High Temperature Heat PUMP in France

EDF R&D

RESEARCH AND DEVELOPMENT

Jean-Benoît RITZ

EDF strategy in term of Energy Efficiency

- **Be a European leader in the energy market with respect to the environment within a framework of economic performance**

  Some Guidelines

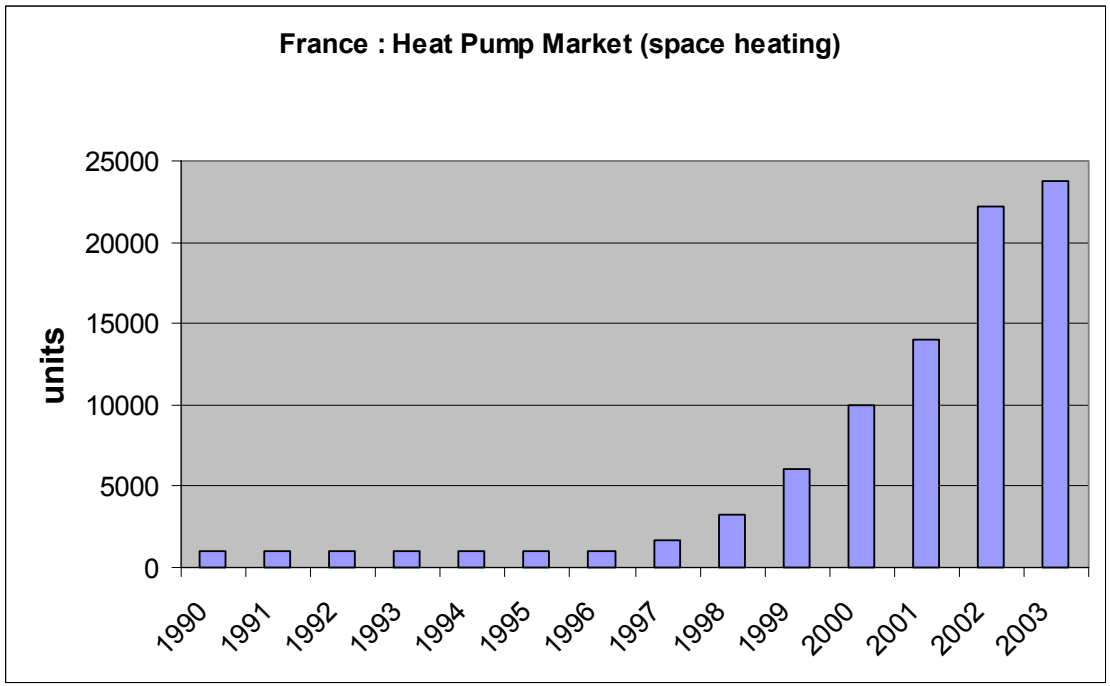
  - › **Increasing Energy efficiency**
  - › **Reducing Energy consumption**
  - › **Limiting the impact on the natural environment (greenhouse effect, CO2 emission reduction)**
  - › **Developing renewable energies**

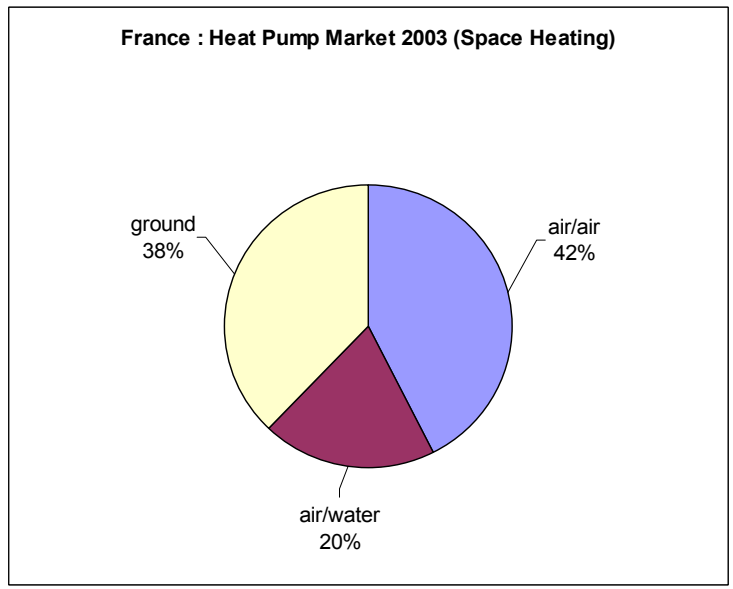
- **Develop the heat pump market is in the scope of EDF strategy.**
- **In this framework, we aim at being a significant player in Europe for thermodynamic heating systems**

