



Development of a high temperature CO₂ Heat Pump for space heating

Dr.-Ing. Georges KHOURY
SANDEN Manufacturing Europe, France
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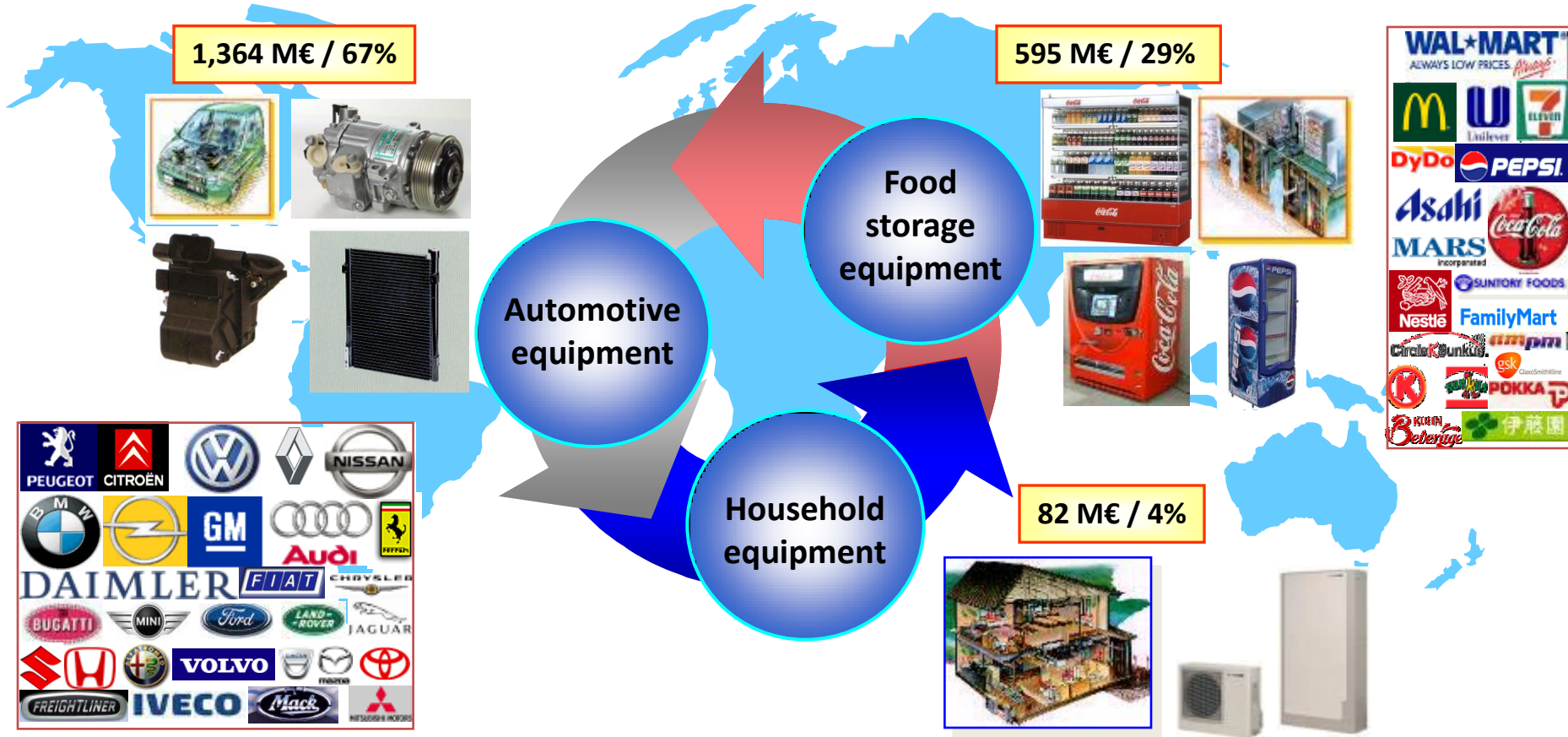
Development of a high temperature CO₂ Heat Pump for space heating

- SANDEN profile
- House heating in France
- CO₂ as Refrigerant
- CO₂ Heat Pump for space heating
- Test Results
- Cost Analysis
- Conclusions



SANDEN Group Profile

Creation	July 30., 1943
Turnover	2 041 M€ in 2011
Employees	8 750 (15 000 with JV)



1/4 of vehicles are air conditioned by SANDEN products
1/3 of food storage equipments are SANDEN products

GLOBAL FACILITIES : Mfg and R&D

With the concept of "Closer to customers"

Global SCM and development structure with 56 facilities in 23 countries.



Sanden International USA
Wylie Plant
Comp. for North America

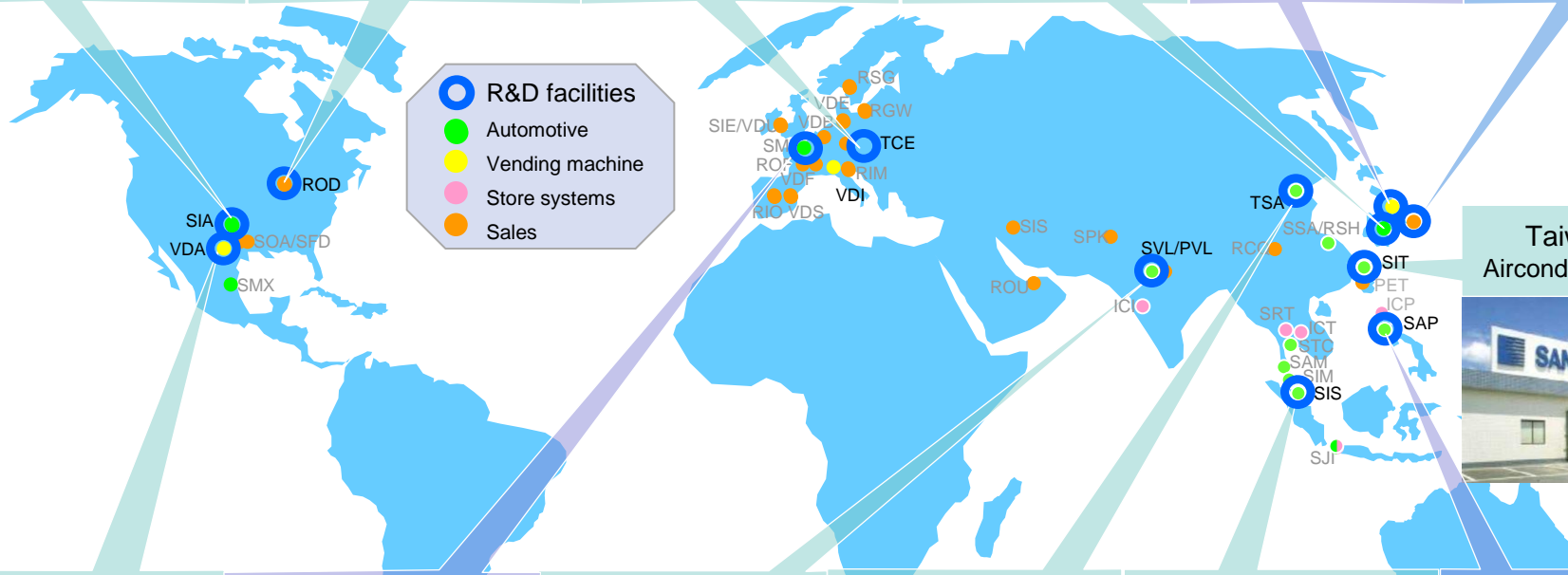
Sanden International USA
Detroit Office
Compressor for North America

