AGENZIA NAZIONALE
PER LE NUOVE TECNOLOGIE, L'ENERGIA
E LO SVILUPPO ECONOMICO SOSTENIBILE

DEMOSOFC – Open Workshop
Biogas fed fuel cell systems for industrial applications

The role of FC in the waste to energy chain Pathway in Italy

Torino, 24 September 2015

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Pope Francis

Pope Francis @Pontifex · 8h

Climate change represents one of the principal challenges facing humanity in our day. #LaudatoSi

5.4K 6K

Pope Francis @Pontifex · 9h

The climate is a common good, belonging to all and meant for all.

5.1K 6.5K

The three main challenges

- Clean air
- Global warming
- Secure supply

EU Energy Roadmap 2050

The Energy Roadmap 2050: a basis for developing a long-term policy framework (*Ref: COM 2011 885)*

- *EU objective for 2050 – GHG emissions down to 80-95% below 1990 levels*
- *A low-carbon 2050 strategy*
- *A framework for longer-term action in energy and related sectors*

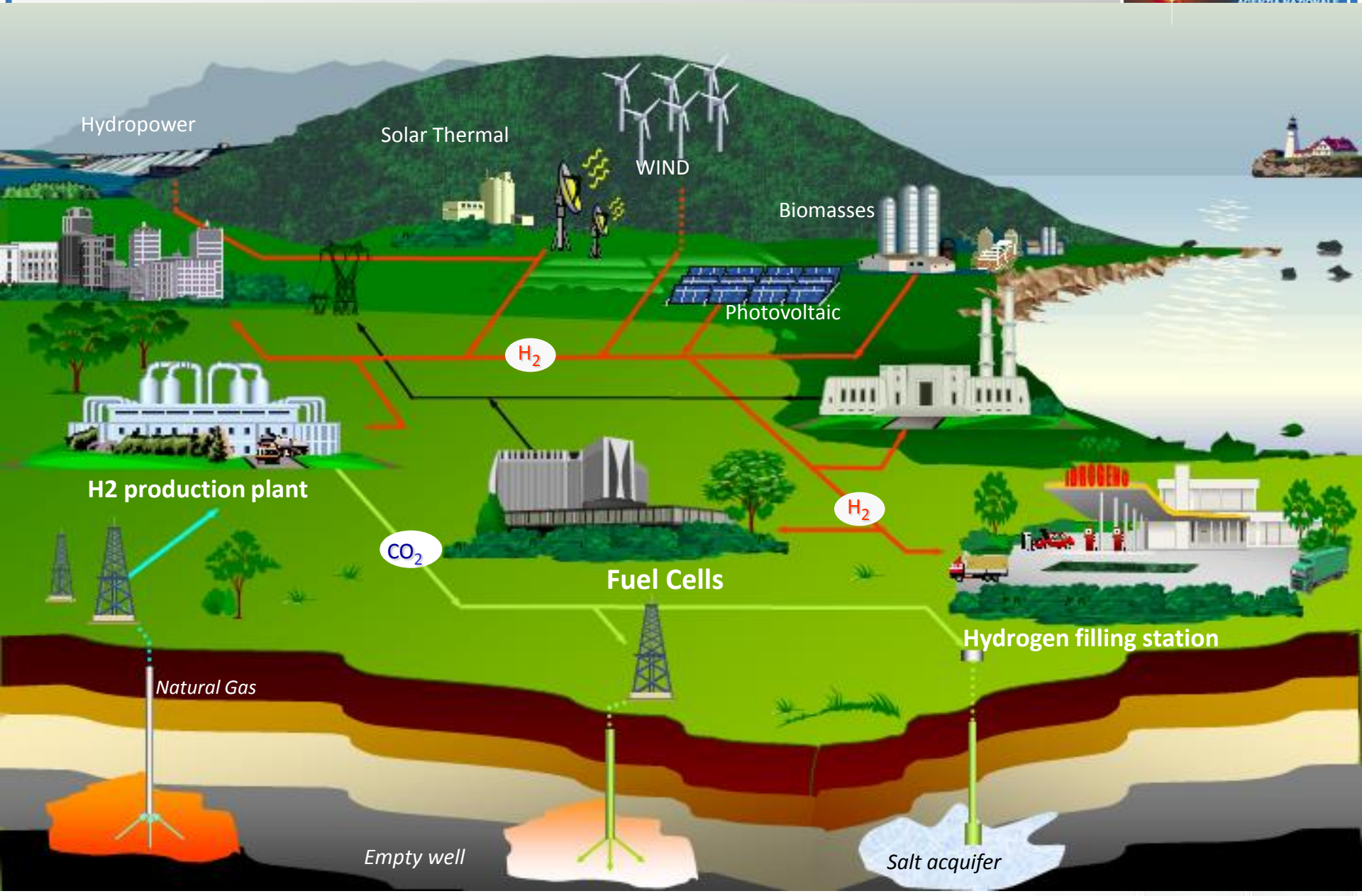
Aim of the Roadmap

- *Give more certainty to governments and investors*
- *Explore routes towards a low-carbon energy system by 2050 considering competitiveness and security of supply*
- *Basis for developing the 2030 policy framework and concrete milestones*

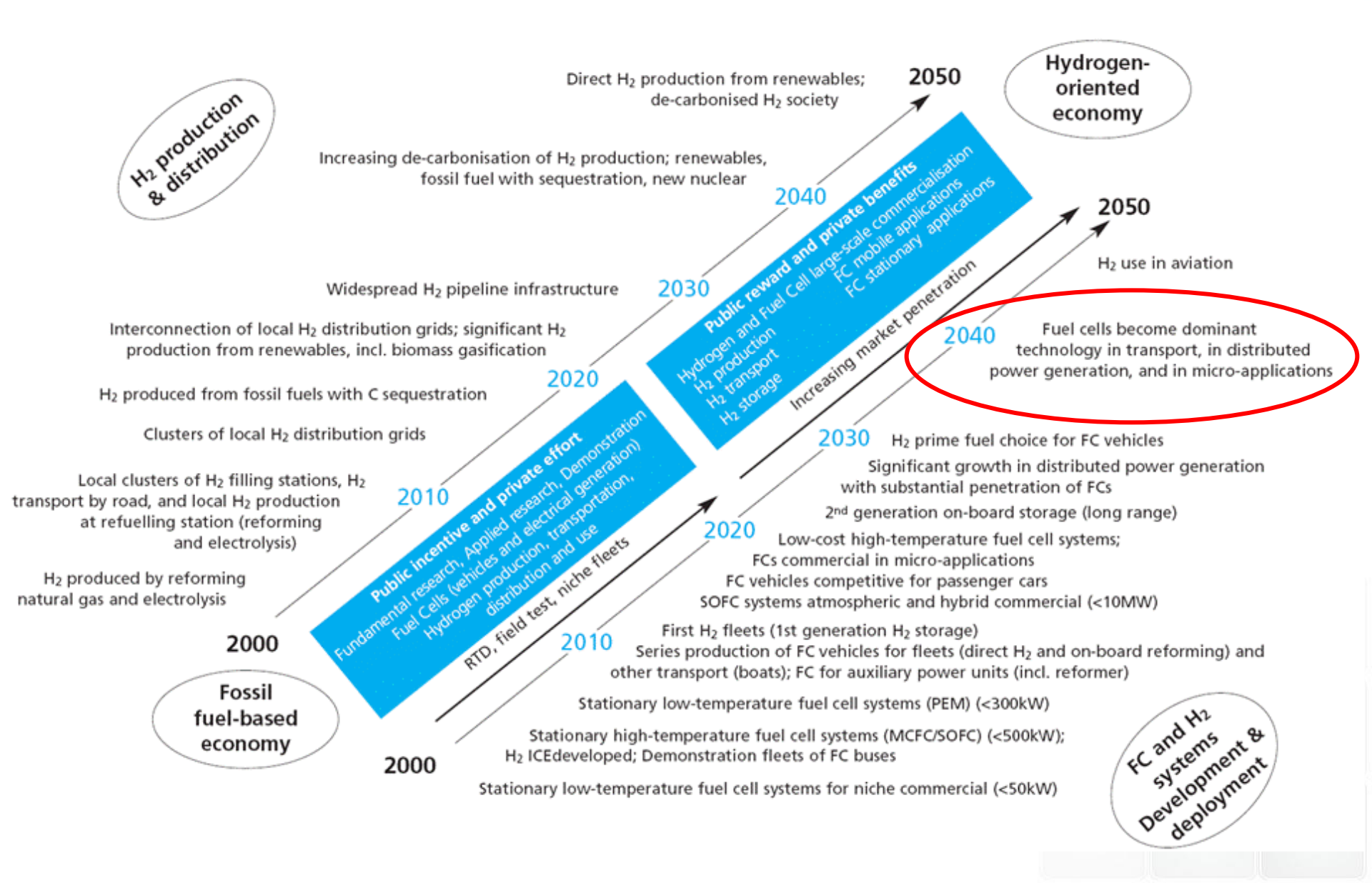
Need for a wide range of new generations of energy technologies to achieve the transition to a sustainable and secure energy sector

