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

Adapting the grid system to the requirements of energy transition – efficiency in electric and thermal grids in Italy

Ing. Biagio Di Pietra

alpenkonvention • convention alpine
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Zurigo 13 Febbraio 2014

Summary

- Main recent changes in the Italian electricity sector
- Italian Smart-grid pilot projects
- Smart grid in ENEA – C.R Casaccia (Roma)
- Efficiency in thermal grids in Italy

ENEA

Italian National Agency for New Technologies, Energy and Sustainable Economic Development

ENEA is a public institution whose activities are targeted to research, innovation technology and advanced services in the fields of energy ustainable economic development (art. 37 of Law no. 99 of July 23rd, 2009).

Infrastructures

- **Headquarters located in Rome**
- **9 Research Centres**
- **5 Research Laboratories**
- **43 pilot plants and research facilities**
- **11 Local Offices**
- **Brussels Liason Office**

Human Resources:

- **2640 permanent staff**
- **Master and PhD students**
- **International Fellows**

ENEA's R&D activities

- Energy Efficiency
- Renewable Energy Sources:
  - Concentrated Solar Power, Biomass and Biofuels, Solar Thermal, Hydrogen and Fuel Cells, Energy Storage Systems
- Nuclear Energy
  - Fission and Fusion
- Environment and Climate Change:
  - environmental technologies, modelling, prevention, conservation and reclamation activities
- Health and Safety:
  - Seismic protection, biological effects of ionising radiations, radioprotection, metrology of ionising radiations
- New Technologies:
  - material sciences, applications of ionising radiations, Agro-industrial innovation & technologies, ICT
- Power System Research

Agency for Energy Efficiency

ENEA, according to decree 115 of May 30th 2008, transposing the EU Directive 2006/32/CE, has been assigned an important role in the certification of processes to improve energy efficiency**,** acting as **National Agency for Energy Efficiency.**

In this respect, ENEA – EE Agency certifies the interventions proposed by Distribution System Operators (DSO), Energy Services Company (ESCO)….

- ENEA prepares **Annual Report on Energy Efficiency** of residential and office sector, transport, industry, thermal and electric distribution systems

- ENEA, under a framework agreement with the Ministry of Economic Development, carries out a set of research activities for energy savings in services, public lighting, air conditioning and transports

National Electric Grid (2012)

Electricity crossing the italian grid: 328.219 GWh/year

Energy losses: 6,4% (respect to total demand)

Power generation

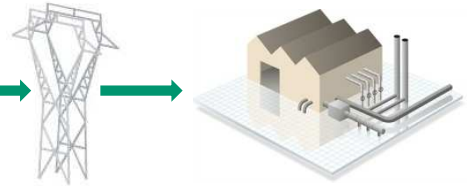
transmission infrastructure
132 kV –380kV
~ 63.500 km

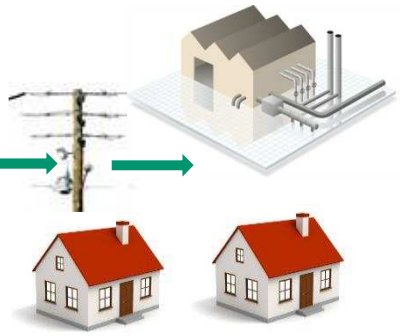
Distribution line
20 kV MV - 400 V LV

Electric Energy fed into the italian grid : 340,4 GWh

From traditional fonts: 60,2% (-5,8 % respect to 2011)

From renewable energy : 27,1% (+11,2% respect to 2011)





source: TERNA Spa – dati statistici - year 2012- www.terna.it

Directives and laws to support the installations of renewable energy systems and distributed plants

Directive 2009/28/EC of the on the promotion of the use of energy from renewable sources

ITALIAN TARGET FOR SHARE OF ENERGY FROM RENEWABLE SOURCES IN GROSS FINAL CONSUMPTION OF ENERGY, 2020: 17 %

-Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market

-Italian Law DL 28/2011: trasposition Directive 2009/28/EC

- Italian Law DL 20/2007 : Trasposion Directive 2004/8/EC

- **Incentives for renewable energy plants :**
PV Plants: Feed-in premium from 0,49 €/kWh (2005) to 0,22 €/kWh (2012)
PV Plants : Feed-in tariff 2013 (closed): 0,13 €/kWh (200 kW<P<1000kW)
All Renewable E.P. (no PV): Feed-in tariff from 2012 (average 0,2 €/kWh)