Technical Center Europe
In Deutschland
Compressor for Europe

Yattajima
Automotive systems

Akagi
Vending systems

SGCT
Material & Advanced tech



- R&D facilities
- Automotive
- Vending machine
- Store systems
- Sales

Taiwan Plant
Airconditioner for Asia



The Vendo Company
Dallas Plant
Vend. machine for America

Sanden Manuf'g Europe
Tinténia - France

India Plant
Airconditioner for Asia

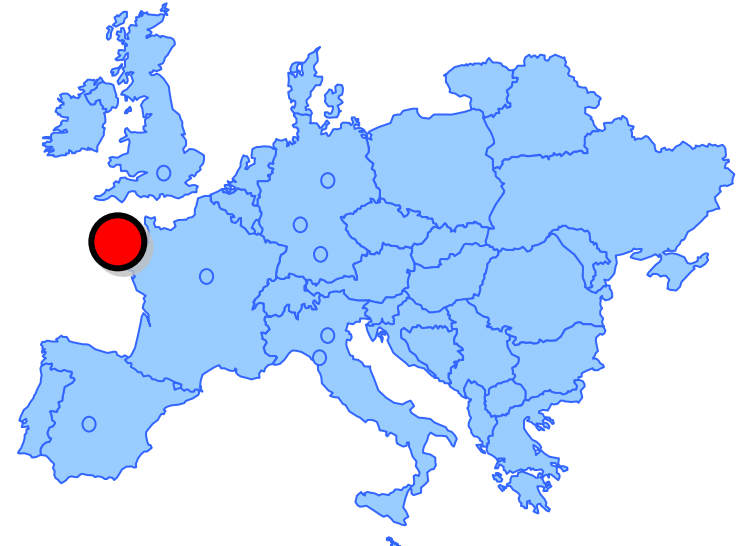
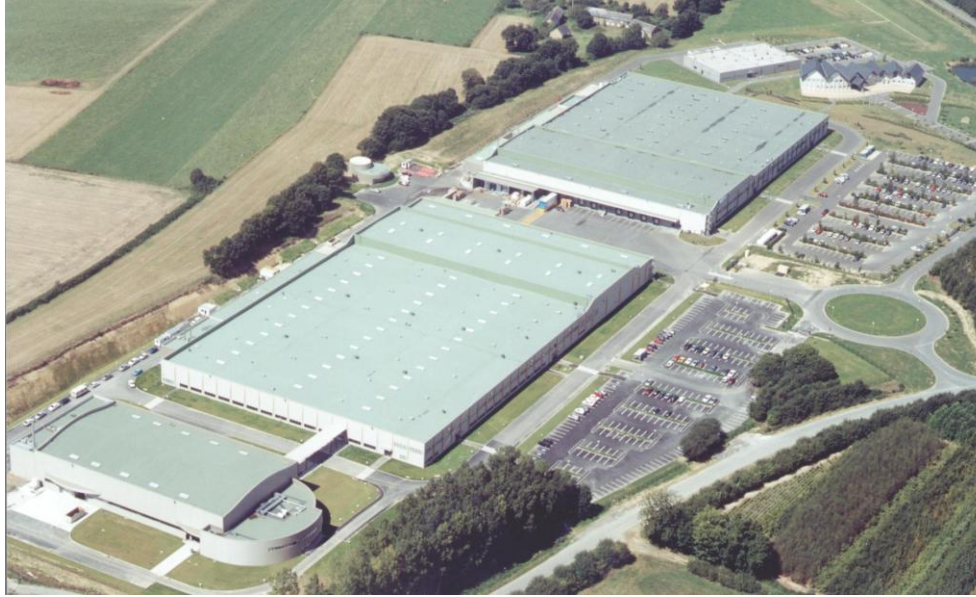
Tianjin Plant
Airconditioner for China

Singapore Plant
Airconditioner for Asia

Philippine Plant
Airconditioner for Asia



Focus: Sanden Manufacturing Europe (SME)



CREATION : April 1995

SOP : June 1996

CAPITAL : 33.2 M Euros

TO : 207 M€ (FY11)

EMPLOYEES : 800 pers

TOTAL SURFACE : 22 Hect.

BUILDING: 5.4 Hect.

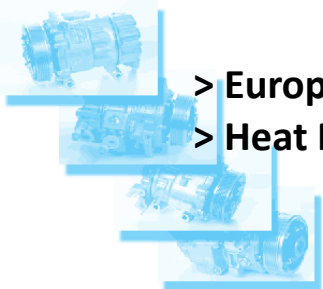


>> Tinténiac (35) in Bretagne

MANUFACTURING & DEVELOPMENT (R&D)

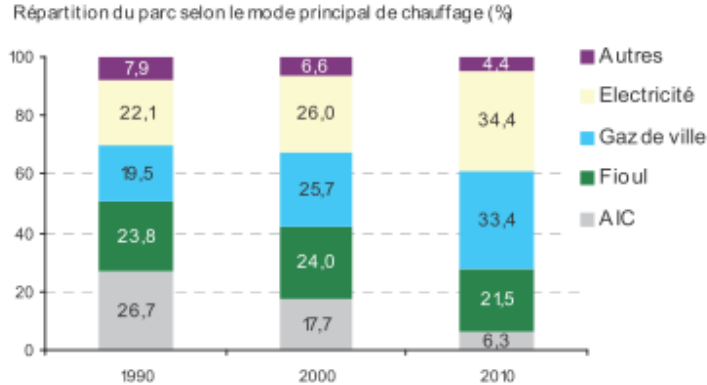
Activities :

- > Compressors + HVAC
 - 5 assembly lines
 - 180 machining centers
 - 7 die casting units
- > European Warranty Centre
- > Heat Pumps
 - 1 assembly line

