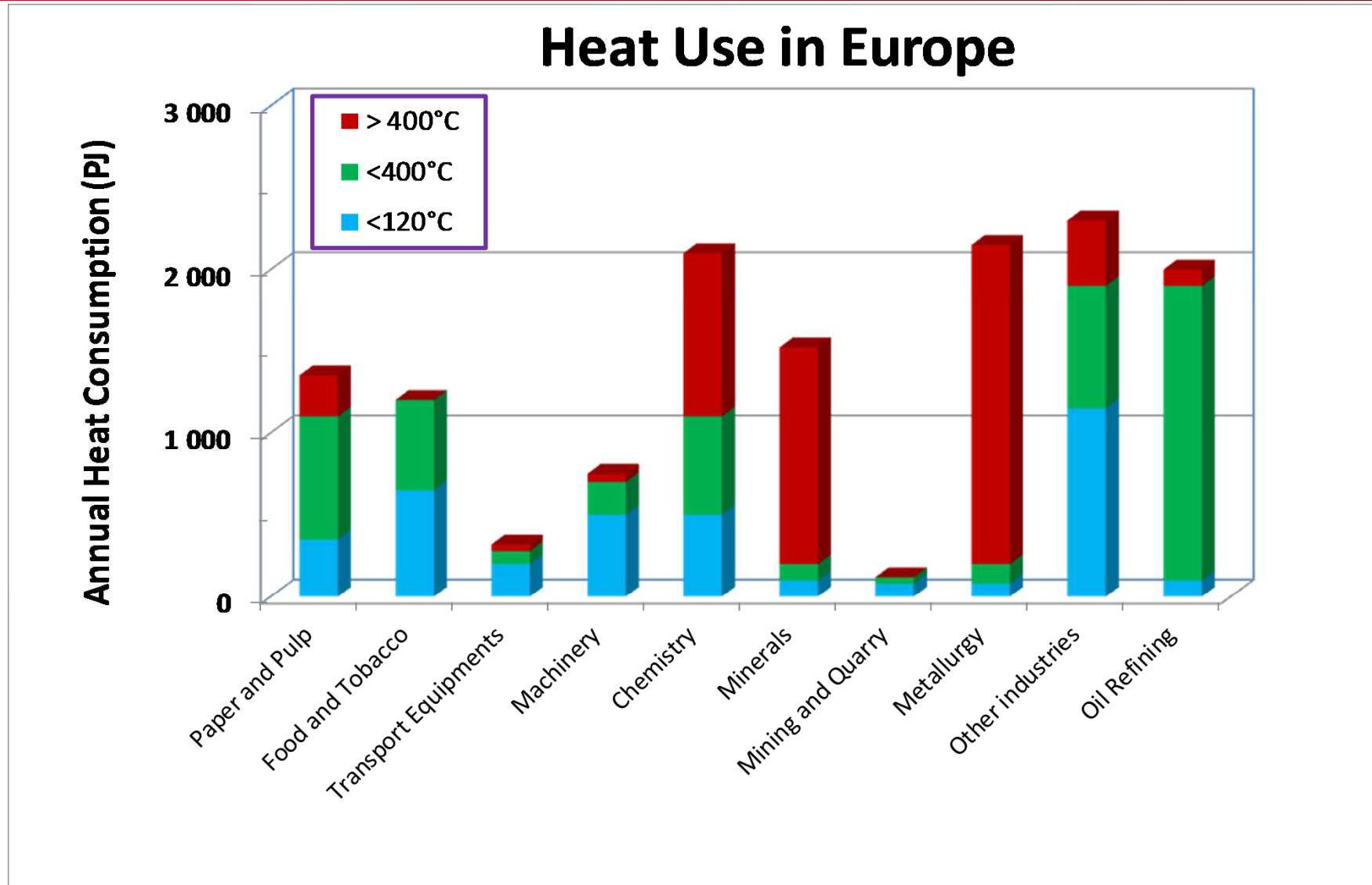World total Heat Demand ~ **40000 TWh**

Energy sources in the European Industry (2009)