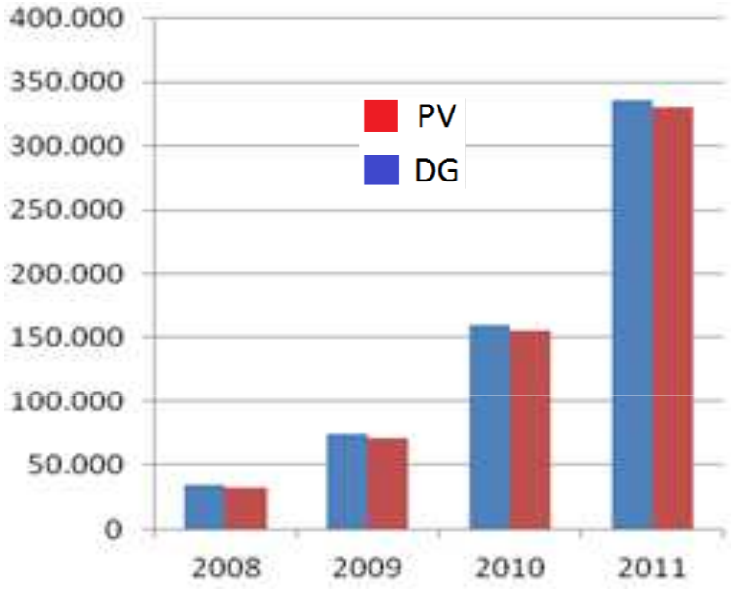
-**Incentives for renewable energy plants (Thermal plants):**
Law 28 December 2012: "Conto termico" for Solar palnt, Heat pump and Energy efficiency

Recent changes in the Italian electricity sector

(DG): smaller sized grid generators or domestic micro-generators in distribution network (MV or LV). It includes: wind, PV, Hydropwer…with total capacity less than 10 MW(AEEG n.160/06)

	Number of plants	Power (MW)	gross electricity production (MWh)
Hydroelectric plants	2.549	2.448	8.553.823
Biomasse, biogas e bioliquidi	*1.088*	*1.005*	*3.788.948*
Rifiuti solidi urbani	*37*	*120*	*441.331*
Fonti non rinnovabili	*872*	*1.499*	*5.208.036*
Ibridi	*17*	*45*	*93.365*
Thermoelectric power plants	2.014	2.669	9.531.680
Geothermal power plants	0	0	0
Wind power plants	~~587~~	~~539~~	805.841
Photovoltaic power plants	330.168	12.255	10.346.240
Total	**335.318**	**17.911**	**29.237.583**

AEEG -DG plants - 2011



Number of DG plants installed per year

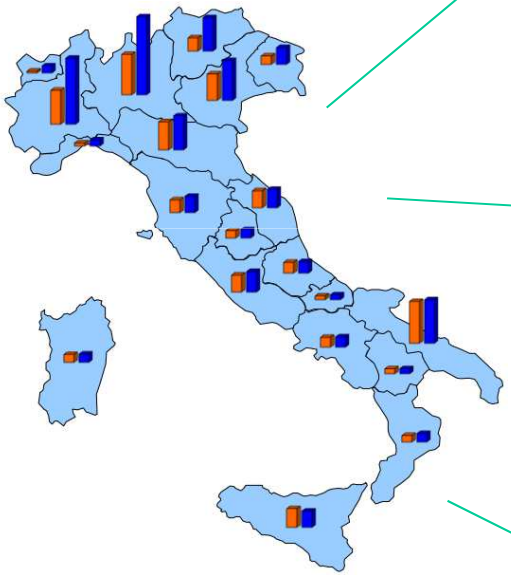
More than 330.000 DG units are installed across the Italy – 98% PV are plants (2011),

DG Energy Production (2011): 35% PV plants - 29% Hydropower

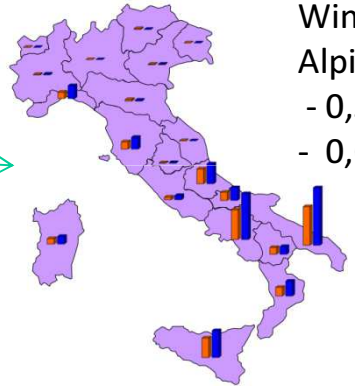
Source : Italian Authority for Electricity and Gas (AEEG) – http://www.autorita.energia.it/t

Deployment of DG across Alpine regions (2011)

Hydroelectric palnts (DG)
Alpine area :
- 73% of Total Power
- 81% of Electricity



Total Renewable energy sources



Wind power plants (GD)
Alpine area :
- 0,5% of Total Power
- 0,6% of Electricity

Photovoltaic plants (GD)
Alpine area:
- 33% of Total Power
- 30% of Electricity

Totale Power (MW)