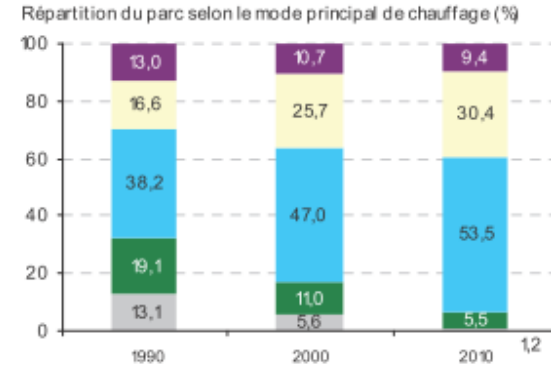


2. Heating technologies repartition in France

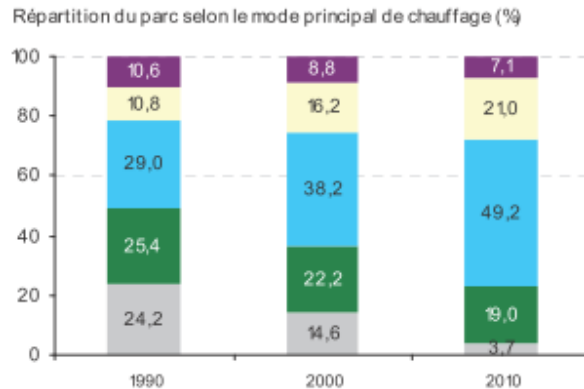
Houses



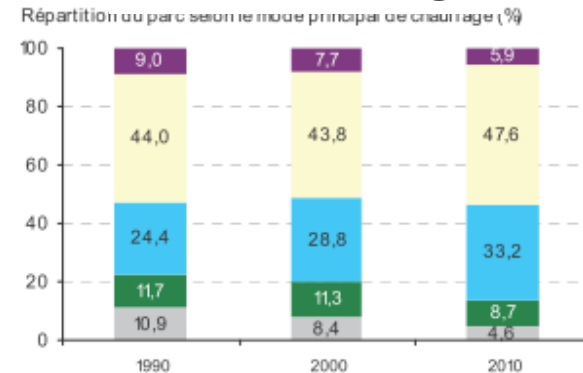
Apartments



Old dwellings



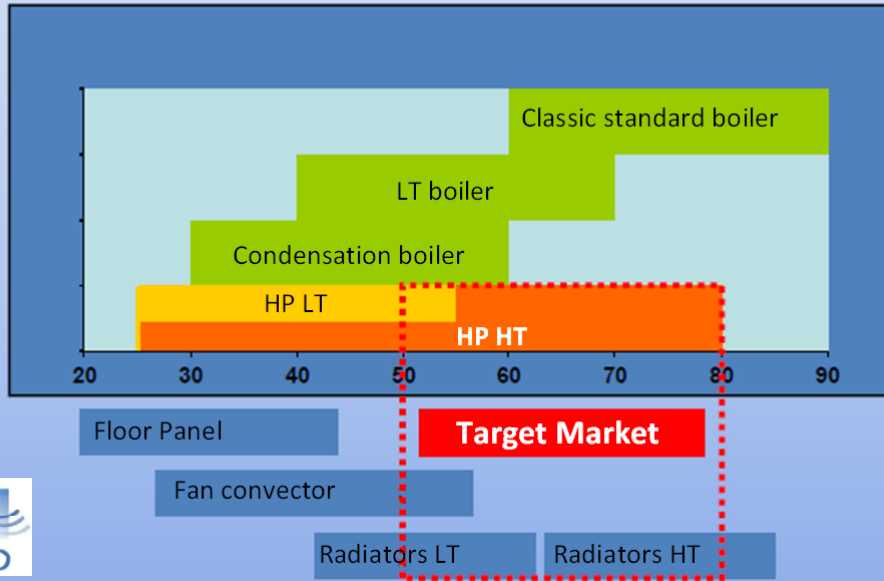
Recent dwellings



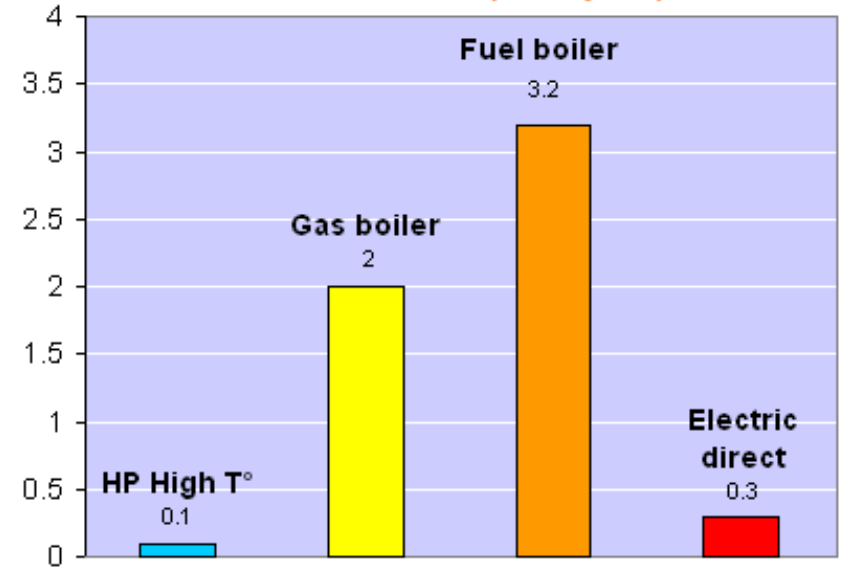
- Increase of electric systems share
- Old houses : mainly Gas and Fuel Boilers