Legend:
- Coal and Peat
- Oil
- Gas
- Renewables
- Biofuels and Waste
- Electricity
- Heat

Pie chart values:
- 10.4%
- 13.9%
- 27.9%
- 0.0%
- 8.1%
- 34.1%
- 5.6%

Total = 271 Mtoe

50% of total energy is used for Heat

Heat Use in Europe

In the domestic and industrial sectors,

- ➢ **80%** of heat usage request temperatures **below 400°C**

- ➢ **65%** of heat usage request temperatures **below 120°C**
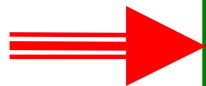
> **The vast majority of heat usage is performed at low, or even very low temperatures**

HEAT REQUIREMENTS

Low temperatures

40°C - 250°C

District Heating
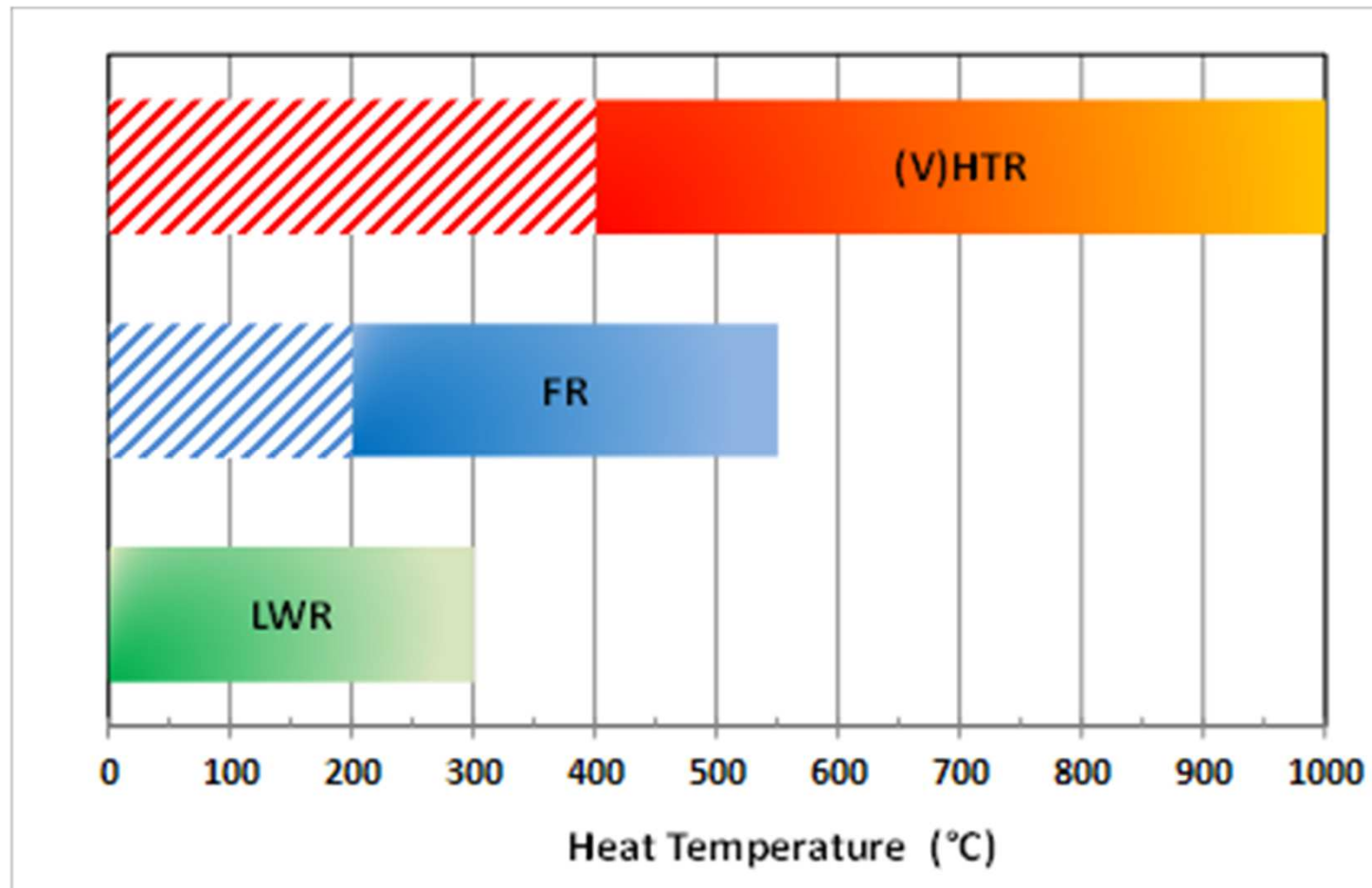
Water Desalination

Medium Temperatures

250°C - 550°C

Industrial Steam

Coal Gasification

Gas and Oil Shale extraction

Tar sands

Biomass and Biofuels

High Temperatures

> 550°C

Hydrogen Production

Metallurgy
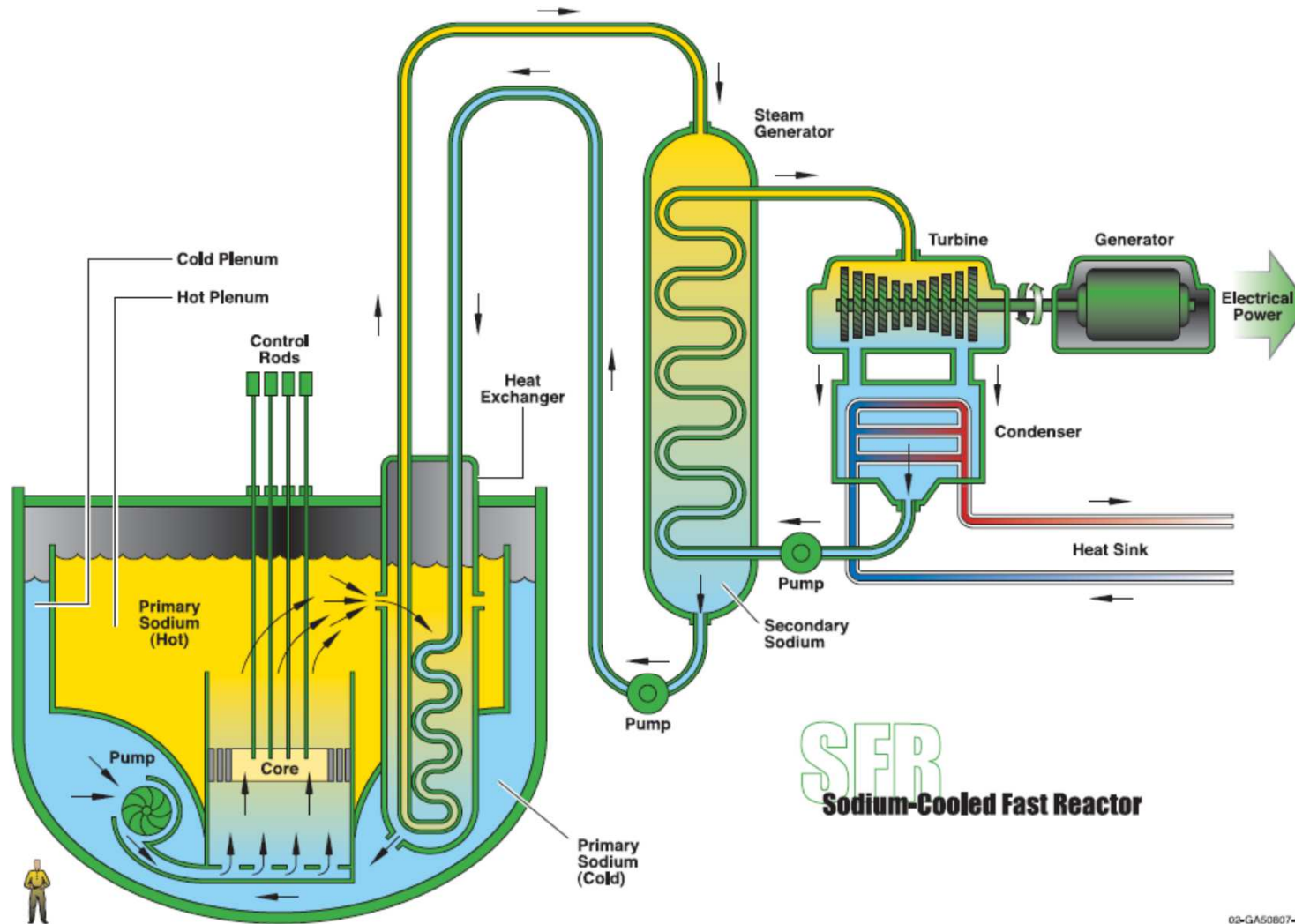
A Technology Roadmap for Generation IV Nuclear Energy Systems

