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# FRANCE'S PERSPECTIVES ON SUSTAINABLE ENERGY AND INTEGRATING DISTRIBUTED GENERATION

**Frank CARRE**

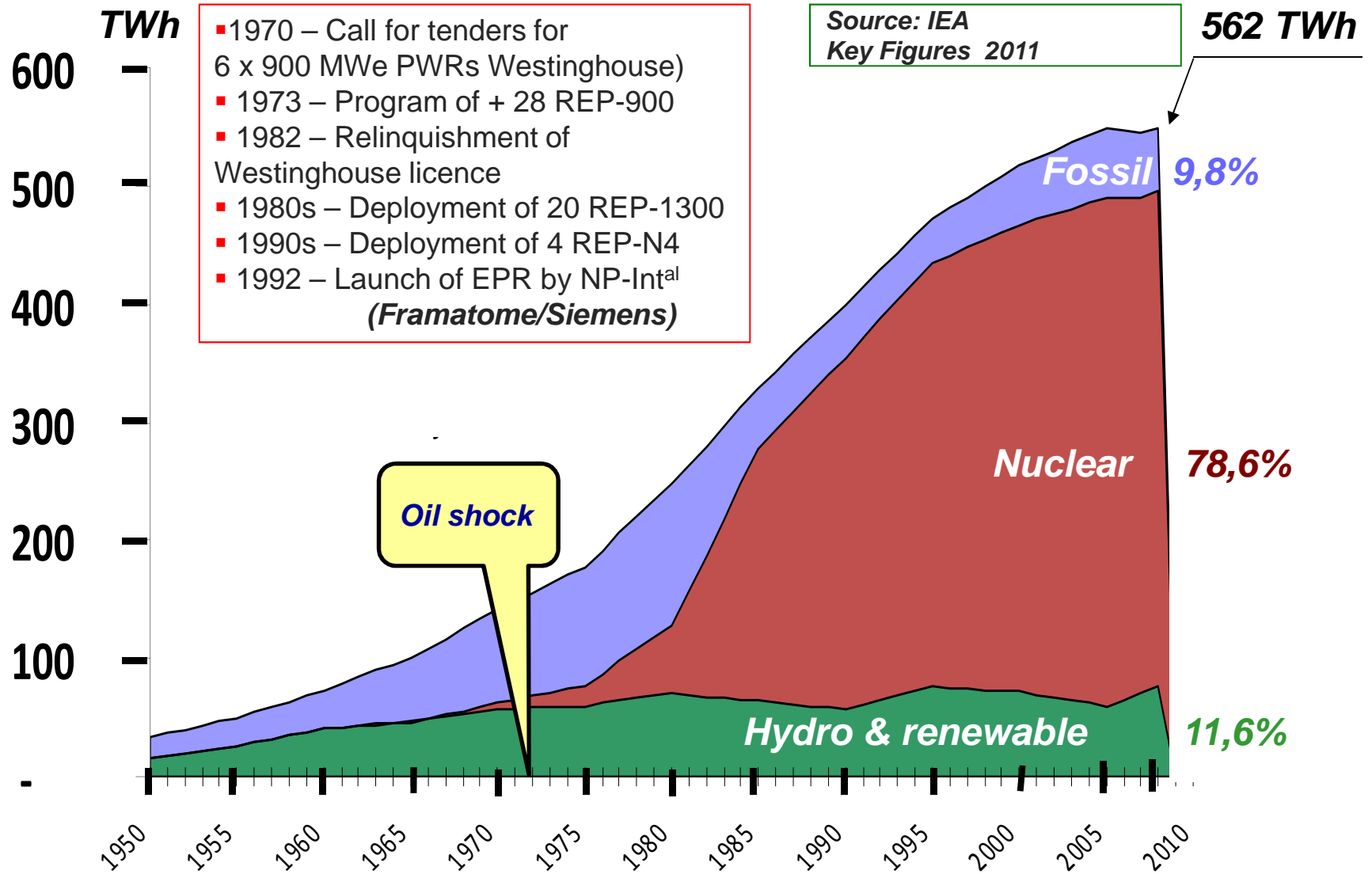
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University of Wisconsin – 2014 Energy Summit

October 29, 2014 - Madison WI USA

# HOW DID FRANCE COME TO NUCLEAR POWER?





# FRENCH FLEET OF NUCLEAR POWER PLANTS

## Current French fleet of NPP

58 operating PWR :