2. Heating technologies repartition in France

Temperature zones for different space heating systems

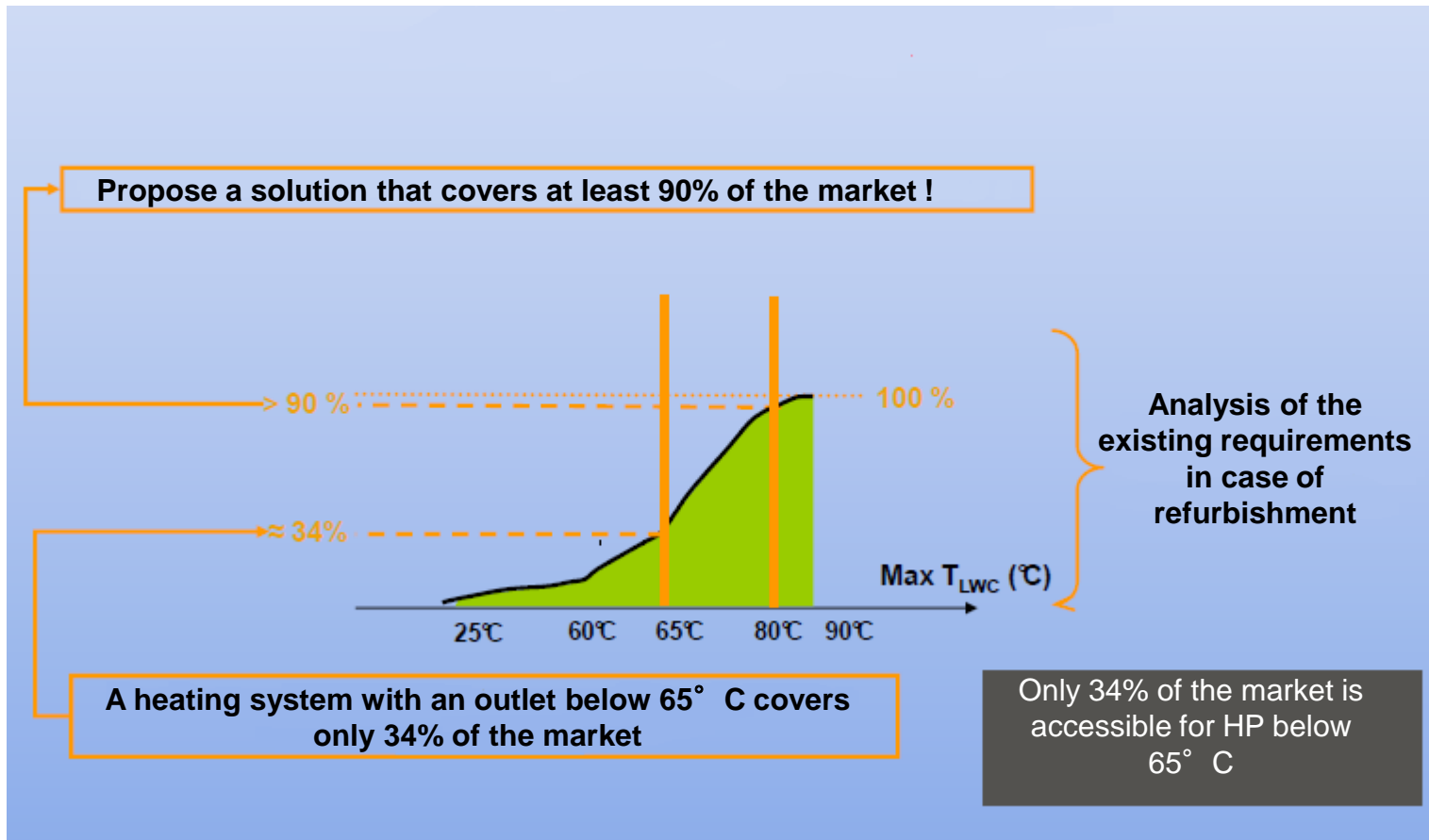


CO₂ emissions (tons/year)



- High T° HP is an alternative to fuel and gas boilers
- It allows to reduce significantly CO₂ emissions
- And reduces the energy bill

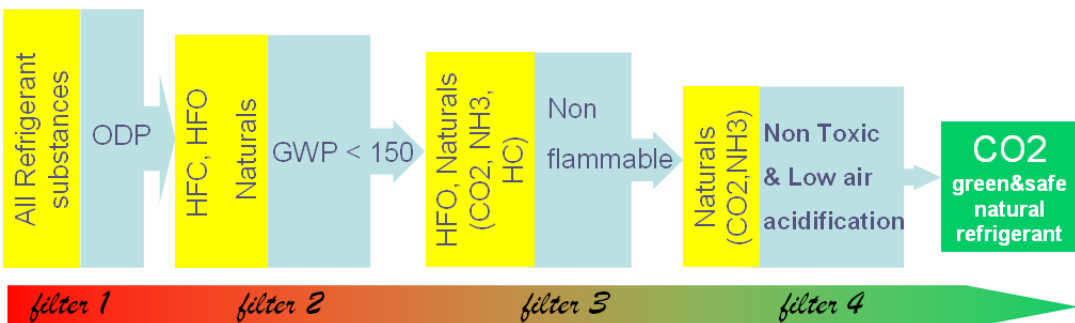
2. Heating technologies repartition in France



CO₂ (R744) has a big advantage

A refrigerant that climbs easily to high Temperature

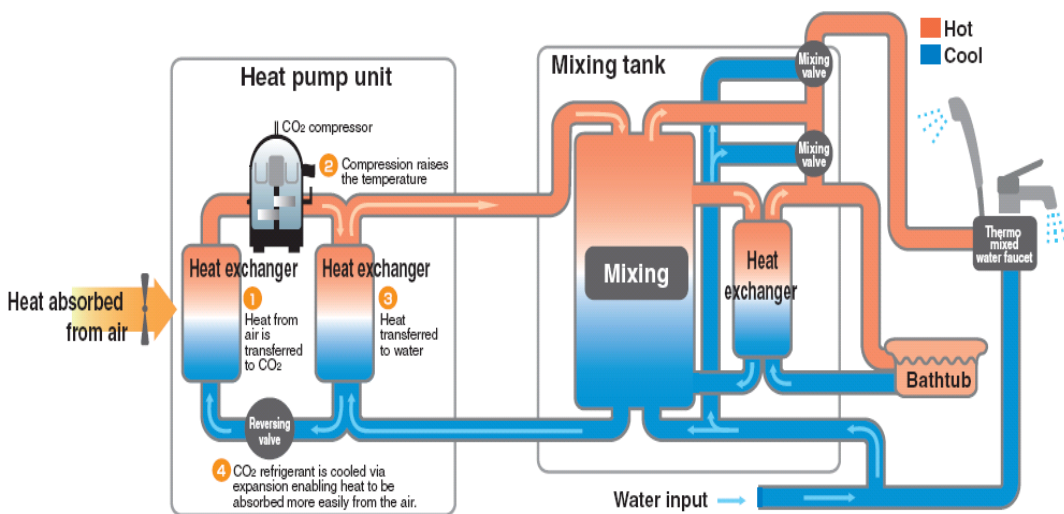
3. CO₂ (R744) as refrigerant



Target Applications



Inside an EcoCute Hot Water System



SANDEN product for Japan



Installation	Outdoor
Heat Capacity	4.5 kW
Tank Capacity	370 Liters
Water T°	55 to 85° C
Water Quality	Soft

3 Million units « EcoCute » sold in Japan since 2000
500k+ units per year

How EcoCute Uses Heat in the Air to Produce Hot Water

Aquaeco2- CO₂ HP for DHW in EU (domestic hot water)



✓ aquaeco2 the most efficient of the market and the most silent (40dBA)

✓ COP 3.42 @ 7 ° C EN16147 (LCIE)

✓ T° water storage @ 65° C

✓ DHW solution for RT2012 (French new thermal regulation for buildings)

✓ COP Field Tests measurements

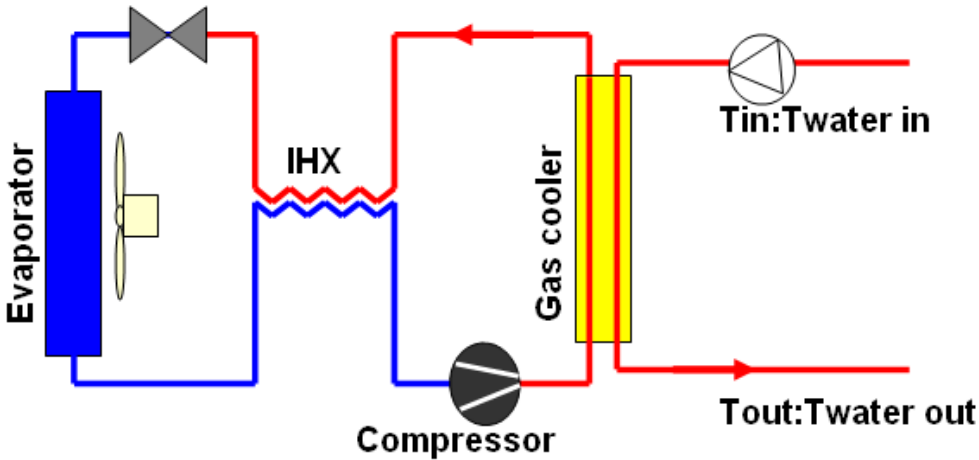
COP aquaeco2 (2.7) = 2 x COP classical (R134a)
(data ADEME-INPAC 2012)