Many industries require moderate temperatures for their industrial processes (from 60°C to 400°C)
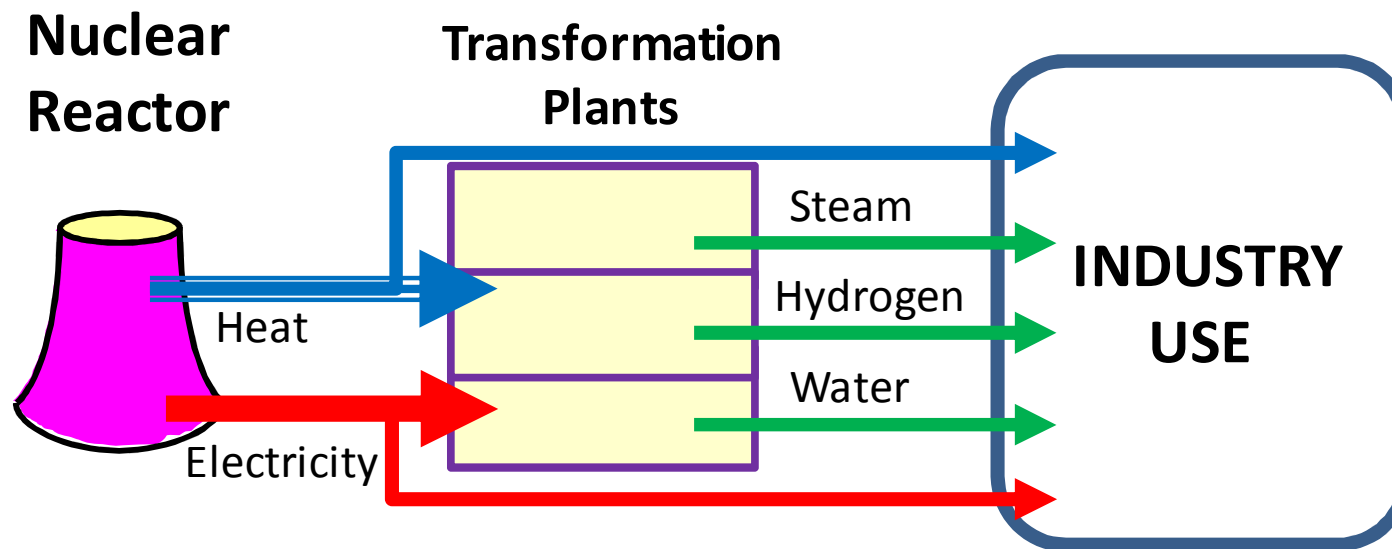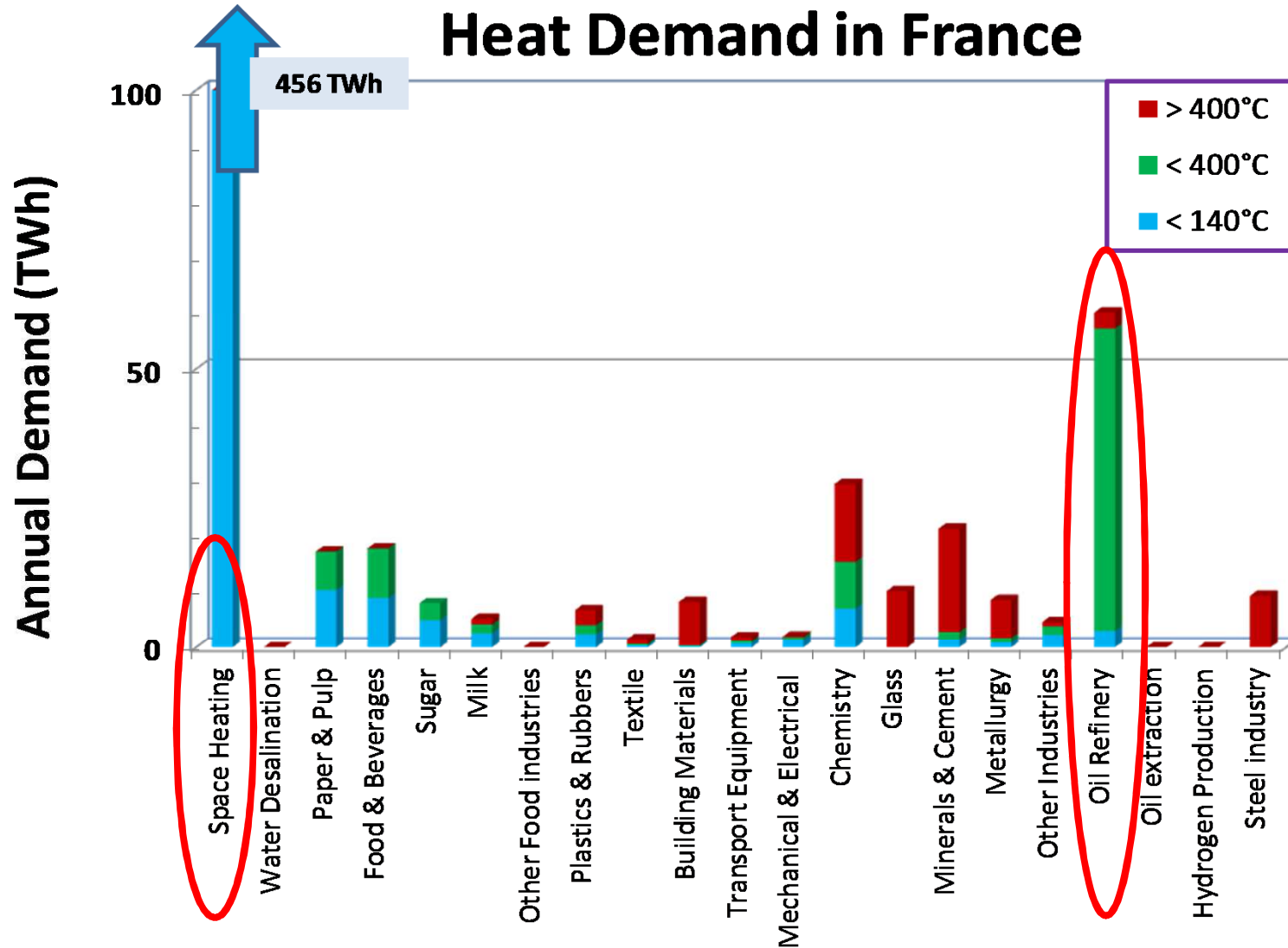