34 / 900 MWe 

20 / 1300 MWe 

4 / 1450 MWe 

## Projects :

1 EPR in construction 

**63 GWe**

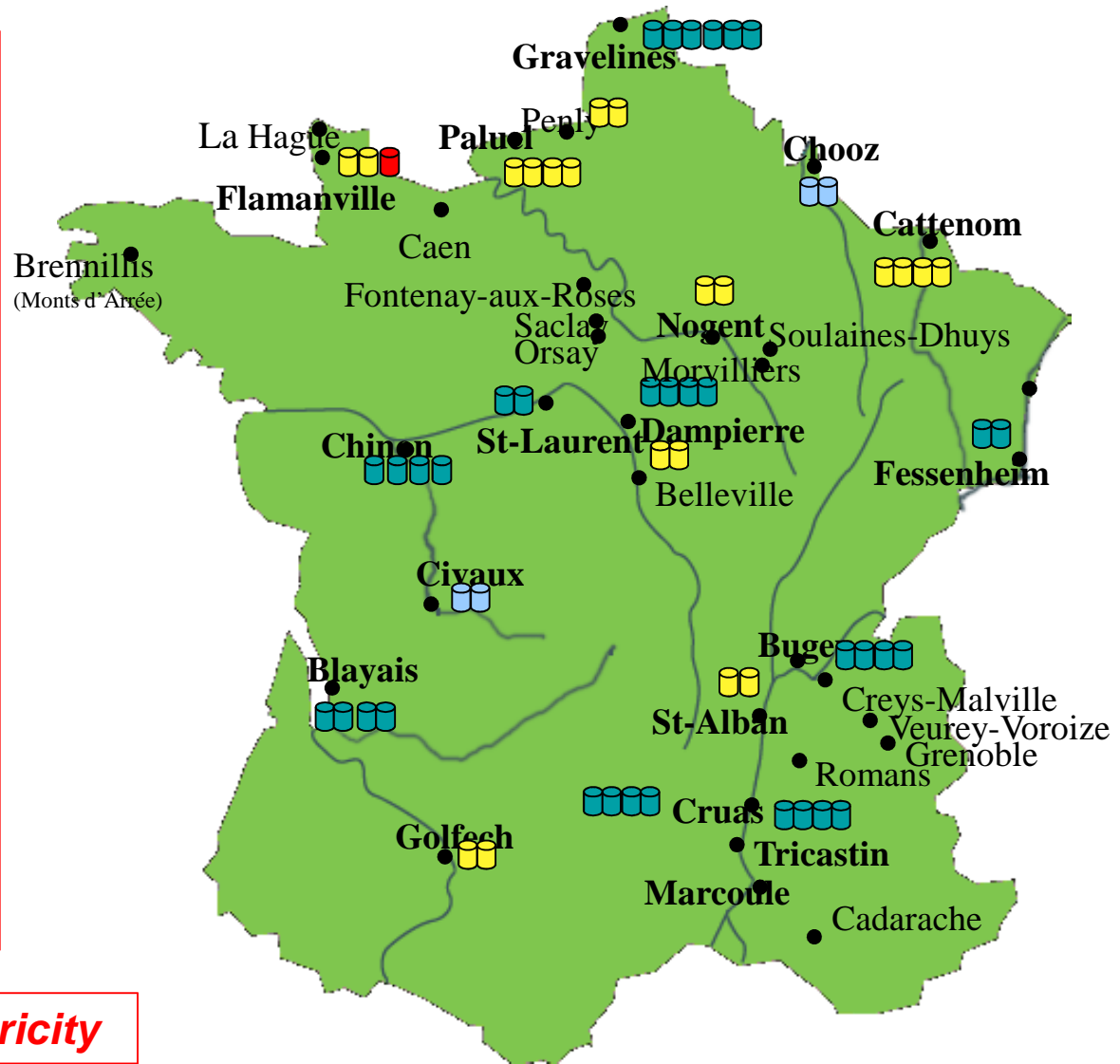
**~ 415 net TWh**

Average age ~29 years (2014)

## Connection to grid:

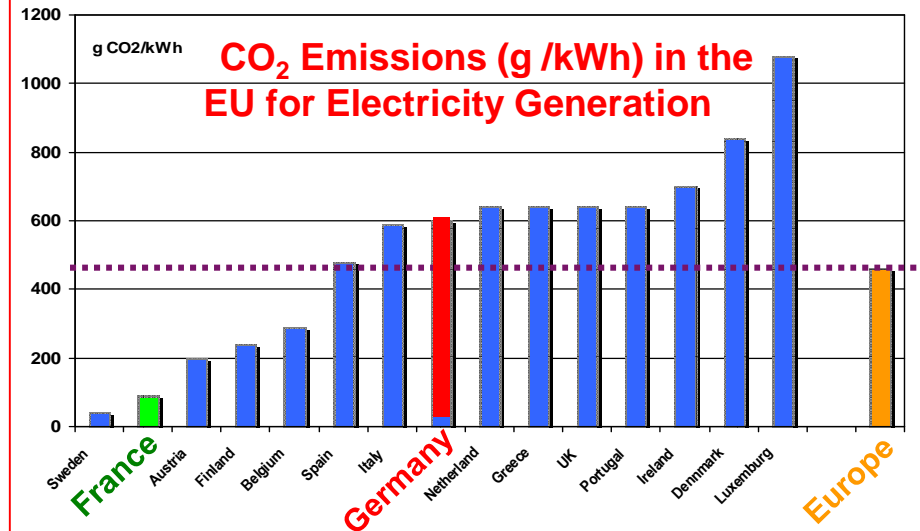
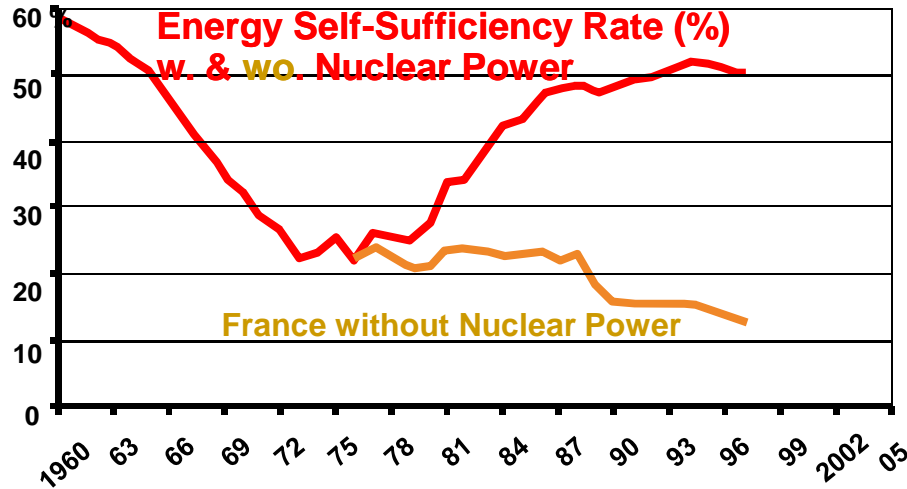
– Fessenheim 1 (n°1) : 1977