Main message: Change everything non to change anything

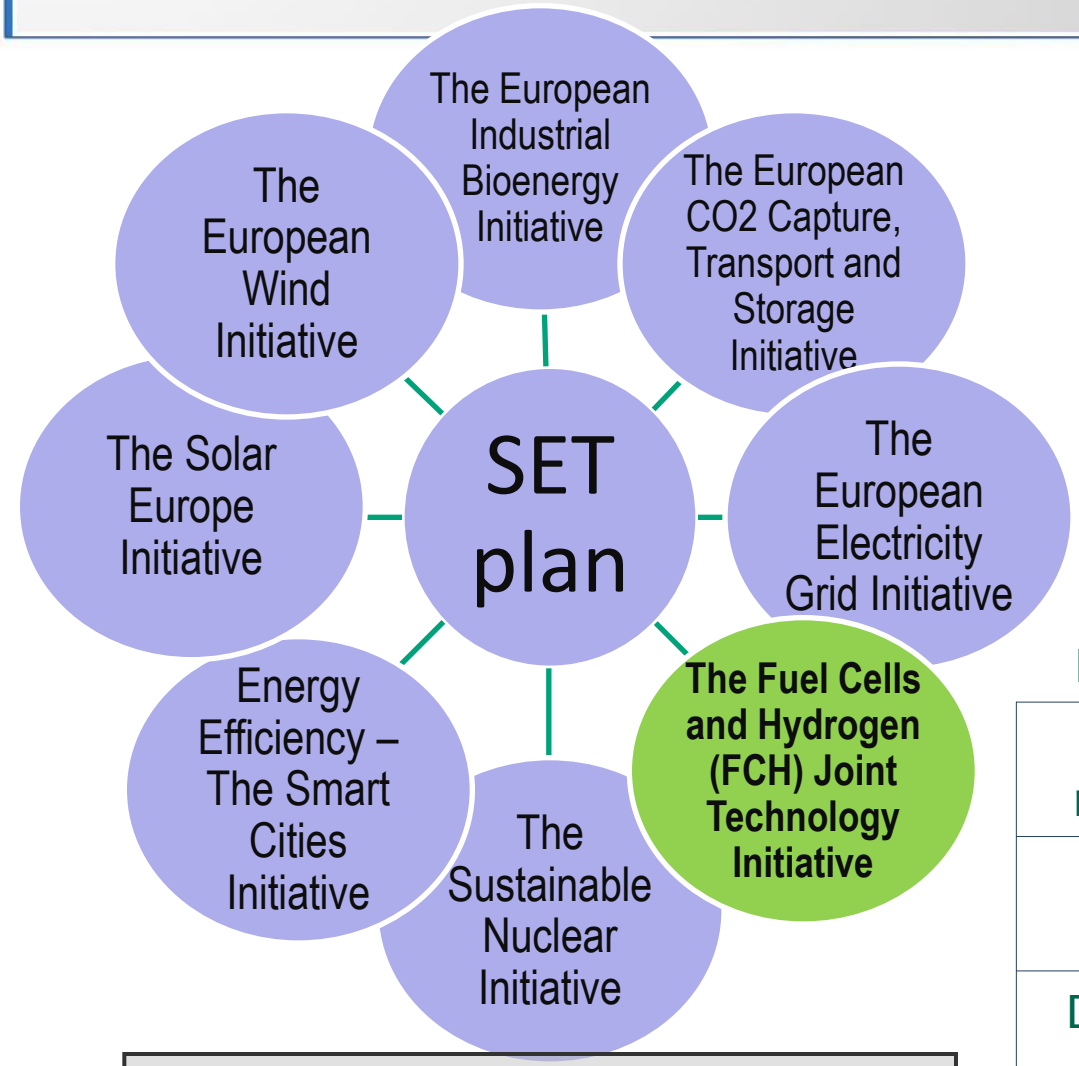
Hydrogen Vision



European Hydrogen Roadmap
Integration& Continuity



SET-Plan

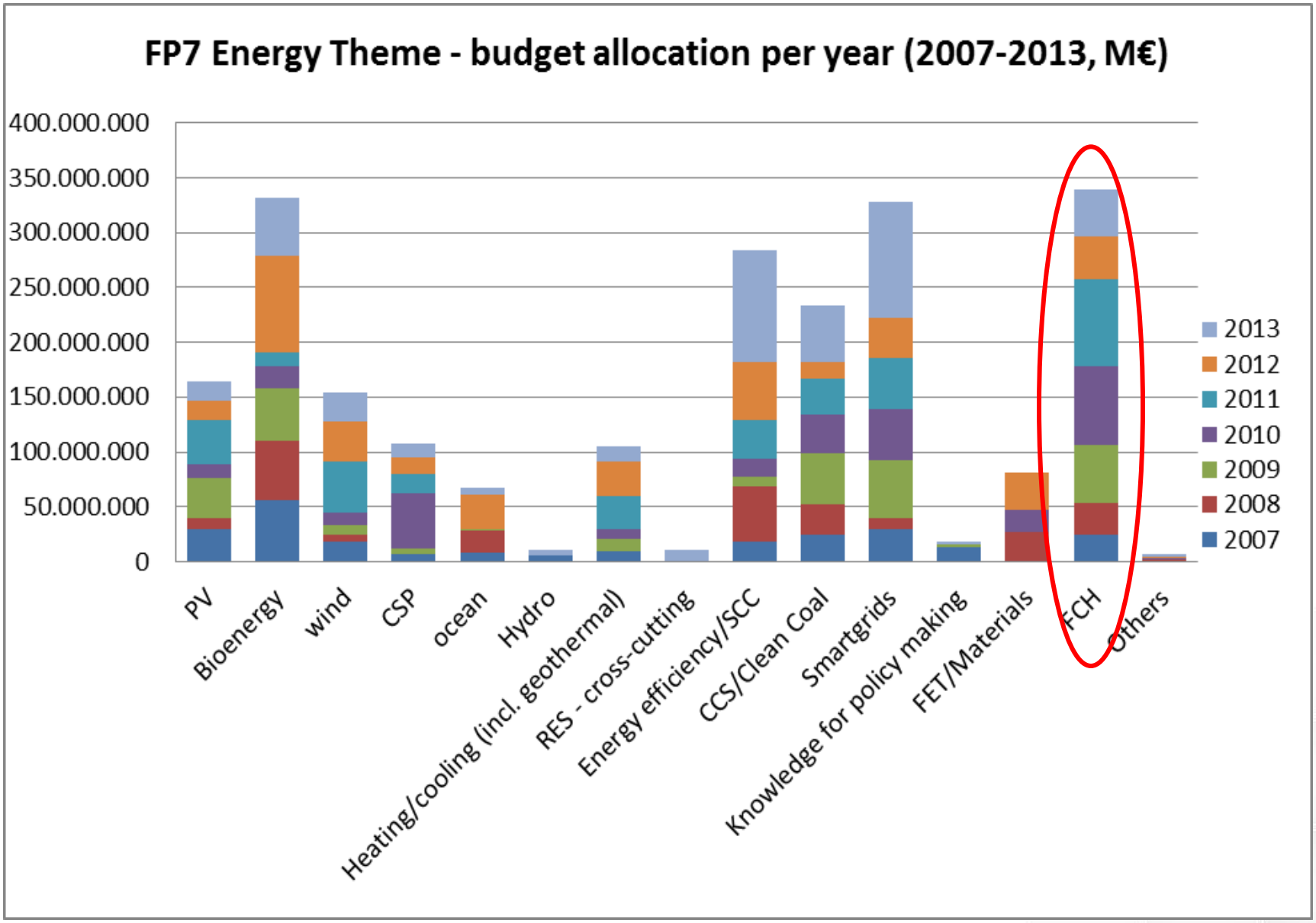


EC targets	By 2020	By 2030 *
Increase of renewables	20 %	27 %
Increase of efficiency	20 %	27 %
Decrease of GHG	20 %	40 %

*European Council conclusions of 23/10/2014

Fuel cells technology is a key technology for Europe towards the 20-20-20 goal by 2020… not only

H2&FC in the energy theme



Why Hydrogen and fuel cells ?

To go from 50% dependency on fossil fuels to 80% reduction in GHG emissions in 40 years we need:

- A complete new strategy for the global energy system
- To move to “low carbon economy” which is not easy, cheap or immediate
- “a must”: new technologies for an efficient use of resources

Hydrogen is:

- a green and clean fuel