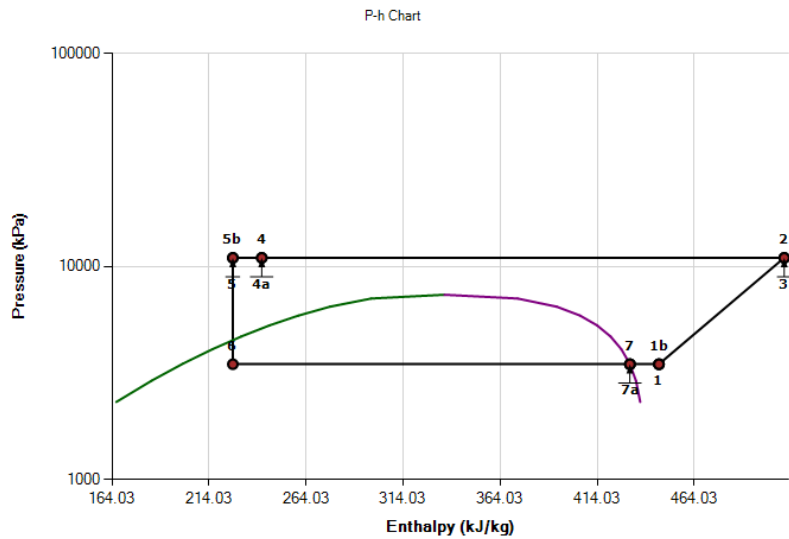
SANDÉN

Delivering Excellence

4. CO₂ for space heating ?

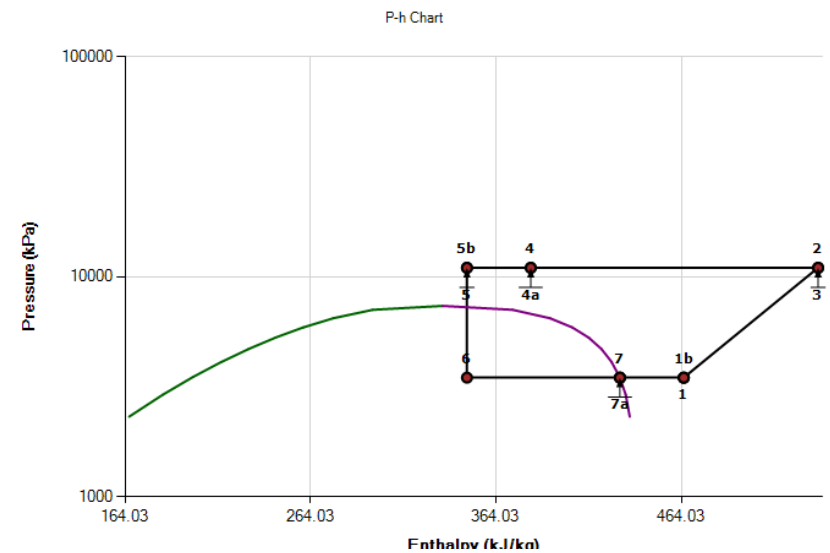


- ✓ CO₂ (R744) is the best for DHW
- ✓ Modest performance for space heating with a classical system



T_{in}=10° C & T_{out}=70° C

COP = 4.2 (high)



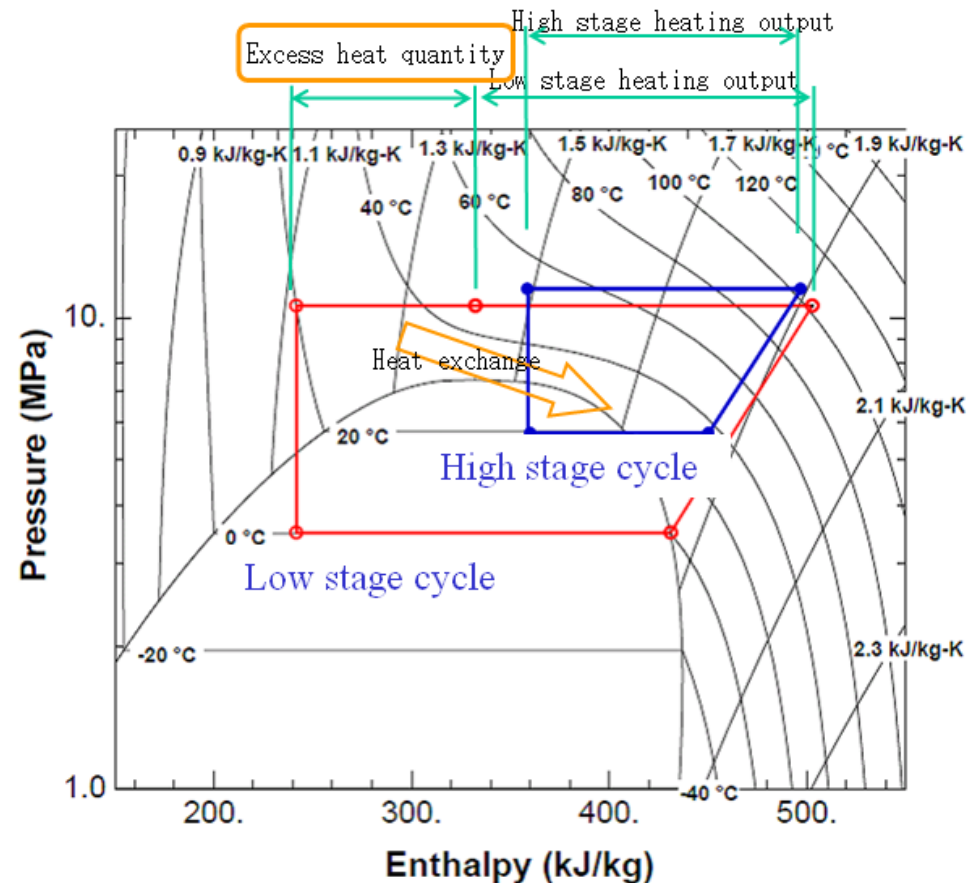
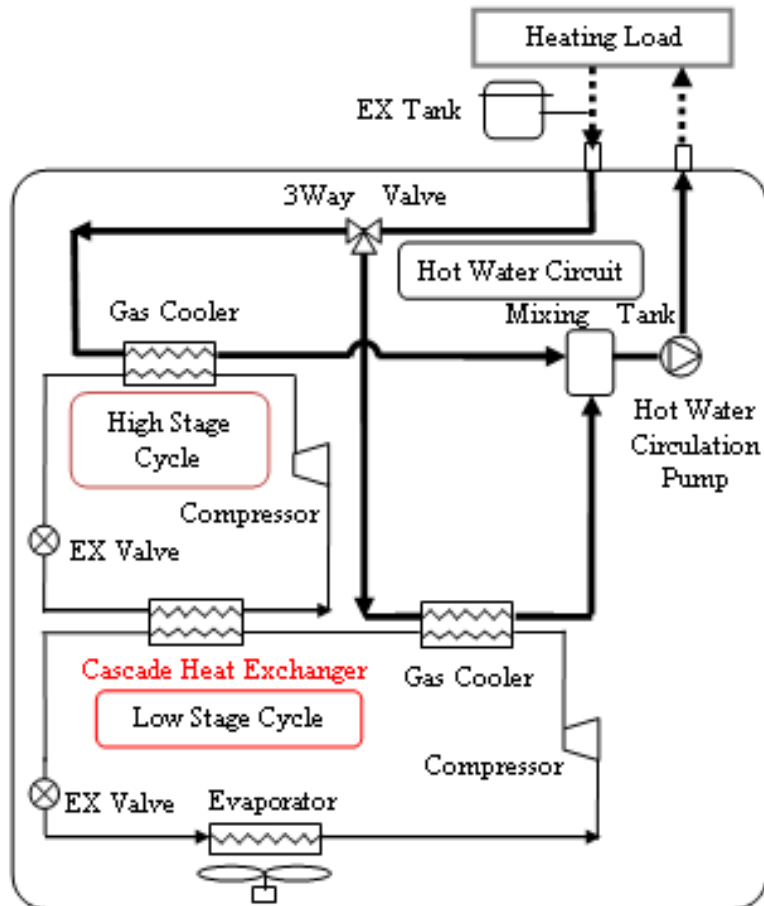
T_{in}=45° C & T_{out}=70° C