– Civaux 2 (n°58) : 1999

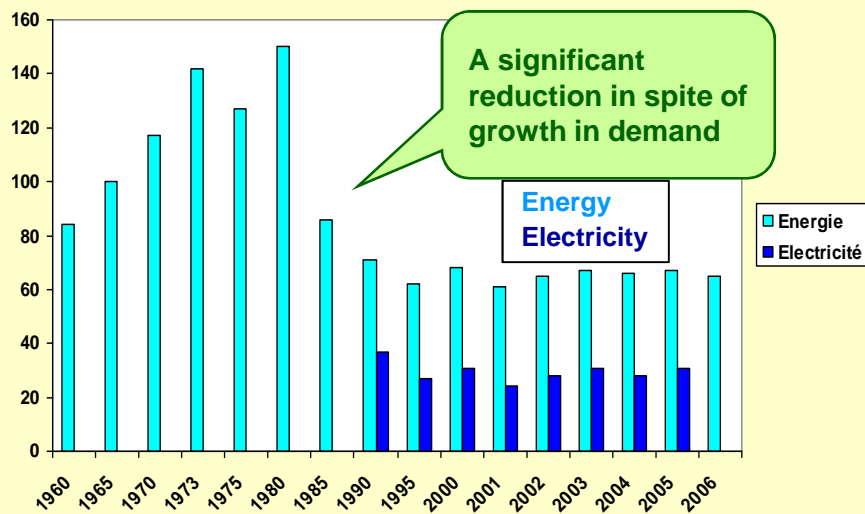


**~73% share of nuclear electricity**

# NUCLEAR POWER FOR ENERGY SECURITY & CLIMATE



## CO<sub>2</sub> Releases by the French Industry (Mt)

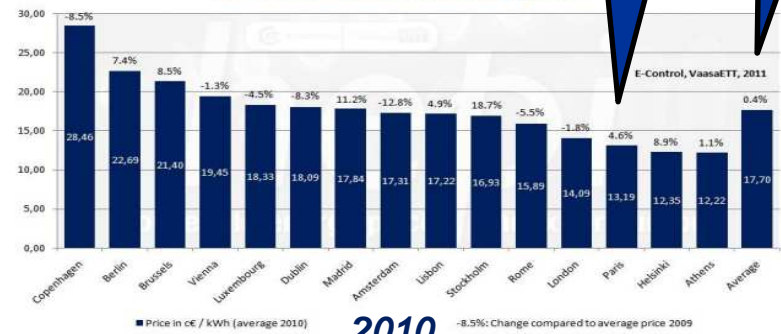


## Electric bill among the least expensive in Europe

**Court of Auditors 2014 Report**  
 Certified cost of Nuclear power  
 ~59,8 €/MWh  
 (Waste, Dismantling, Safety upgrades...)

EU-15 Average 177,0 €/MWh

France 131,9 €/MWh



## Towards a Low-carbon Energy Future

- 4/23/2006 – **Green Book on « Energy Policy for Europe »** issued by the European Commission

- March 2007 – **A new Energy Policy for Europe** proposed by the EC and endorsed by the Council  
→ Negotiation of a European « Energy-Climate package » issued on Dec. 11-12, 2008



- 11/22/2007 – **European Strategic Energy Technology Plan (SET-Plan)** setting European Commission goals for "**2020 Climate-Energy Package**"
  - 20% decrease in energy demand
  - 20% cut in greenhouse gas emissions
  - 20% of renewable power generation
 → Creation of « Technology platforms » (Solar, Wind, 2G-Biofuels, CCS, Smart Grids...+ Fission (SNE-TP))

- <2005 – **European Union Emissions Trading System**
  - Price of released CO2 ton too low to spur reduction (<<25 €)



# TOWARDS A MORE DIVERSIFIED LOW CARBON ENERGY SYSTEM IN FRANCE

## Developing renewable energies & Keeping the nuclear option open

Energy Policy Acts	Energy Security	Mitigating Climate change	Renewable Energies	Energy Efficiency	Others
<b>Energy Policy Act 7/13/2005</b>	<b>+</b> Diversifying energy sources	Sustainable development CO <sub>2</sub> emissions x1/4 by 2050 /1990	14% → 25% (2025)		Keeping the nuclear option open
« Grenelle de l'environnement » Act 1 6/24/2009 Act 2 7/13/2010  EU 2020 Climate-Energy Package		-3% CO <sub>2</sub> /y /1990  -20% EU GHG emissions (2020)	→ 23% (2020)  20% Renewable electricity in EU (2020)	EE incentives in buildings Norms for new builds <50 kWh/m <sup>2</sup> /y -20% EU energy demand (2020)	Incentives to electric & hybrid transport technologies
<b>2014 Act for Energy Transition &amp; Green Growth</b>  EU 2030 Climate-Energy Package	<b>Mastering the energy bill</b> → Decarbonization	<b>-40% GHG emissions (2030)</b> → Decarbonization  -40% EU GHG emissions (2030)	<b>32% Renewable electricity (2030)</b>  >27% Renewable electricity in EU (2030)	<b>-30% energy demand (2030) &amp; -50% (2050)</b> 500 000/y thermal insulation works in housing  >27% Energy savings in EU (2030)	<b>Nuclear capped to 63 GWe &amp; 50% of electric power in 2025</b>

# TOWARDS A LOW CARBON ENERGY SYSTEM



## Fossil energies

**50 % of primary energy needs**

**Growing cost towards unbearable levels:**

- 2003-2005 ▶ 10 % of export revenues (25 G€)
- 2010 ▶ 25 % of export revenues (48 G€)
- 2011 ▶ 35 % of export revenues (> 60 G€)