- an energy vector both for transport and stationary applications
- an energy storage medium connected with renewable sources
- a commodity

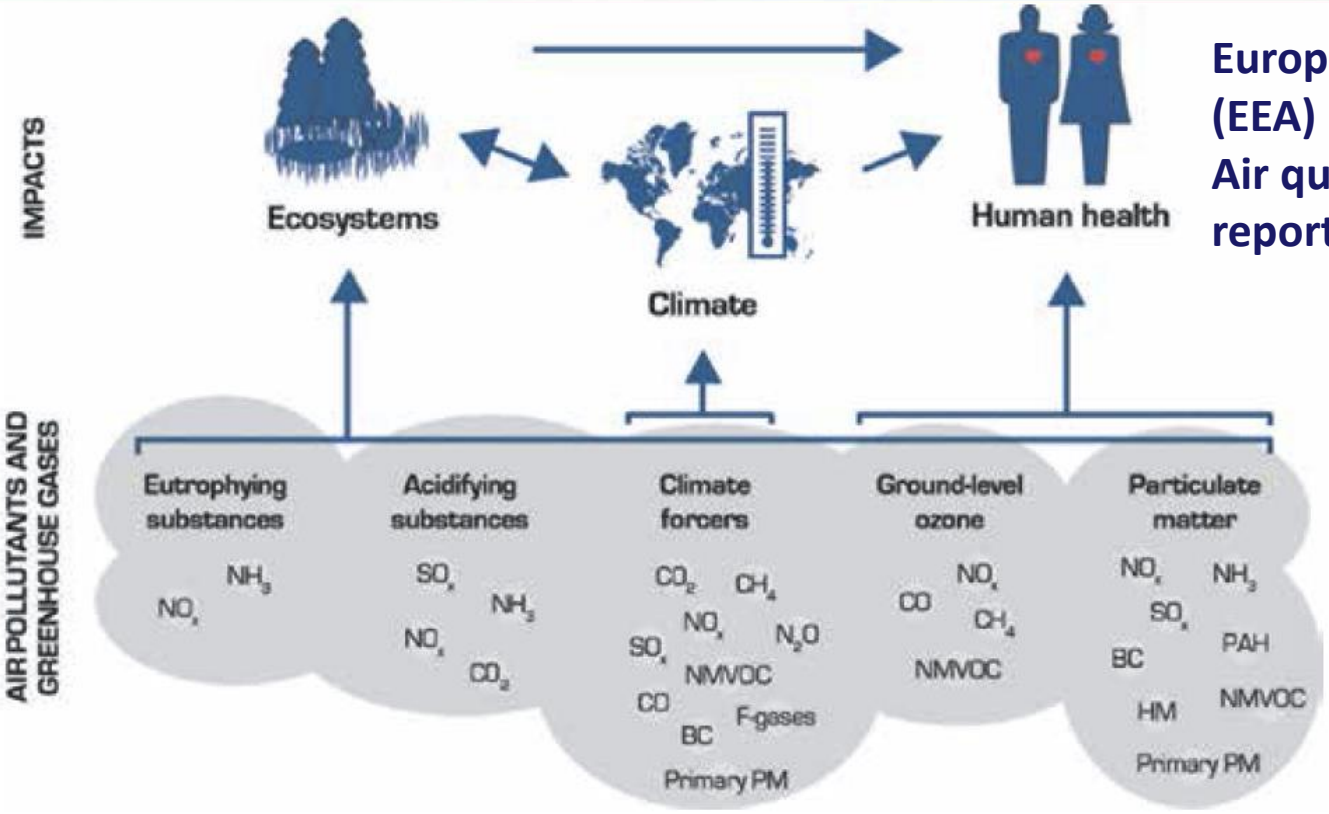
Fuel cells are very efficient and **clean technology** and will replace incumbent technologies:

- in the transport moving it toward full electric vehicles
- in stationary applications (power, heat and cold) replacing mainly ICE and GT, from few kWs to multi MWs plants
- in portable applications replacing batteries whatever size
- in back up power, UPS,APU

What is that?

The 60 MW MCFC power plant of POSCO in Korea

Clean air – Externalities!!!



European Environment Agency (EEA)
Air quality in Europe 2014 report (ISSN 1725-9177)

Fine particulate matter (PM2.5) concentrations in 2011 were responsible for about 430 000 premature deaths in the EU-28, originating from long-term exposure from which :

Italy 64.544 (min 42.650; max 84.475)