COP = 2.1 (medium)

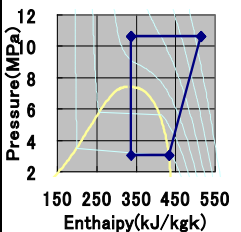
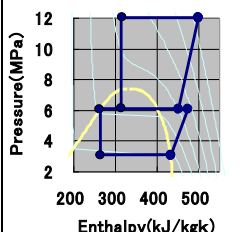
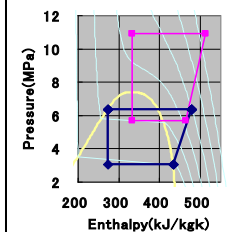
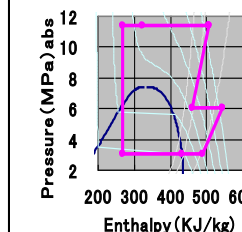
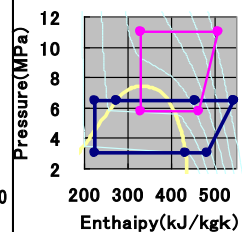
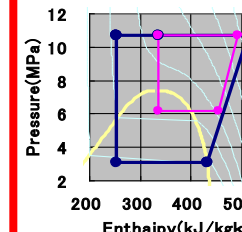
4. CO₂ for space heating ?

Sanden CO₂ system : New cascade and New control

The upper stage recovers the excess of heat in the first stage through an intermediate heat exchanger (refrigerant/refrigerant)



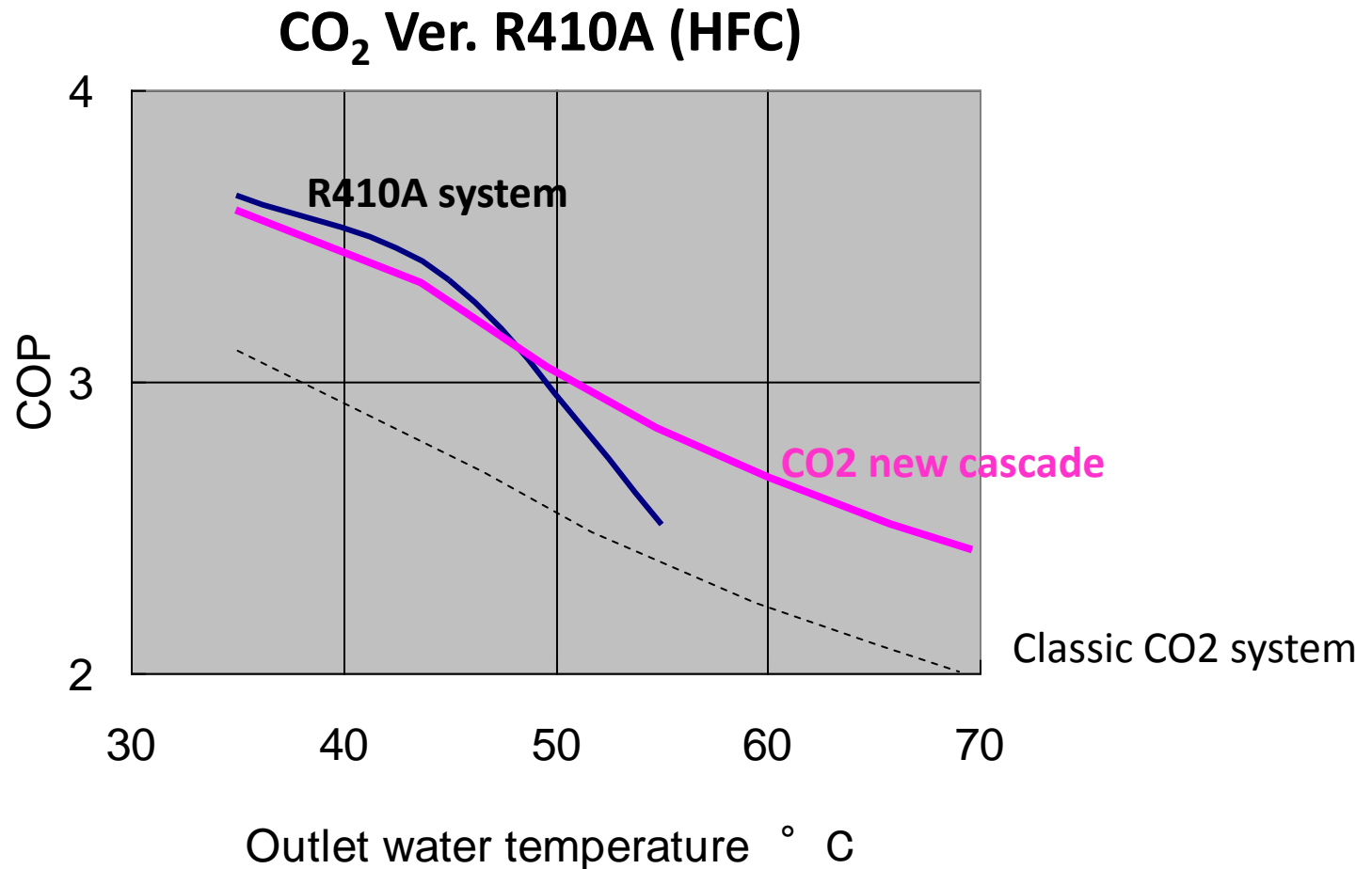
Sanden reinvents the CO₂ with a new patented technology

	Classic system	Injection system (1GC)	Classic cascade system (1GC)	2 stage system (2GC)	New cascade system (2GC) + classic control	New cascade system (2GC) + new control
	Heating	Heating	Heating	Heating	Heating	Heating
Maximum heating capacity (Priority:COP)	5.3kW	7.2kW	8.4kW	5.7kW	7.8kW	8.6kW
Maximum heating capacity (Priority:heating capacity)	5.3kW	7.2kW	9kW	6kW	8.1kW	10.4kW
COP	2.1	2.3	2.3	2.6	2.6	2.6
						

Possibility to make space heating and produce DHW simultaneously

A Sanden Cascade system with a new specific control logic boost the CO₂ efficiency and heat capacity for space heating application.