## Renewable energies

**9 % of primary energy needs**

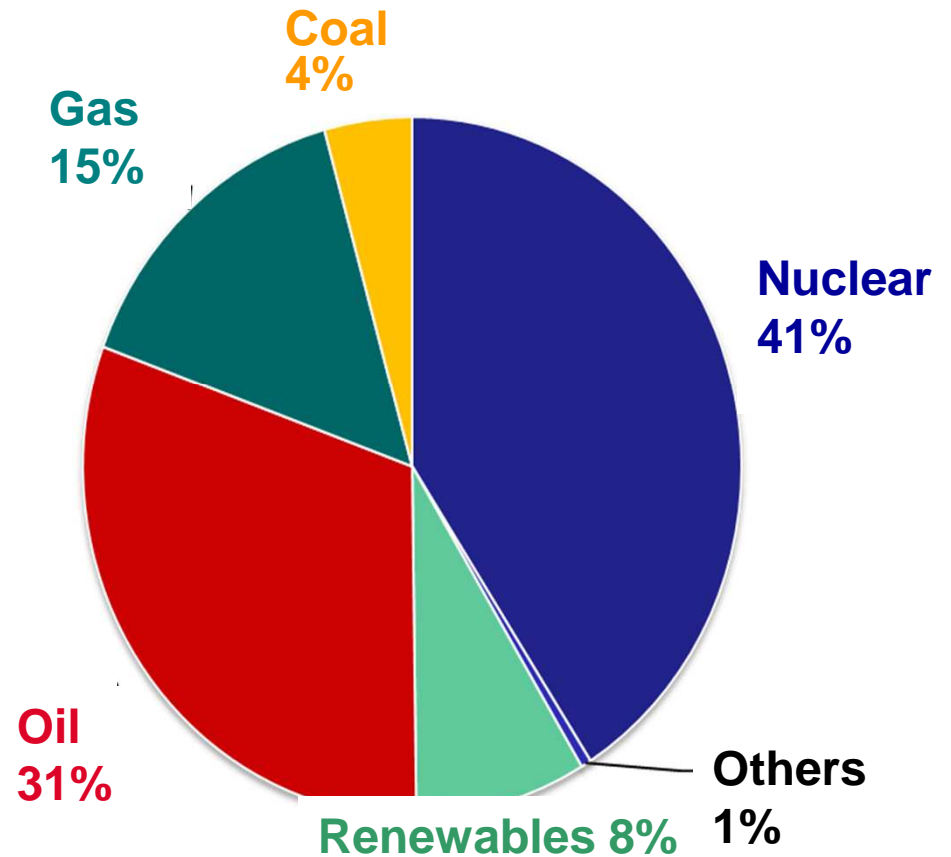
*(15 % of electricity generation)*

## Nuclear power

**41 % of primary energy needs**

*(75 % of electricity generation)*

## France's Primary Energy Consumption in 2010: 266 Mtoe



## 2030 goals of Energy Transition & Green Growth Act → CO<sub>2</sub> releases x 1/4 by 2050

Reduction by 30%  
of the global primary energy  
consumption

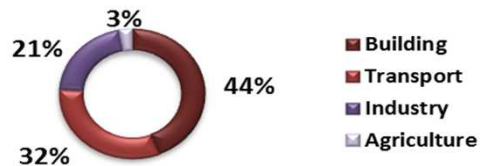
Reduction by 40%  
of greenhouse gas emissions  
(compared to 1990)

32% share  
of renewable energy  
in the energy mix

### Efficiency/Sobriety

- in industrial processes
- in housing
- in transport
- ● ●

Final energy consumption in France (2011)



### Nuclear and Renewable Energies :

Two pillars of the 2020 French energy mix:

- Renewables: intermittent supply
- Nuclear power: controllable power supply



*Preserve the use of fossil energies  
where they cannot be replaced*



## Objective:

- Diminishing the dependence from fossil fuels by **reducing energy consumption** and promoting **renewable energies**
- Progress towards a **more efficient low carbon energy model** that supports French citizens and economy's energy needs in a sustainable, fair and safe manner

## Current lines of research

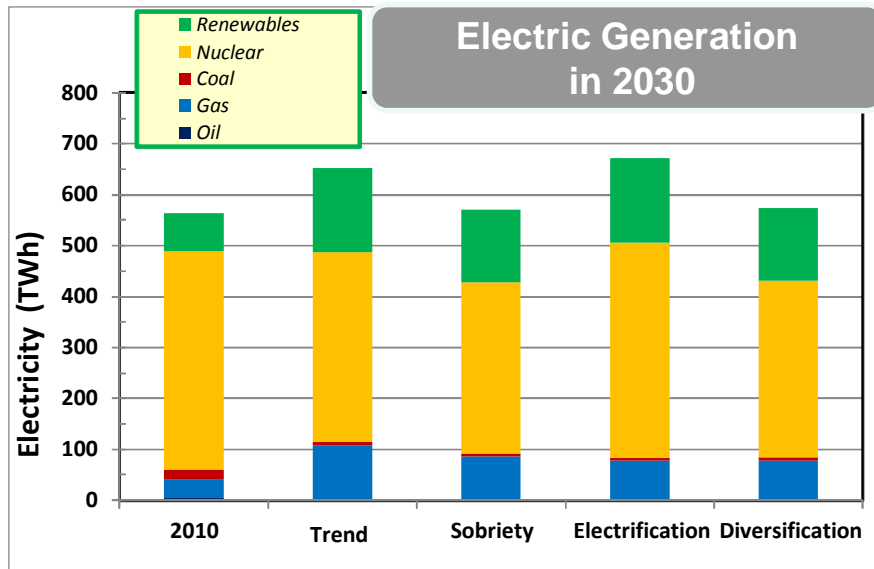
- **Energy efficiency and sobriety**
  - **Housing & Residential:** 500 000 home insulation renovations per year
  - **Transports:** increasing fuel vehicle efficiency to 2 l/100 km (~115 mpg) by 2025 and support the development of electric, hybrid and hydrogen fuelled vehicles
  - **Industry:** strengthen energy efficiency and on site recovery of waste heat
- **Renewable energies and nuclear as pillars for low carbon energy generation**
  - New tenders for solar and wind parks + off-shore windmills, Improved use of biomass
  - Nuclear & Solar cogeneration (H<sub>2</sub>, district heating, process heat...)
- **Electricity & Energy storage, Integration of power, H<sub>2</sub> and heat networks, CCS...**