EDF R&D supports the development of heat pump market

- Contribute to define technical rules and specifications
- Technical and economical studies to compare initial and running cost with others systems
- Development of scientific models to predict the behaviour of systems or components
- In partnership with manufacturers design and development of new products
- Tests of products and systems in laboratory
- Technical training of sale's forces
- Set up a structure to examine and deal with poor quality installations to solve customers problems
- Energy monitoring on reference installations

French residential heat pump market





- **Remarkable increase in the number of heat pumps sold since 1990 in France**
- **In 2003, 23800 HP sold in France**
  market share : 42% air/air HP, 38% ground HP and 20% air/water HP
  (Difficulties for assessing air/air systems used for mainly heating)

- **HP are mainly sold in the new buildings market**

Focus on heating in France

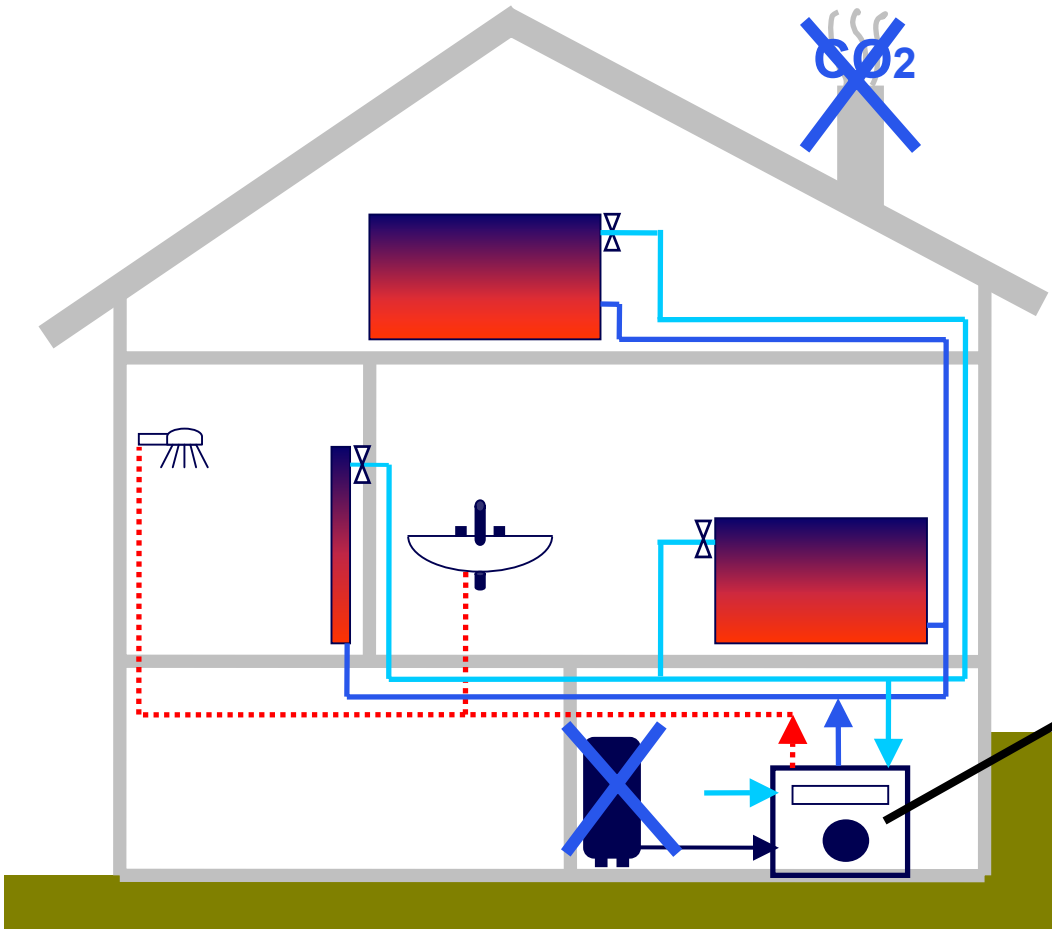
- **Single-family Houses**
  - 14 M of single-family houses (28 M of dwellings)
  - New building construction rate per year : 1-2% of new individual houses,
  - 300 000 owners renovate their heating system per year in existing single-family houses
  - Market potential : 180000 boilers can be retrofited by HP each year (8.4 M oil/gaz boilers)