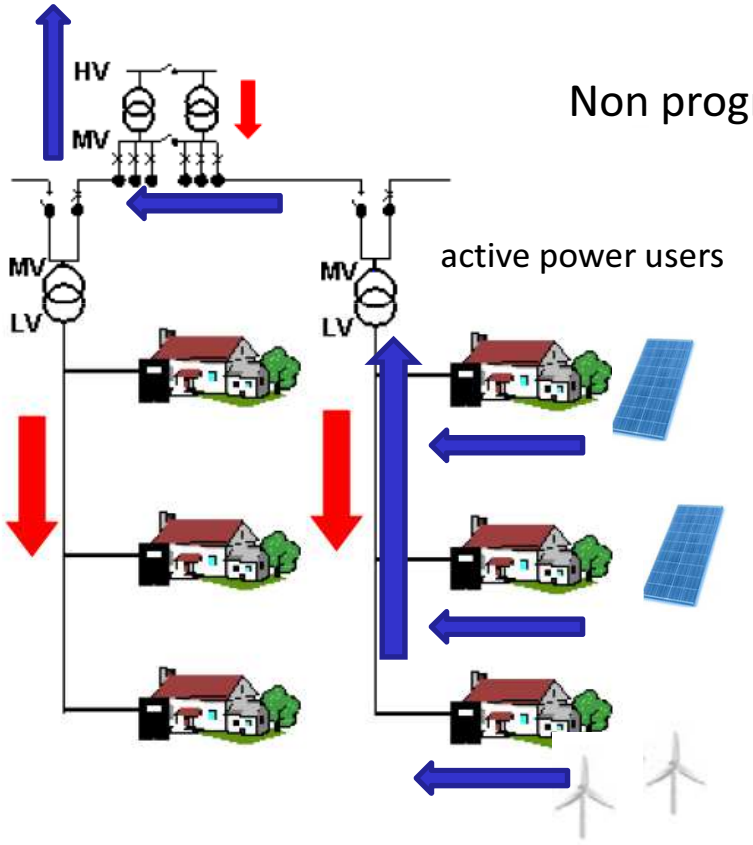
Electricity (GWh)

source : AEEG -2011

Impacts and risks (1)

The vast majority of distributions systems were designed for one-way power flow from the substation to the customer.

Grid protection devices were designed for one way power flow



Non programmable Distributed Generation could be cause of :

- Energy production more than local load
- power flow inversion LV -> HV
- Hosting capacity problems in critical area (south of italy)
- Overvoltage in many nodes of distribution lines (violation of EN 50160 prescriptions)
- Incresing short circuit current

Impacts and risks (1)

Until 2012 DG plants had been installed into the electrical system according to a “fit and forget” approach :

DG power plants have not offered any service for the network operation in term of quality of supply and the system stability.

In case of frequency oscillations (range allowed 49,7 Hz – 50,3 Hz) and voltage profile perturbation, protection device disconnect PV palnts from the rest of the electrical system

A real event happened in Sicily region on 18 May 2011: damage to 150 MW traditional power plant caused a strong frequency decreasing and loss of 80 MW of DG and 200 MW of load shedding were necessary in order to restore power balance

Warning : An ever-greater penetration of intermittent DG units, replacing traditional power plants, causes a reduction of reduction of the total rotating inertia and a lower capability to support the system in case of frequency oscillations

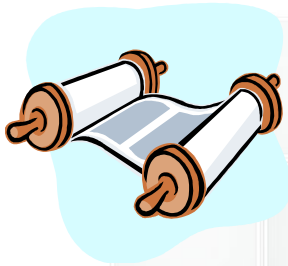
Investment and solution for system stability and safety

- **Smart grids tecnology**:

incorporate new technologies such as advanced metering, automation, communication, distributed generation and storage in order to improve the efficiency, reliability and safety of renewable energy plants in the grid.

- According to Italian Authority for Electricity and Gas (ARG/elt 39/10), **SEVEN** smart-grid pilot projects were selected in order to achieve the development of smart grid in Italy

- Reserch on the smart grid carried out by ENEA, RSE and CNR in the framework of "R&D activities of general interest for the National Electric System" funded by Ministry of Economic Development (MSE).



- **New interconnection standards** to protect both the grid and the DG equipment: According to the new Italian **standard CEI 0-21** each DG plant connected to the LV system has to participate in voltage regulation by the injection/absorption of reactive power

Seven Italian Smart-grid pilot projects

Selected smart grid pilot projects according to ARG/elt 39/10 of Italian Authority for Electricity and Gas .