## Energy scenario studies (DGEC, RTE, NGOs, Industry, ADEME, ANCRE...)

- Strengthened **energy efficiency and sobriety**
- Energy efficiency and **more (low carbon) electricity**
- Energy efficiency and **diversifying energy carriers**



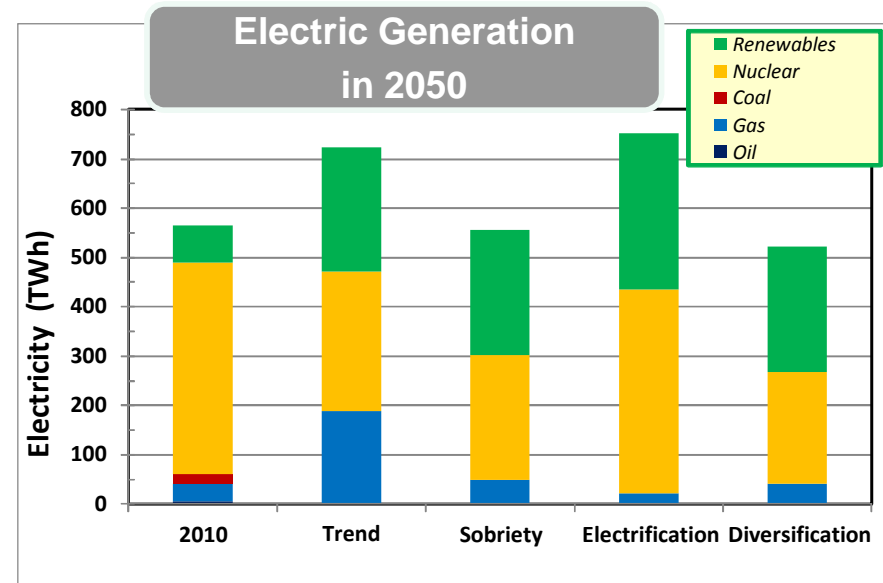
## First indications of trends



The management of intermittency & Factor 4 on CO<sub>2</sub> rely on:

- Smart grids & CCS (SOB)
- Storage of electricity (ELEC)
- Cogeneration (DIV)

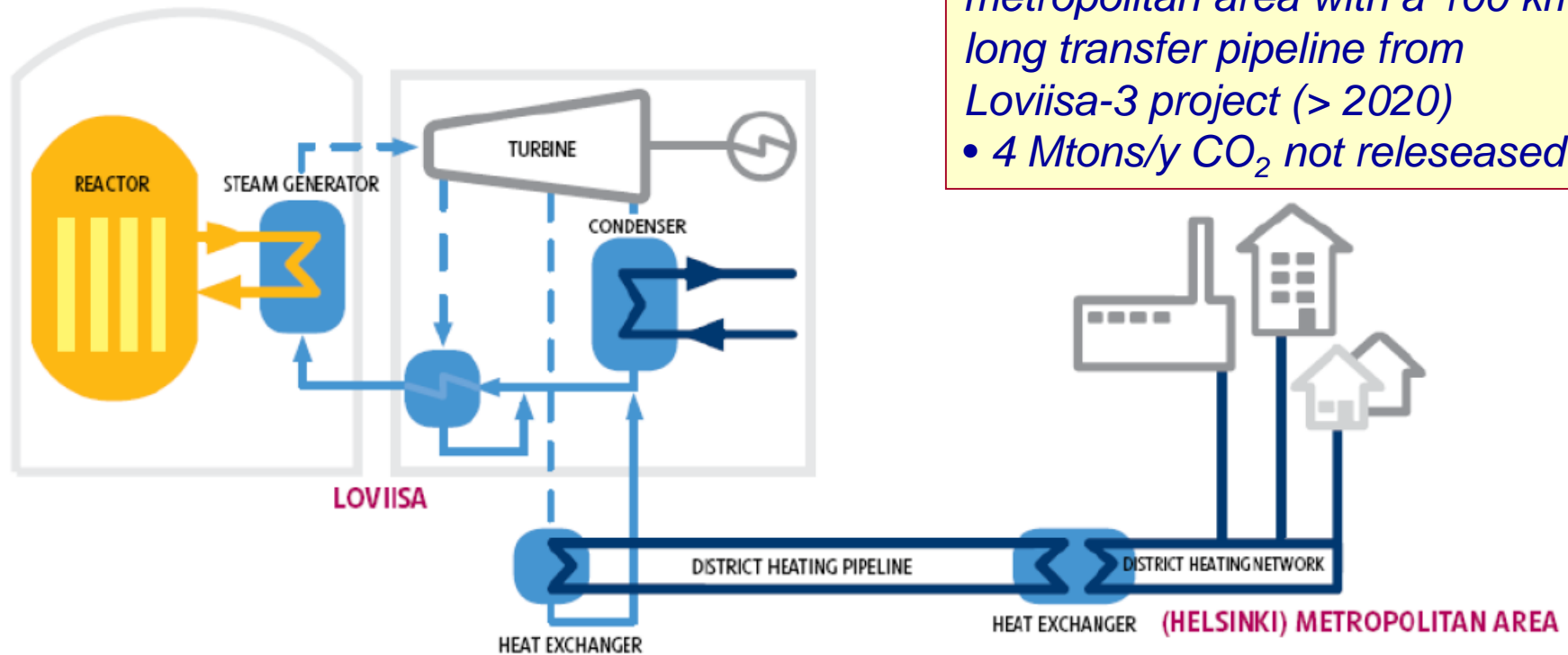
- Nuclear power will remain an important share of electric generation
- Meeting the factor-4 reduction of CO<sub>2</sub> calls for technology breakthroughs
- The increasing share of intermittent renewables calls for sufficient monitorable generation for grid stability