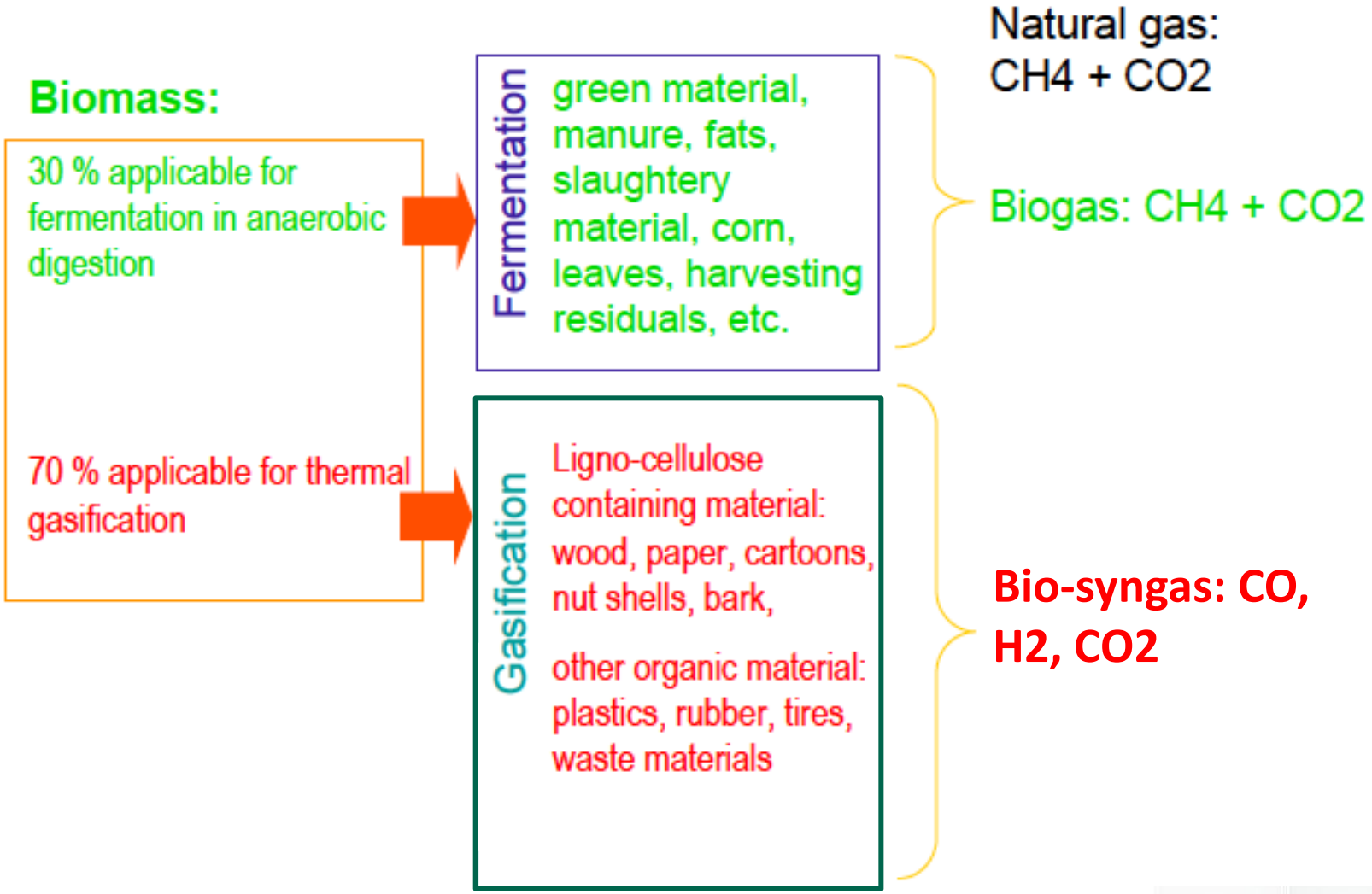
Germany 69.762 (min 45.754; max 91.947)

The Clean Air Policy Package – 2013
New air-quality objectives up to 2030

If fully implemented by 2030 and compared to business as usual and if conditions are as expected, the new Clean Air Policy Package will:

- produce health benefits which alone will result in savings of between 40 and 140 billion €
- provide about 3 billion € in direct benefits thanks to higher productivity of the workforce, lower healthcare costs, higher crop yields and less damage to buildings,
- have a positive net impact on economic growth in Europe and generate new jobs.

Biogases


Biomass:
30 % applicable for fermentation in anaerobic digestion
70 % applicable for thermal gasification
Fermentation
green material, manure, fats, slaughtery material, corn, leaves, harvesting residuals, etc.
Gasification
Ligno-cellulose containing material: wood, paper, cartoons, nut shells, bark,
other organic material: plastics, rubber, tires, waste materials
Natural gas: CH4 + CO2
Biogas: CH4 + CO2
Bio-syngas: CO, H2, CO2

Biogas availability in Europe

- Biogas production
  - Europe: 10.1 Mtoe biogas, 35,9 TWh Electricity
  - Germany: 5.1 Mtoe (50%) biogas production, 19.4 TWh (54%) Electricity
  - Italy: Italy: 1.1Mtoe (11%) biogas production, 3.4TWh (9%) Electricity
- Source
  - Europe: 31% Landfill, 12% Sewage sludge, 57% Other with anaerobic digestion
- Use of biogas
  - Electricity 59%, Cogeneration and other 41%

2011, EurObserv'er

Biogas availability in Italy

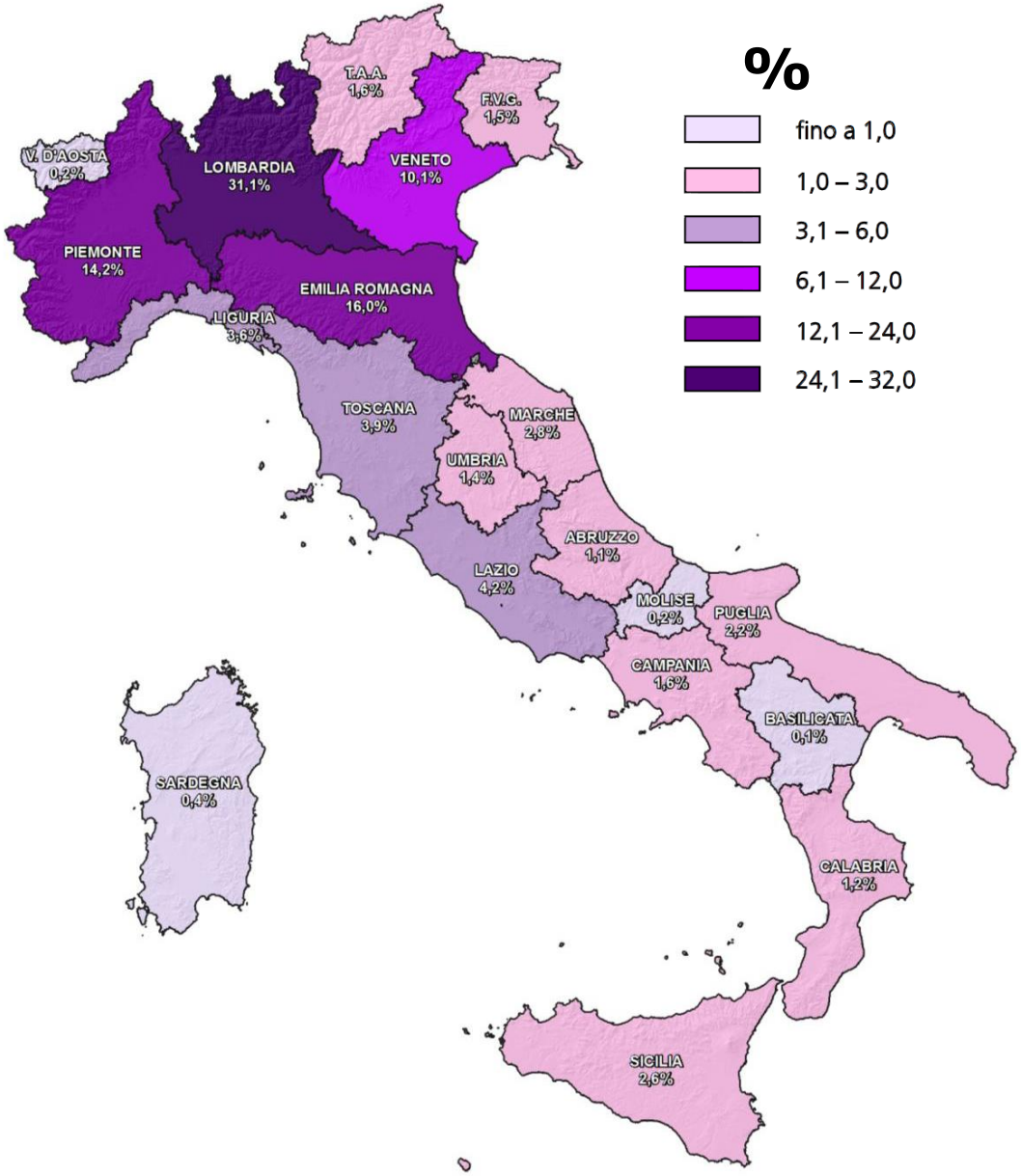
- Energy from biomass in Italy - 2011: 2.8GW (7% RES), 10.8TWh (13% RES)
- Biogas plants – 2011