Sanden reinvents the CO₂ with a new patented technology



With CO₂ Heat Pump, High Temperature heating is feasible and production of DHW without back-up

Project: CO₂ air/water High Temperature Heat Pump

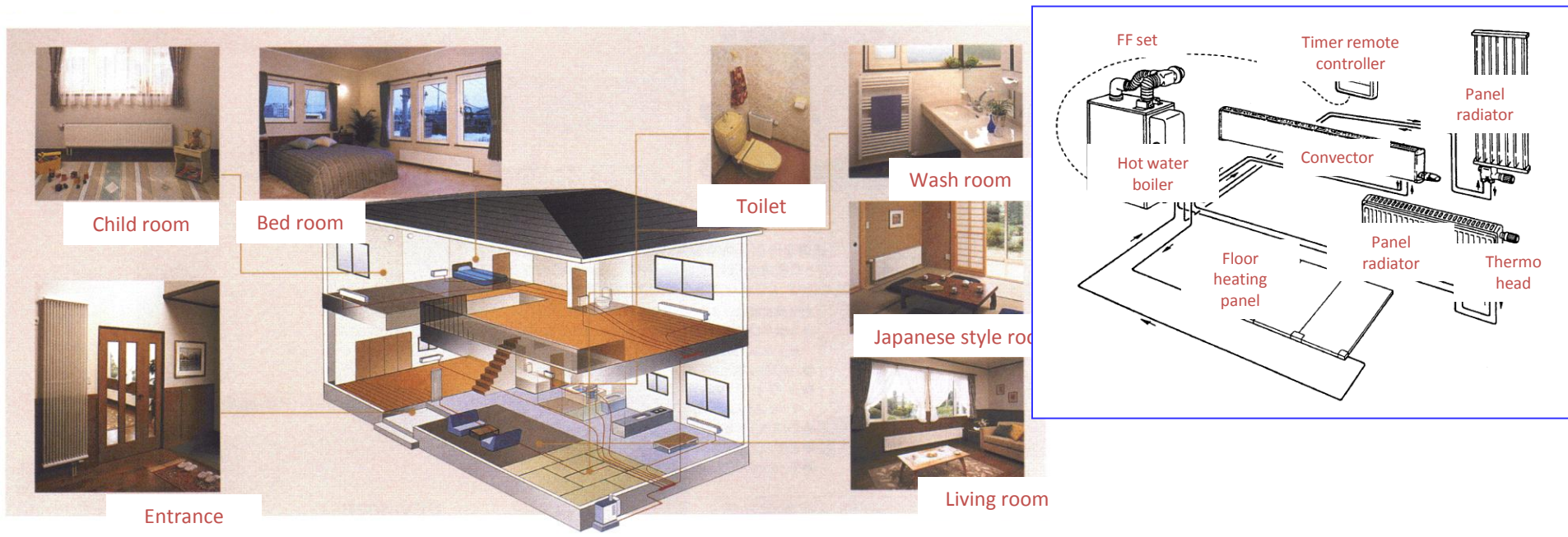
✓ Consortium in Japan with 3 partners:

- 1) Central Research Institute of Electric Power Industry
- 2) Hokkaido Electric Power Co., Inc.
- 3) Sanden Co. Ltd

✓ Target:

Introduce to market a high Temperature CO₂ Heat pump.

Propose a solution to replace central boiling heating systems. Such systems with water loop are popular in the North of Japan.



Result: Product since February 2012 in Japanese market

CO₂ High Temperature air/water heat pump for central heating



MODEL			EDS-C90A
Heating Capacity*		kW	9.0
Dimensions	Height	mm	1280
	Length	mm	828
	Depth	mm	283
Weight		kg	98
Noise		dBA	47
Outlet Temperature		°C	40~70



Remote controller

*Temperature Air 7°C
Temperature water inlet 30°C

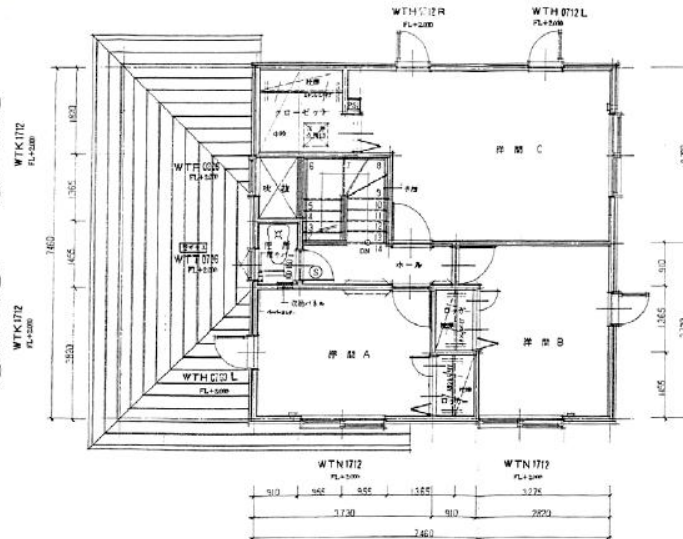
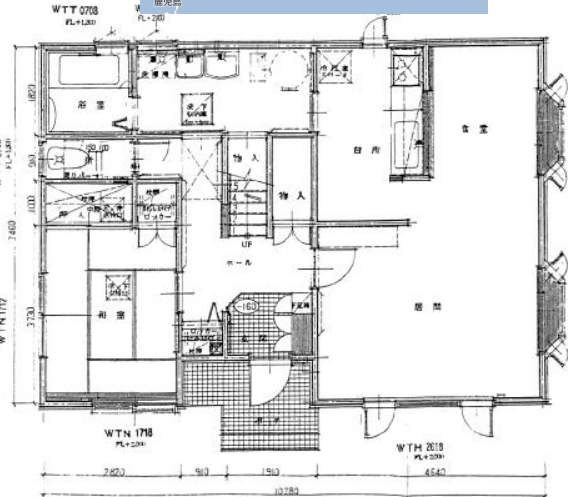
Field Tests in Japan

Individual House 120 m² according to new thermal regulation
(equivalent to BBC in France)

Kiyota, Sapporo
city



FT situation (taken on 12.12.2012)