**Assumptions: 50% nuclear electricity in 2025, 100% back-up with gas power stations**

# District Heating from LWR Discharge Heat

## Heat extraction from a Pressurized Water Reactor



- *District heating of Helsinki metropolitan area with a 100 km long transfer pipeline from Loviisa-3 project (> 2020)*
- *4 Mtons/y CO<sub>2</sub> not released*

*from Harri Tuomisto, Fortum Power, Finland,  
Loviisa 3 project - October 2010*

# EU FRAMEWORK FOR GLOBAL CLIMATE & ENERGY GOALS WITH DIVERSIFIED NATIONAL ENERGY MIX

## Common goals

- Energy efficiency
- Reduction of GHG
- Growth of renewable energies

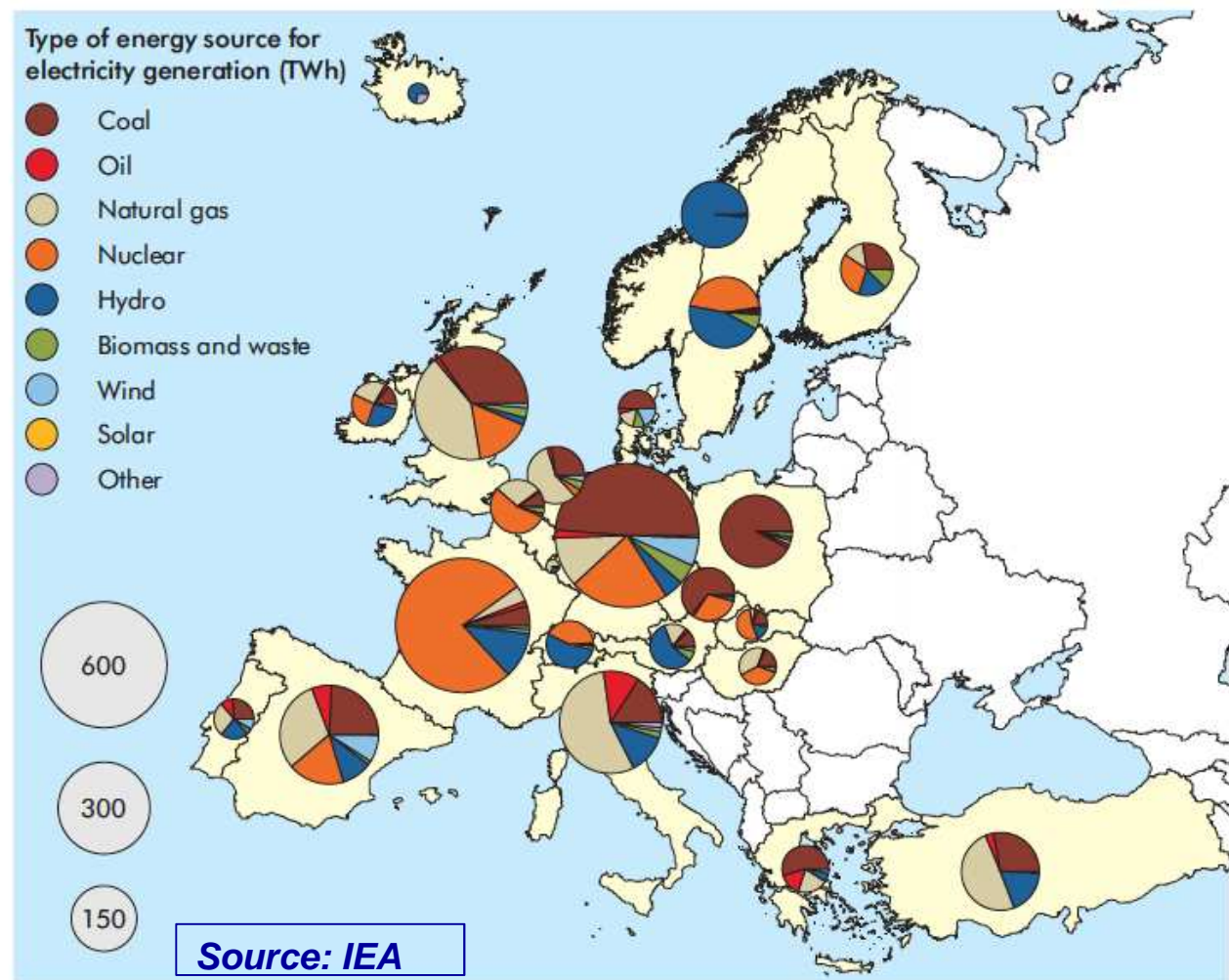
## Specific features

- Historic energy mix (*coal, nuclear, hydro*)
- Energy networks & storage + capacity
- Integrating variable renewable energies

## Issues

- ~40% variable power limit for grid stability
- Control must-take power from abroad
- Account for system costs for renewables
  - *Back-up, Balancing*
  - *Grid connection & extension*

**Figure 8.7** ► Electricity generation mix, OECD Europe, 2007



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

# PRINCIPLE OF SMART GRIDS TO BALANCE POWER SUPPLY AND DEMAND AT NATIONAL & LOCAL LEVELS

## Power supply

- Increased planning for variable energies
- Load following
- Storage
- Combined heat and power (CHP)
- Capacity market
- Energy efficient buildings