- **Market potential of HP for existing buildings is much greater than for new buildings**

- **Heat distribution systems**
  - 60% by hydronic system with radiators (most of case) and floor heating
  - Oil (20%) and gas (40%) of heating energy, mainly hydronic system

Heat pump in retrofit market

1 - Opportunities and barriers



How to replace Oil & Gas Burner heating by a HP ?

2 – Specifications of the High temperature HP

- **Description of the retrofit market**
  - **Traditional hydronic heating system sized in the range temperature of 90°C – 70°C or 80°C – 60°C**
  - **Systems designed for higher heating capacities than heat demands**
  - **Less needs because of insulation made since the building**

- **Distribution Temperatures may be reduced below the original design values**

- **Need of the product : Heat Pump producing water at 65 °C until –12 °C of external temperature can be suitable for substituting old boiler in the range temperature of 80°C – 60°C**

but **no product in the market in 2000 : the best : 50 °C until – 7°C**

3 - Collaboration for the develop. of the product

- **Development started four years ago :**

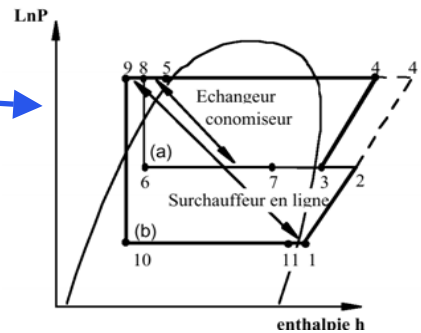
  EDF, EPFL (Switzerland) , Viessmann/Satag (heat pump/boiler manufacturer), Copeland (scroll technology)

  <u>Technologic break</u> around the compressor

  Collaboration with COPELAND

  - Enhance Vapor Injection scroll technology

  - One stage cycle with economiser and intermediate injection of vapor



- **Prototypes of Heat Pump built & tested in 2001/2002**

- **Heat Pumps of pilot production ready for field tests since end of 2002**

4 - Technical data of the product

Ducted air/water Heat Pump (not reversible)
3 levels of electrical backup (3 kW – 6 kW – 3+6 kW)

Outside air T° limit (HP) = - 15 °C

Heating and tap water production

A –7°C / W 65 Pheat : 9,4 kW COP : 1,9

A+ 7°C/ W 35 Pheat : 11,8 kW COP : 3,8

(testing at EDF R&D)

Advantage : Production of water temperature at 65°C (HP only) for – 12 °C, external air temperature

5 - Tests at EDF R&D

Tests in natural climate

Seasonal performance

Real outside weather (Paris, Tbase = -7°C)
- Simulation of a single house (150 m^2)

-5 °C < Text < 15 °C
35 °C < Twater < 65 °C

COP (dec.2001. – april 2002) = 2,8
COP (dec.2002. – april 2003) = 2,7

6 - Field tests with Viessmann S.A.