Type	Number of plants	MW	GWh
Landfills	260	356.4	1528.1
Wastewater TP	60	29.7	62.5
Manure	165	89.5	361.6
Residues from agricultural and forestry	334	297.9	1452.5
tot	**819**	**773.4**	**3404.7**
Organic waste	71	827.5	2217.7
tot	**890**	**1601.0**	**5622.4**

- Average power Bioenergy : 2.3 MW
- Average power Biogas plant (only Landfill, WWTP, Manure, Residues): 1 MW

Report 2011, GSE

Biogas availability in Italy

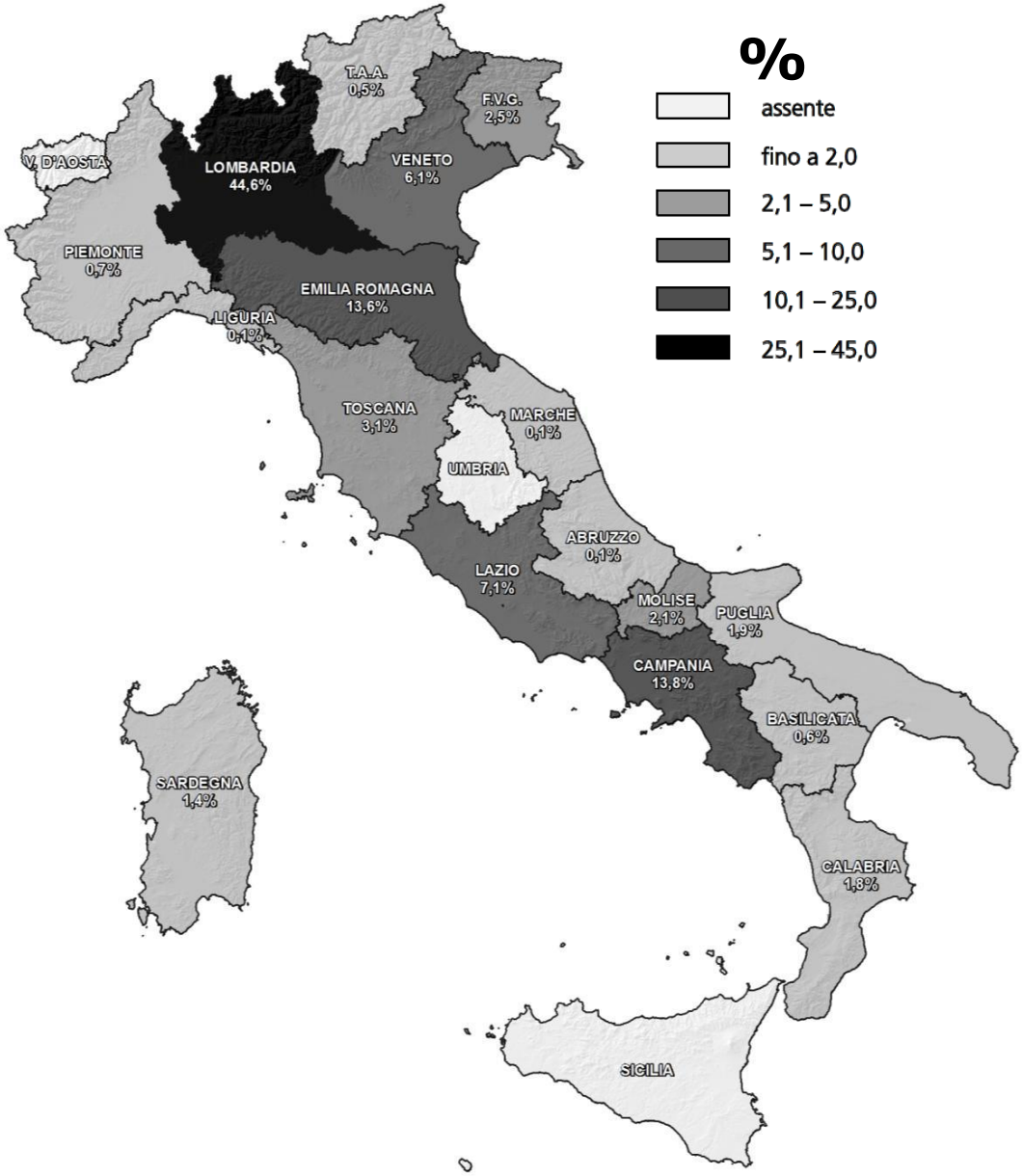


Biogas production from Landfill, WWTP, Manure, Residues

3405 GWh - 2011

Report 2011, GSE

Biogas availability in Italy



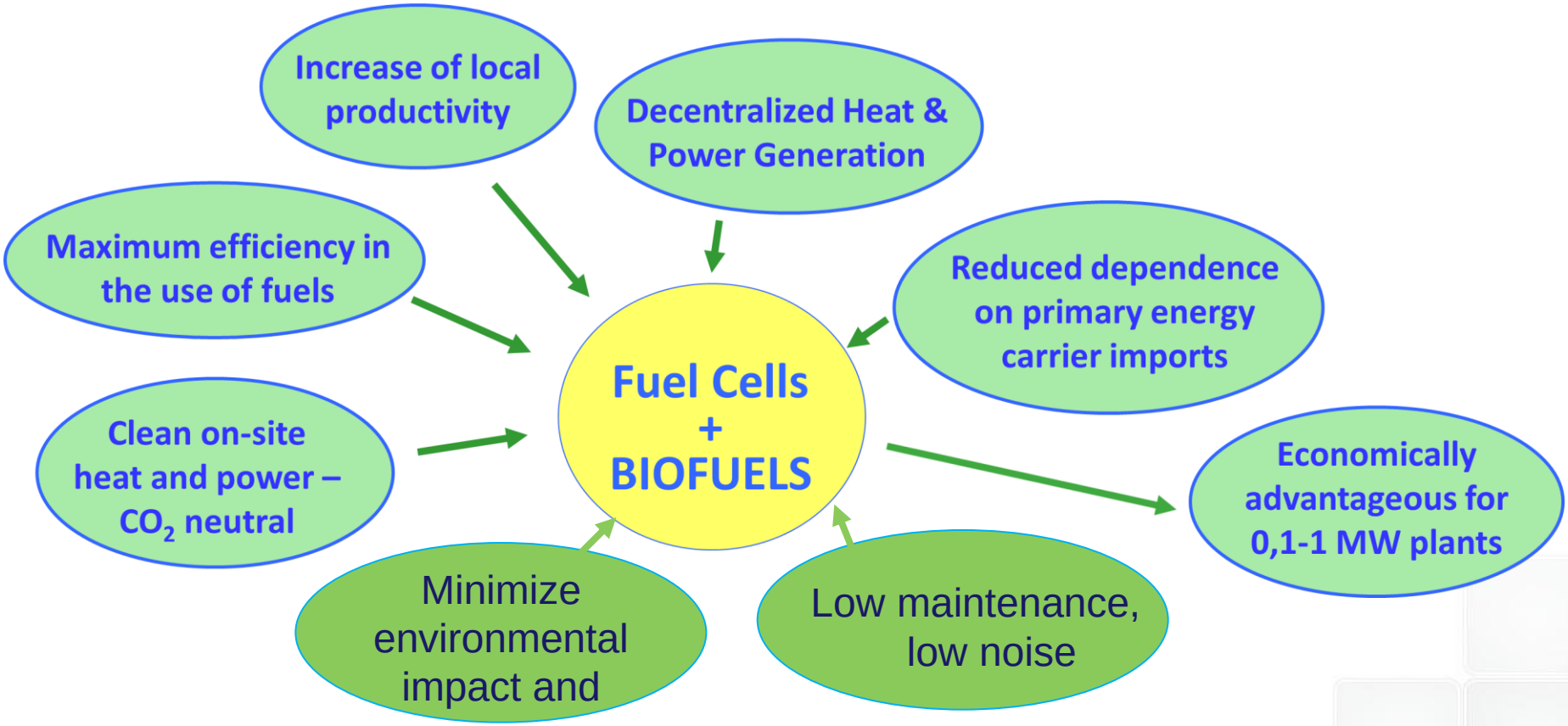
Biogas production from Organic waste

2218 GWh - 2011

Report 2011, GSE

Why FC into waste to energy chain?