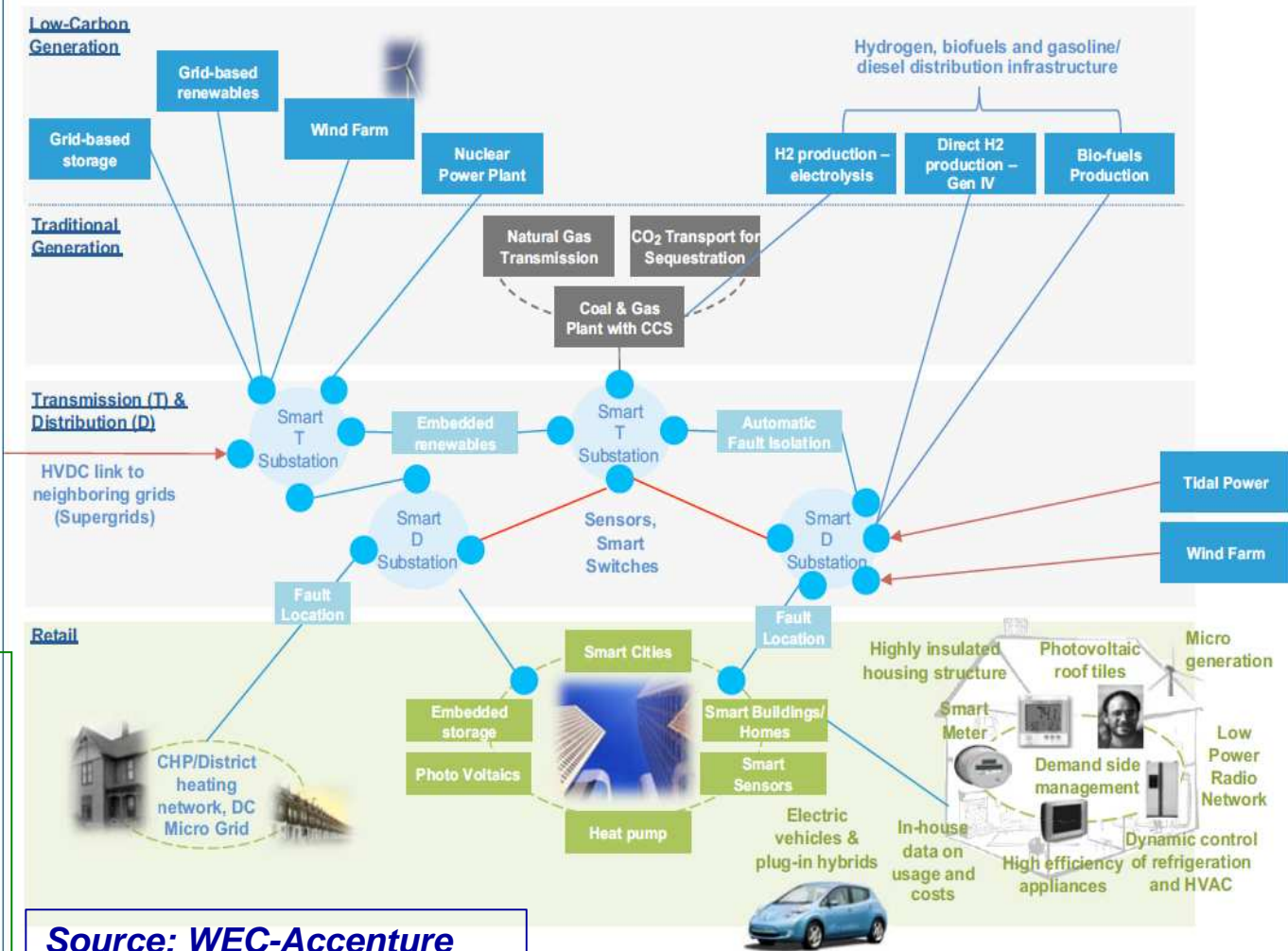
## Transmission & Distribution

- Dynamic distribution
- Smart metering
- Balancing demand & supply

## Power demand

- Increased planning for power demand
- Peak shaving & load shifting at household & regional levels
- Electrification of transport & Industry

Figure 1: The Smart Grid Definition

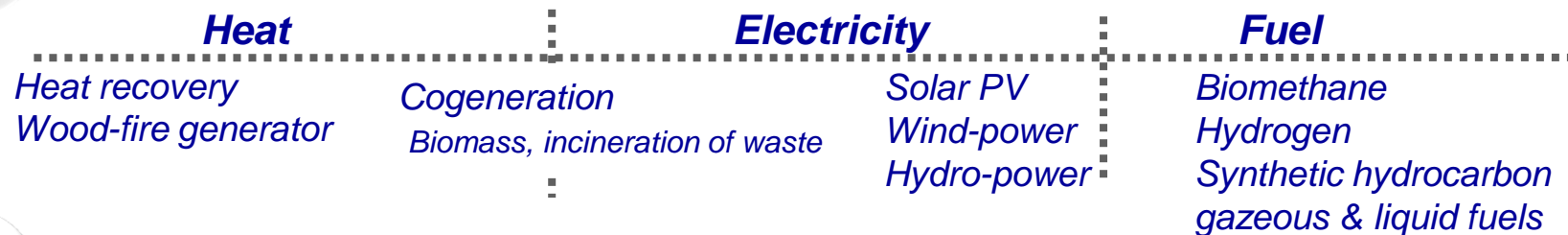


Source: WEC-Accenture

## Global Cities called to increasingly manage their energy

1

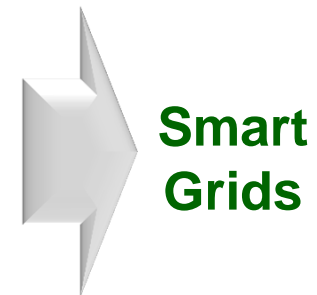
### While generating part of their *low carbon energy needs*



2

### While locally balancing energy demand & supply (*elec, gas, heat...*)

- Development, deployment & clustering of energy storage (electricity, heat)
- Combining cut-offs (industry, municipal venues ...)
- Encouragement for on site consumption for private energy supplier
- Energy management: measuring & managing use (BBC, smart-meters, ...)
- Options for investments in infrastructures (**energy efficient new districts, energy self-sufficient, and even energy-positive...**)