Test of 4 Hight Temperature Heat Pumps

Flers, 125 m² – oct./ nov. 2002
Heating and hot water
Propane

Moret, 130 m² – Janv 2004

Heating and hot water gaz

Egleny, 120 m² – May 2002
Heating and hot water
Fuel

Vendenesse, 110 m2– oct./ nov. 2002
Heating and hot water Fuel

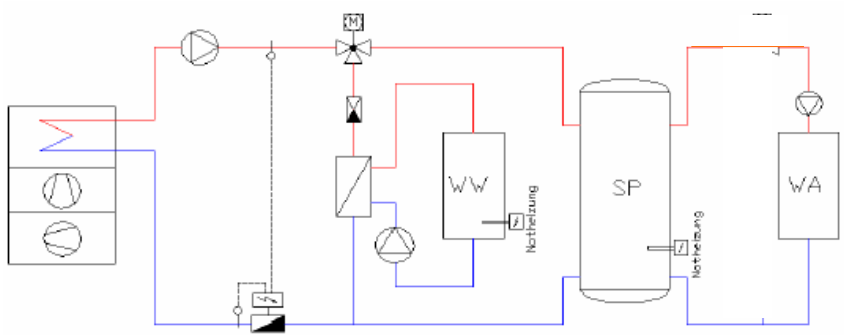
Target : **Single house (around 150 m²)**
Original system of heating : oil or gas boiler with radiators,
Design Temperature Text= - 10 °C, Losses of heat < 15 kW,
Hydronic distribution, 70°C max. water temperature in the inlet of radiators,

6 – Field tests

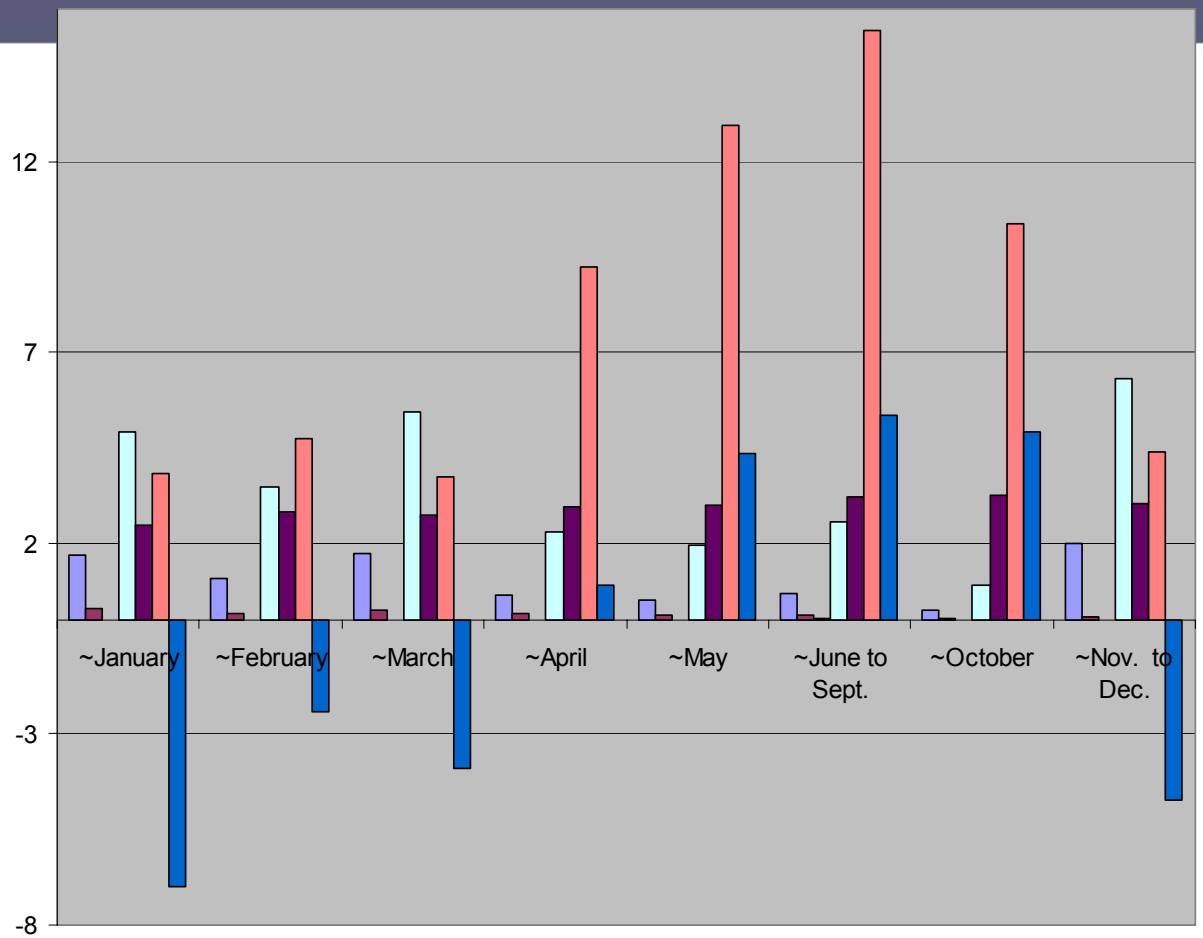
Field test in Flers (North of Paris)