- A.S.SE.M. S.p.A — S. Severino Marche
- A2A Reti elettriche S.p.A. — Lambrate MI
- ACEA Distribuzione S.p.A — Roma
- ASM Terni S.p.A — Terni
- ENEL Distribuzione S.p.A. — Carpinone (Isernia)
- DEVAL S.p.A — Valle d'Aosta - Villeneuve

2011 start all projects
2014 Expeimentation

Source and more info: http://www.autorita.energia.it/it/operatori/smartgrid.htm

Villeneuve Smart grid project

Distribution system operators : Deval spa supplies 69 city of Val D'Aosta

- Part of grid object of new installations: Substation Villeneuve (AO)

network properties at the beginning of the project:

- total length of the Medium voltage grid (MV): 428 km
- Total MV users supplied: 93 (11.8 MW)
- total length of the Low voltage grid: 461 km
- Totale LV users supplied : 14318 (14 MW)
- Total MV lines :11

MV Lines with new Smart grid tecnology: Rhemes, Introd e e Thumel

Active users in Smart grid project : 6 hydroelectric plants connected to MV grid - **from 200 kW a 5000 kW**

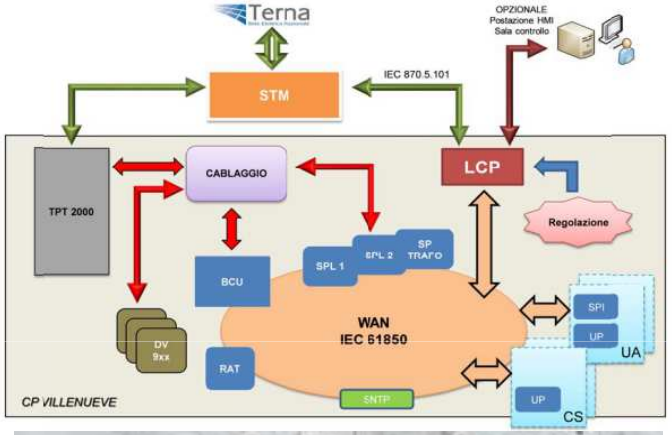
Energy production by DG more than local load : power flow inversion LV -> HV for 48,7% of time working (2009)

Source and more info: http://www.autorita.energia.it/it/operatori/smartgrid.htm

Goal of Villeneuve Smart grid project

Installation of new device and new Information and Comunication tecnology in order to:

- increasing the Hosting Capacity and at the same time guarantee power quality, stability and safety over time
- Real time monitoring DG plants and load
- control protection device in remotely way
- Voltage profile regulation along the feeders
- Exchange data with TSO
- Coordinate Electric vehicles charging strategy with RES power plants



Main items

- Deployment of new comunication system (HSDPA, public 3G) in order to connect devices of Distribution substation and active users via protocollo IEC 61850
- cost for new communication network (190 k€ - Total cost of the final project 2194 k€

Incresing of Hosting capacity after project : **251.300 kWh** (calculated)

http://www.autorita.energia.it

New Italian Satndars: CEI 021

New CEI 0-21: Reference technical rules for the connection of active and passive users to the LV electrical Utilities:

DG participates in the provision of **ancillary services** needed for a secure and reliable operation of the power system

-DG participates **in voltage regulation** by the injection/absorption of reactive power. Q=f(V) – capacity of Inverter > 6 kW

-**New range of grid frequency allowed** : 47,5 Hz ≤ f ≤ 51,5 Hz

- **Insensitivity to voltage drops** - LVFRT (Low Voltage Fault Ride Through)