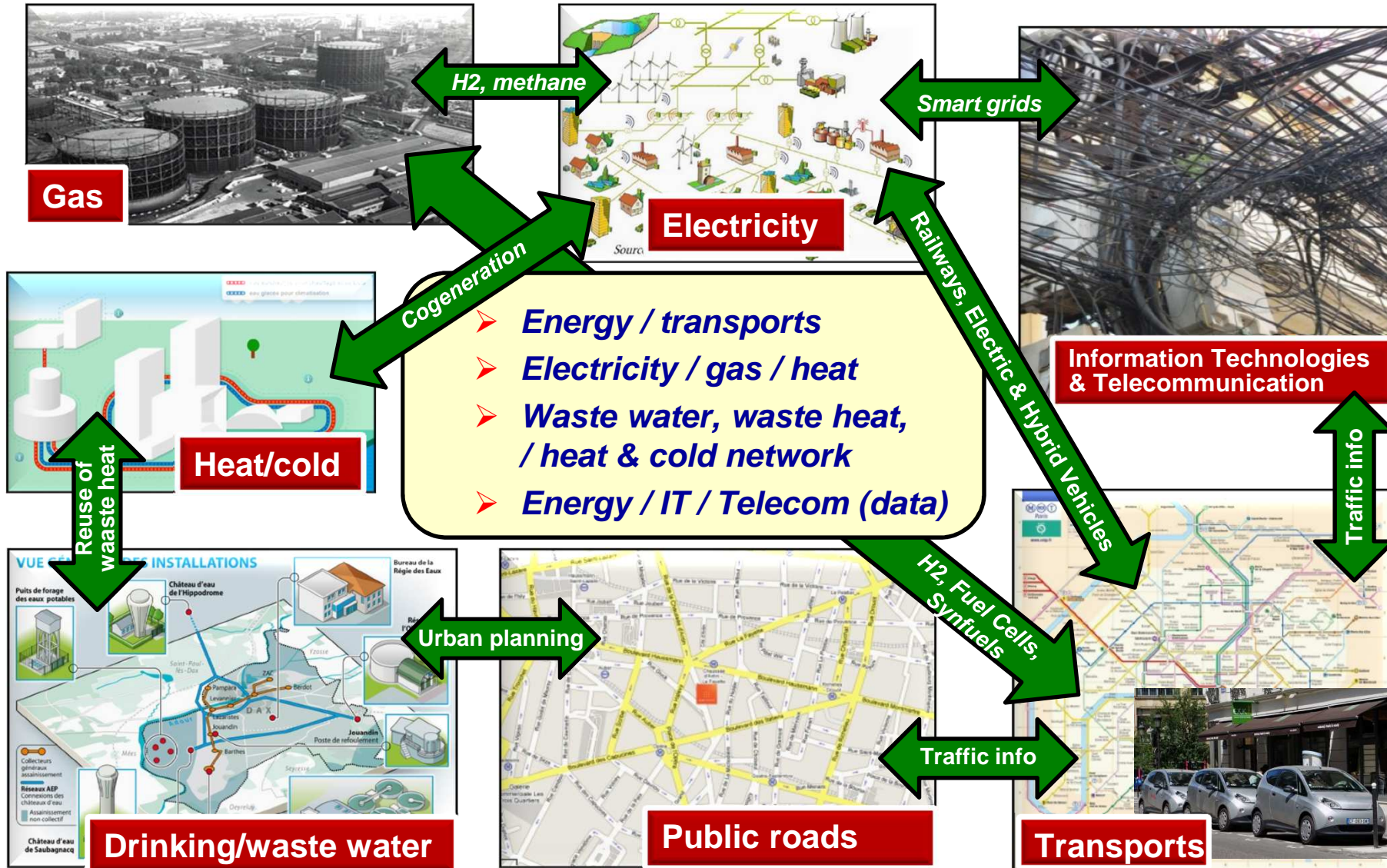


**New missions for global cities, new services to be developed around energy grids... and other linked services?**

**Issues:** Legal obligation to implement smart technologies as in the US and EU

- Dynamic regulation of local grids + Regulation Power supply by Central Generation & Transmission
- Massive investments needed in new infrastructures, sensors & controls. Financial incentives?
- Rising cost of energy? More flexible pricing mechanisms → Increased complexity? Lack of transparency?

# GLOBAL CITIES: A COMPLEX SYSTEM OF INTERCONNECTED NETWORKS



## Energy transitions in France

- (1950-2000) – **Nuclear energy for energy security**: an historical decision with a strong political support magnified by oil shocks of the 1970s
    - Deployment of French Fleet of 58 LWR Nuclear Power Plants
  - (> 2000) – **Diversifying energy sources and keeping the nuclear option open in a low carbon energy mix – Convergence with EC Energy Goals**
    - Energy Policy Act (7/13/2005)
    - A European Strategic Energy Technology Plan (11/22/2007)
  - > 2014 – **Further integration within the European energy system**
  - 2014 – **Act on Energy Transition and Green Growth**
    - Energy efficiency & displacing fossil fuels for a low carbon energy future ( $\frac{1}{4}$  CO<sub>2</sub> by 2050)
    - Development of renewable energies & Integration with nuclear power capped at 63 GWe
- **Challenges ahead:**
- *Management strategy for **grid stability with an increasing share of variable renewables***
  - ***Smart grids** for a dynamic balancing of power supply and demand with an **increasing share of distributed generation***
  - ***Massive investments in infrastructures, sensors, controls and home renovation works***
  - ***Technology breakthroughs (i.e. R&D) and significant behavioral changes required***
- **Economic viability and social acceptance of planned Energy transition still to be proven**