The coupling of fuel cells to alternative fuels has potentially enormous benefits:



Optimized Integrated systems (digestate, heat/cold, electricity and CO2) could enhance environmental benefits by acting as a carbon sink (use of CO_2) and by reducing the demand for primary energy sources.

Biomass - Waste to Energy Chain: Why FC?

Italian current Situation → FORSU, Manure (bovine and swine), Sewage sludge

"Total Theoretical Potential" case*	Internal Combustion Engine η_e 38%, η_{th} 40%	Gas Turbine η_e 33 %, η_{th} 51%	Molten Carbonate Fuel Cell η_e 50%, η_{th} 40%
Electricity produced (GWh_e/a)	6,599	5,719	8,711
Heat produced (GWh_{th}/a)	7,039	8,887	7,039
% of Italian Electricity Demand	2%	1.8%	2.7%
Avoided ktoe	1,234	1,069	1,629
Avoided CO_2 (ton)	3,504	3,037	4,625

DEMOSOFC System : η_e 53%, η_{th} 27%

Biogas: Italian energetic potential of waste

Biomass - Waste to Energy Chain

Italian current Situation → OFMSW, Manure (bovine and swine), Sewage sludge*

"Real" Potential

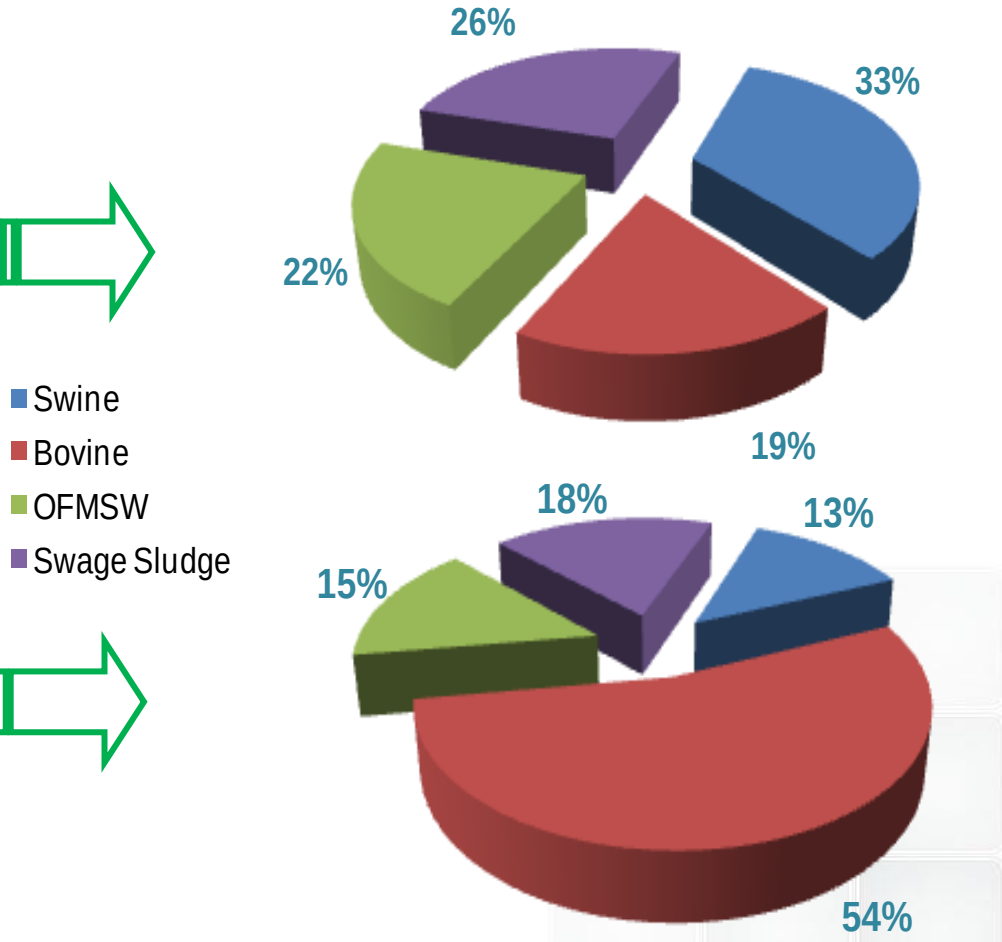
OFMSW = from separate collection (year 2006)
Sewage Sludge > 100.000 SEI
Swine > 1000 head of cattle
Bovine > 500 head of cattle

910 millions of Nm^3 biogas/a

"Total theoretical" Potential

OFMSW = 16,8% SC (SC=65 % MSW)
Sewage Sludge = Total SEI
Swine = Total head of cattle
Bovine = Total head of cattle