40% of energy use in industry is low temperature heat < 400°C

In France, **Heat** share is

➢ **80%** of the total energy consumption in the residential and commercial business

➢ **40%** of the energy needs in industry

Domestic uses: space heating, hot water, cooking

Industrial uses: drying, oil refinery, chemistry, transformation, melting, …

Heat Demand in France

A cogeneration unit and a Steam Methane Reforming plant built on site.

Energy Needs for a typical large refinery

Heat	550 kWh/t
High pressure steam	350 kWh/t
Hydrogen	6 kg/t
Electricity	40 kWh/t

Bird's eye view of Gonfreville refinery in Normandy, France having a refining capacity up to15 Mtons/y of crude oil   (Courtesy of TOTAL)

Any refinery uses **6%-10%** of the energy content of its end products to generate steam, electricity and hydrogen for its own uses.

FR13 Conference – Paris, 5 March 2013

Heat Demand for the main Units

Main unit	Temperature range for heat demand	Heat demand (kWh/baril)	Extra steam (kWh/baril)
Crude oil distillation	370-400	19.8	13.43
Vacuum Distillation	390-450	6.37	6.95
Hydrotreater	260-430	20.1	21.5
Coking	310-370 (preheating)	34.2	-4.25
Catalytic Reformer	450-540	51.8	25.4
Fluid Catalytic Cracker	480-540	16.8	0.07
Hydrocracker	250-450	39.5	21.3
Deasphalting	50-160	41.9	0.78

All main units on site require heat with a temperature below 540°C and in addition, a large amount of extra steam

A single SFR reactor (1800 MW thermal) may provide all energy needs for a typical modern oil refinery
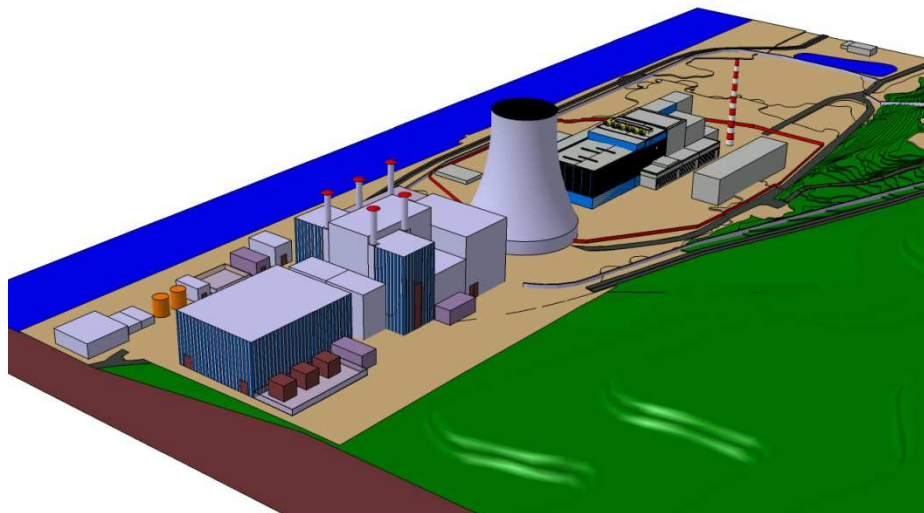
Utility Production	
Heat	930 MW
Steam	600 MW
Electricity	70 MWe
Water	2300 m³/h

Nuclear cogeneration may save **1.5 Mtoe/year** in **oil and gas input.** and would cancel most of **CO_2 emissions** of the site **(3 to 4 Mt/y)**

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ISSUES NEEDED TO BE ADRESSED

➢ Operating a FR in a cogeneration mode
- ✓ Energy conversion modifications
- ✓ Coupling to the industrial process
- ✓ Control, Drive modes, Optimization of operation

  (Electricity vs. Steam)

➢ Design of the Heat Transport Steam Line
- ✓ Connecting the NPP to the site units

➢ Safety issues
- ✓ Instrumentation *(operation, surveillance, degraded modes,…)*
- ✓ Loss of power, Loss of demand, …

➢ Technical-economic evaluations
- ✓ Costs vs Benefits

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➤ Most of industrial applications **(80%)** require **low temperature** heat below 540°C

➤ **Fast Reactors** are technically suitable to provide industrial steam at temperatures not accessible by standard LWRs

➤ As an illustrative example, the application at an **oil refinery** site has been studied showing the **economic benefits**

➤ **Nuclear Cogeneration** enhances the overall **energy efficiency** of the power plant

➤ Nuclear Cogeneration allows **massive cut in CO_2 emissions**