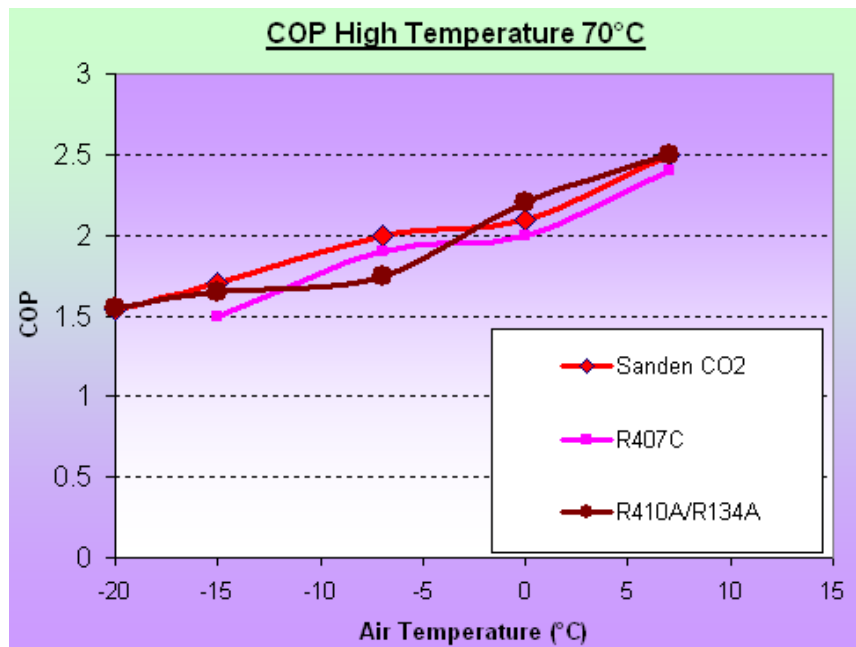


Field Tests in France since February 2012



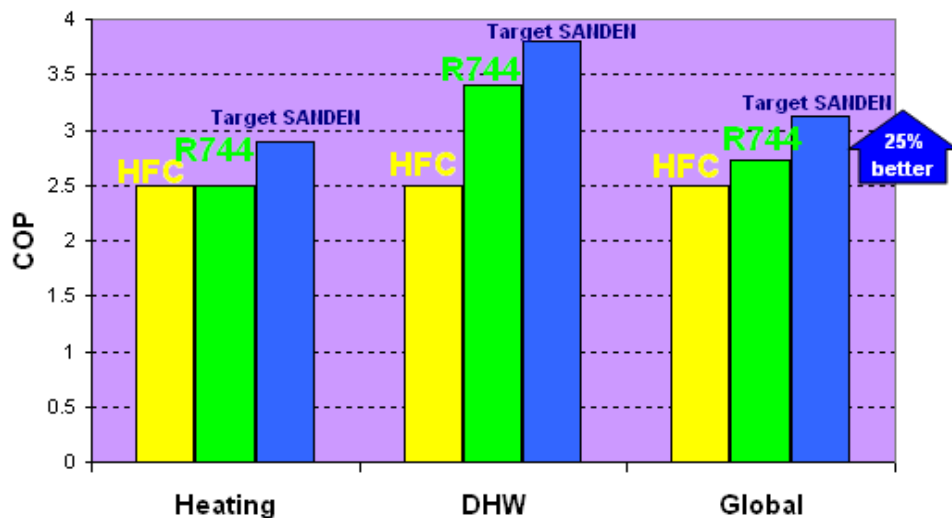
- 3 different areas
- Local Installers without any special previous training
- Positive feedback & COP ~2.5
- Need to optimize the control

COP CO₂ versus HFC (laboratory tests)



For high temperature space heating
R744 reaches the classical HFC level

In space heating mode, Sanden CO₂ becomes as efficient as HFC in TOP market products



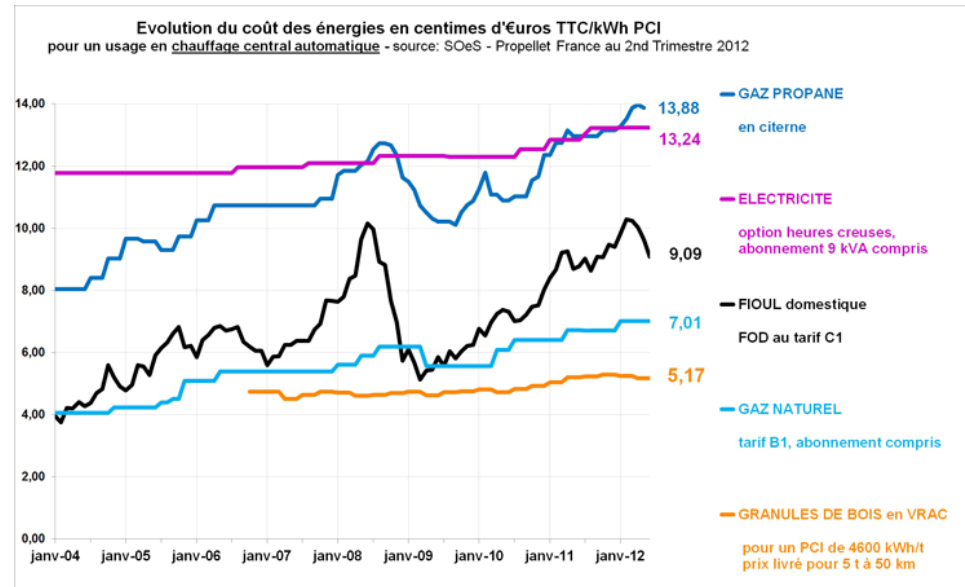
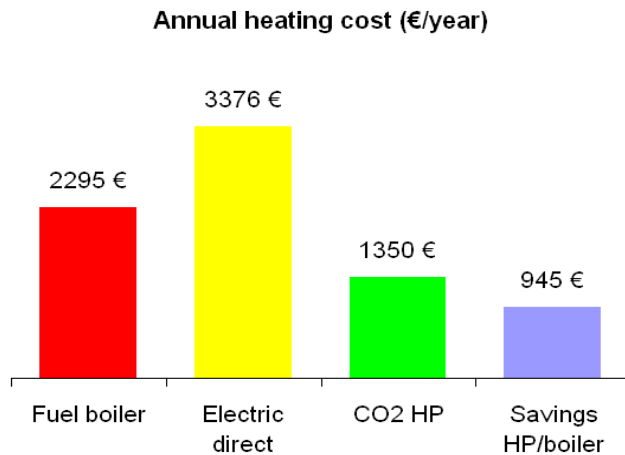
In case of a multifunction heat pump (space heating & DHW), R744 would be more efficient than HFC

GWP R744 = 1

GWP (HFC)~2000 & HFC represent 3% of the « Global Warming »

6. Cost Analysis for high T° HP in case of boiler replacement

Annual average cost for a 100m² house in France



With an efficient HT heat pump, the savings amount for an average 100m² house is around 945€

- HP (11 kW) Investment of 9000 € (after Tax credit recovery)**
- Fuel Boiler ~5000 € (including installation with all taxes included)**
- ROI = 8 years (replace existing boiler)**
- ROI = 4 years (new installation – versus a new boiler)**

*The average energy consumption for house heating is estimated at 255 kWh/m².year
It is equivalent to an average annual consumption of 2 550 liters of fuel for a 100 m² dwelling (Source ANAH).*

- **CO₂ HP a green & safe alternative for gas and fuel boilers**
- **CO₂ global efficiency is much higher than HFC**
- **Comfort is ensured at very low outside temperatures**
- **First product on worldwide level**
- **ROI starting from 4 years**





**Thank you for
your attention**