2.700 millions of Nm^3 biogas/a



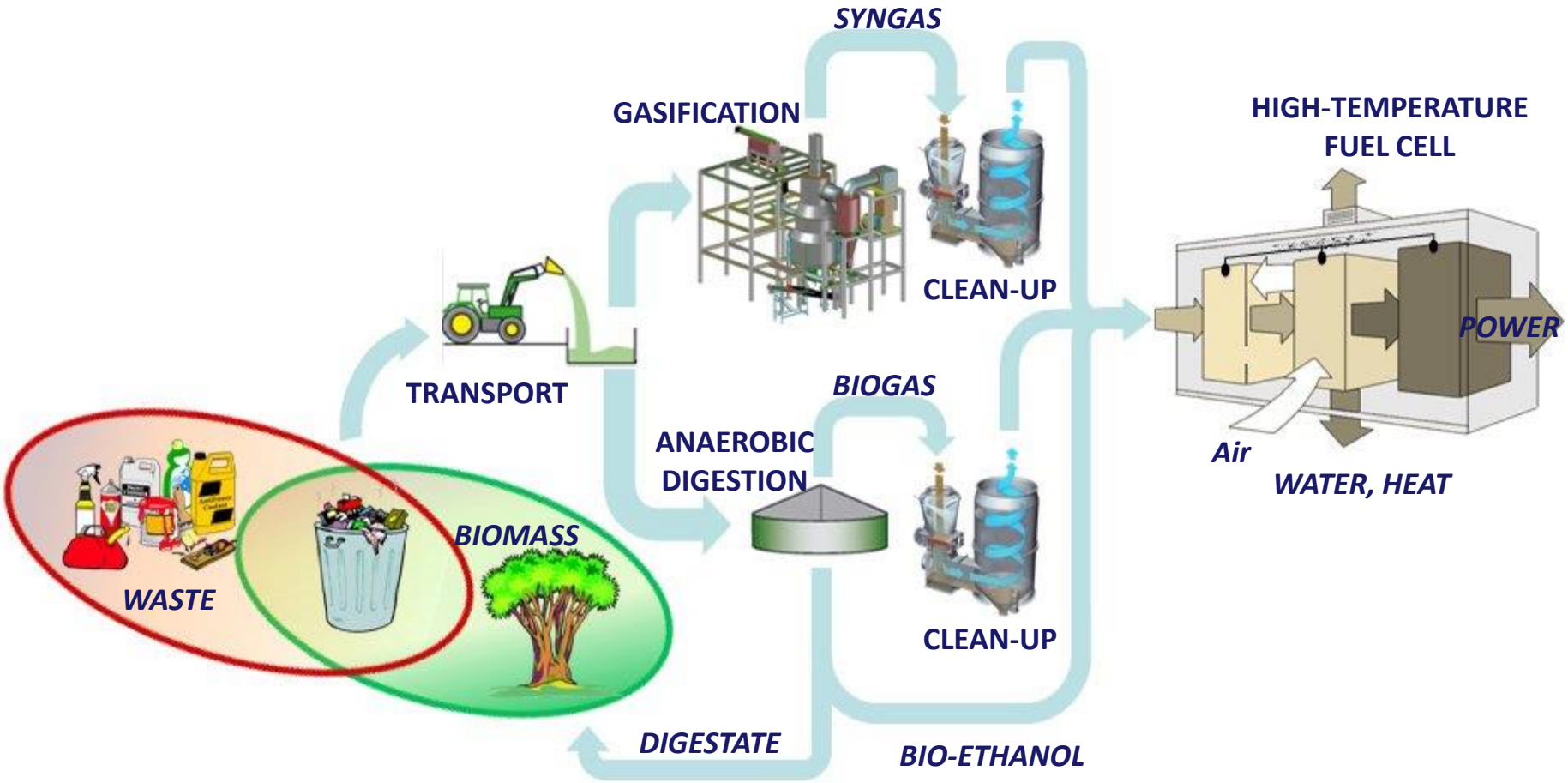
Censimento Potenziale Energetico Biomasse, Ricerca Sistema Elelttrico, ENEA

Energy Potential from Biomass

A.I.D.A. - Advanced and Innovative tool for Developing feasibility Analysis of biomass plants

- A web software tool to evaluate the technical and economic feasibility of biomass plants in the Italian context, by providing users a web guided decision support system
- Supported by ENEA (National Agency for New Technologies, Energy and Sustainable Economic Development)
- Linked to the Italian Atlas on Biomasses

Two possible systems: Biogas and bio-syngas



Ultra clean "Waste to Energy" chain: an integrated approach (MCFC)

High Value Food

Hygienic
Mineral
Fertiliser

SuperHygienic
Green House

New Value Food

50° C Heat

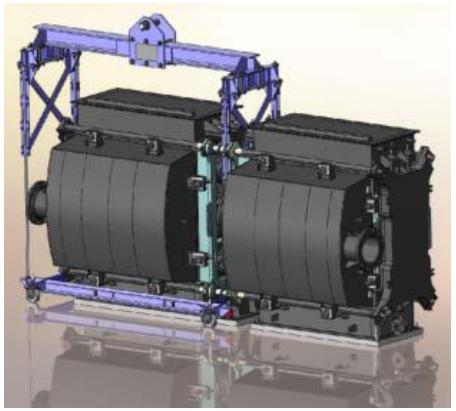
Deposit
Cleaning

Substrate
Cleaning

400° C Heat

Clean CO_2 Fertilising

Biogas

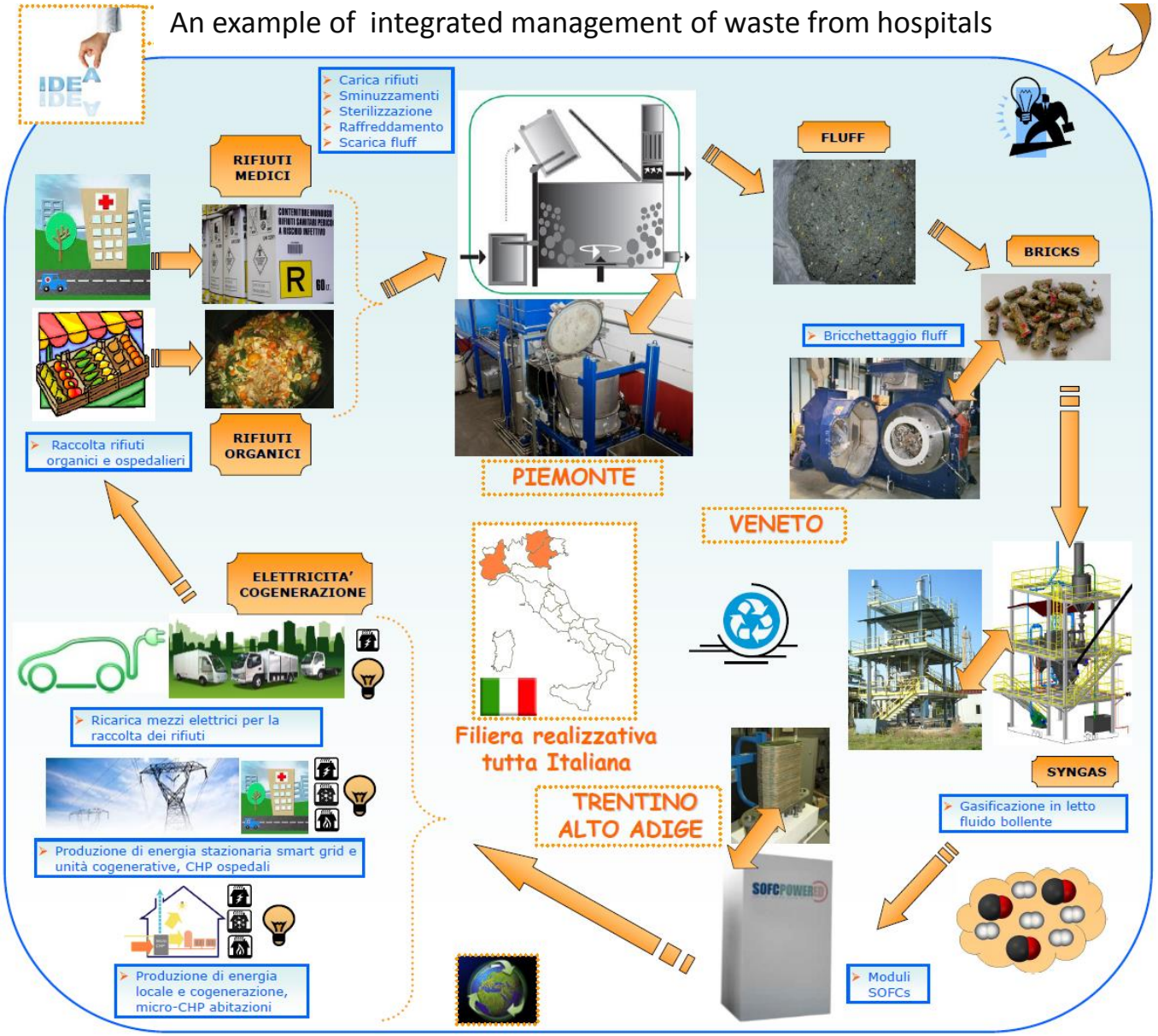


HTFC

Electricity

Biomass gasification: An integrated approach the case of the city of Turin (SOFC)

An example of integrated management of waste from hospitals



SMART CITY: Smart management of medical & organic wastes for their energetic valorisation

FOTORECUPERI S.r.l.