- **Built in 1770**
- **Heating (65°C) and hot water production (55°C)**
  (Parallel storage for heating)
- **Alternate production with priority to tap water**

(Design temperature T= - 6°C)



Field Test Flers in 2004



Global COP : 2,95

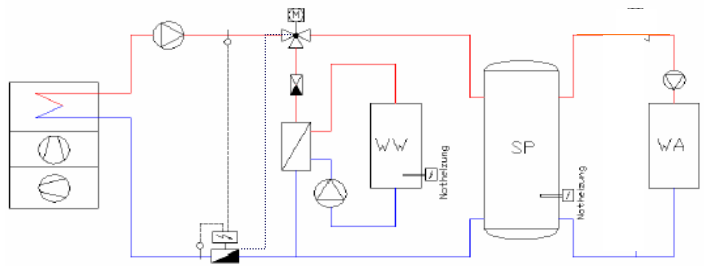
DHW COP summer : 3.21

Period of the year	~January	~February	~March	~April	~May	~June to Sept	~October	~Nov. to Dec.
Electricity input (MWh)	1.678	1.084	1.719	0.635	0.527	0.688	0.236	1.988
Electric backup heating (MWh)	0.303	0.142	0.251	0.143	0.13	0.1	0.047	0.079
Electric backup DHW (MWh)	0	0	0	0	0	0.008	0	0.001
Thermal Energy (MWH)	4.93	3.484	5.421	2.313	1.961	2.559	0.916	6.33
Number of days between 2 measurements	35	28	40	28	42	129	14	49
COP value	2.49	2.84	2.75	2.97	2.98	3.21	3.24	3.06
Outdoor air (°C)	3.82	4.73	3.75	9.25	12.95	15.44	10.35	4.39
Min outdoor air (°C)	-7	-2.4	-3.89	0.9	4.34	5.34	4.93	-4.73

6 – Field tests

Data measurements in progress in Egleny (South of Paris) :

To assess the performance of the combined production of heating and DHW, during the heating period 2004-2005, we measure both the heating COP and the DHW COP



Sample of Data during february 2005

Thermal energy :
6150 kWh for heating
349 kWh for DHW (5%)

Characteristics of the Heat Pump (February)			
	min °C	**Max °C**	**Average °C**
Heating Supply temperature		69,0	56,8
Heating Return Temperature		60,0	50,5
DHW Supply temperature		64,0	40,1 (20 to 60)
Outside Temperature	**-7,0**	18,0	3,4
Ambiant Temperature living room	16,4	22,1	19,20
Ambiant Temperature bedroom	13,3	21,0	19,3
Heating COP			**2,12**
DHW COP			**2,63**
Global COP			**2,14**

Seasonal results soon

6 – Field tests Conclusion

- **Seasonal COPs are between 2,4 and 3 depending on the external weather.**

Example : Installation in Flers

Seasonal Heating COP : 2,95

(Lower T_{out} : -6°C, $T_{ambient}$:20°C with HotWater)

Divided by 2 the price of energy bill (Propan Boiler)

- **Customers satisfaction in term of comfort and energy is quite good *when the HP is properly installed***

No problem concerning the compressor and all components of the HP

Installation problems due to skills of installers (plumbers)

for a new product (need of technical rules and specifications for retroffiting)

- **The HT HP is a good product for heating and tap water production with high potential : relevant and reliable**

HT HP is a good retrofit solution

EDF
Electricité de France

Thank you for your attention

R&D