ENEA
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POLITECNICO DI TORINO
1859 1906

SOFCPOWER
SOLID OXIDE FUEL CELLS

la meccanica
TECHNOLOGY AND EXPERIENCE AT YOUR SERVICE

First Phase : fluff and pellets production

Medical
and
organic wastes

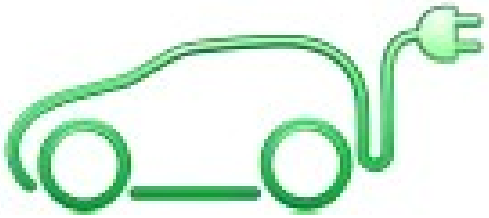
Second Phase : Gasification and clean up

SYNGAS

↓

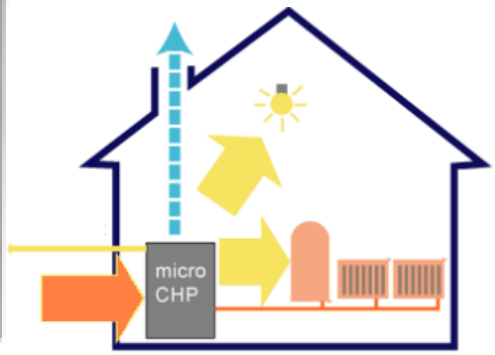
Hot clean up system

Third Phase : Cogeneration– SOFC system



Recharging of electric vehicles for waste collection

Smart grid support and CH for the hospitals



Gas distribution and
domestic micro CHP
H2 for transport application

Integrated solution (PEM)

Metacon: Swedish Company - Metacon's business concept is to replace all types of combustion engines with fuel cells as the new energy transformers and with hydrogen as the new fuel.

Commercial/industrial energy systems

- 20 kWe - 1 MWe
- Biogas, natural gas, LPG

CHP systems for private homes and buildings

- 2 kWe - 40 kWe
- Biogas, natural gas, LPG, ethanol

metacon

FOSSIL FREE ENERGY FOR INDEPENDENCE

Integrated solution

Metacon offers energy systems for complete, clean, closed loop energy supply to greenhouses: Heat, electricity and CO2

Greenhouse waste

- food waste
- meat waste
- manure

Anaerobic digester

Biogas

Reformer, fuel cell and inverter

- Electricity
- heat
- CO2

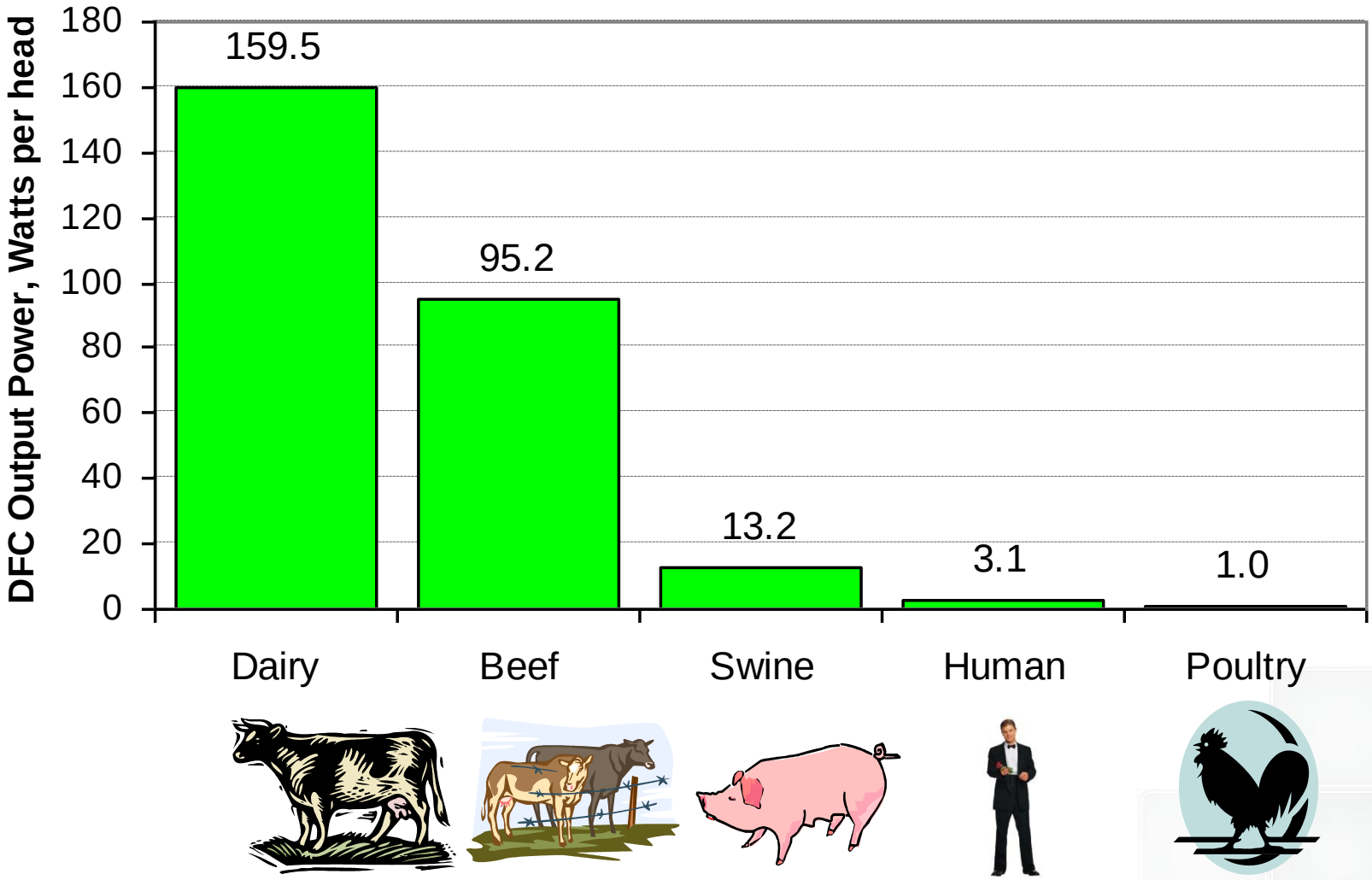
DEMOSOFC

It will become a very important demo project at least for the Italian system, because:

- First Ad plant coupled with FC system
- Far the most efficient (53%) in this size (150 kW) comaored with similar ICE/GT (around 30-35%)
- The cleanest
- The size is the most suitable for the Italian systems
- It is modular (three systems of 50 kW each) that means:
  - ✓ very flexible, load following and adaptable to biogas caractheristic
  - ✓ can be up rated just adding other modules but also down rated to two or even one module
  - ✓ Will allow long operation time per yaer
- the cost?
  - ✓ Take into account the avoided contaminats (Sox, Nox, CO, particulates) it is GREEN and CLEAN
  - ✓ Create the condition to go toward mass production

The importance of DEMOSOFC in the Italian scenario

Thumb-Rule of waste to energy chain



Conclusions: FCs could be the best choice

- Energy and environmental situation calls for **alternative fuels**
- Low energy density of non-conventional fuels calls for **maximum efficiency**
- Clean air calls for **cleaner technologies**
- Very different biogases (landfill, AD, gasification) calls for **very flexible technologies**
- Biomasses dispersion/fragmentation call for on site energy production thus **small and efficient power plants**

Good news for Italy: *Towards an Italian hydrogen infrastructure deployment plan*

CLEAN POWER FOR TRANSPORT DIRECTIVE 2014/94/EU

Italy

- **Electricity: National Deployment Plan for Recharging Infrastructure of Battery Electric Vehicles already adopted by the Government (funding: € 45 million).**
- **NG (both C and L) is going to be approved**
- **Hydrogen « Mobilità idrogeno Italia » a stakeholder group has stared the activities to define the National implementation plan for the deployment of hydrogen infrastructures for H2&FC transport system**

Thank you very much for your kind attention