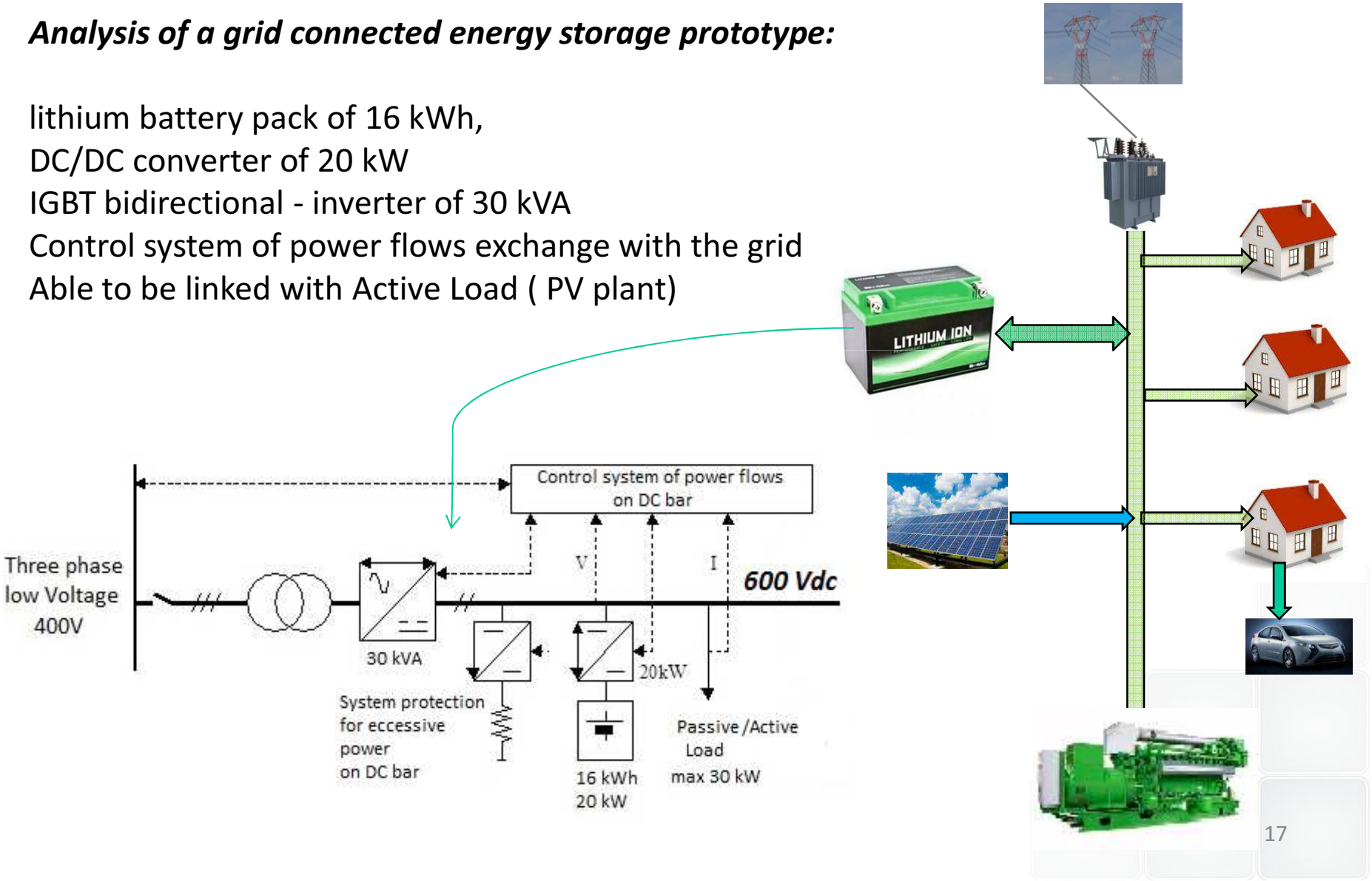
-**Inverter are coordinated and remotely controlled by TSO** in order to regulate power active in case of frequency oscillations in trasmission lines

-installation schemes of **Energy Storage** (battery) in DG plants (2014)

Experimental activity on Energy Storage System in ENEA Labs

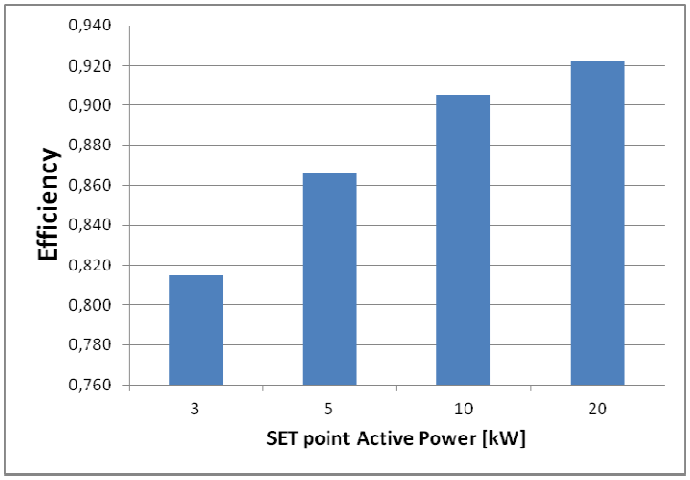
Analysis of a grid connected energy storage prototype:

lithium battery pack of 16 kWh,
DC/DC converter of 20 kW
IGBT bidirectional - inverter of 30 kVA
Control system of power flows exchange with the grid
Able to be linked with Active Load (PV plant)

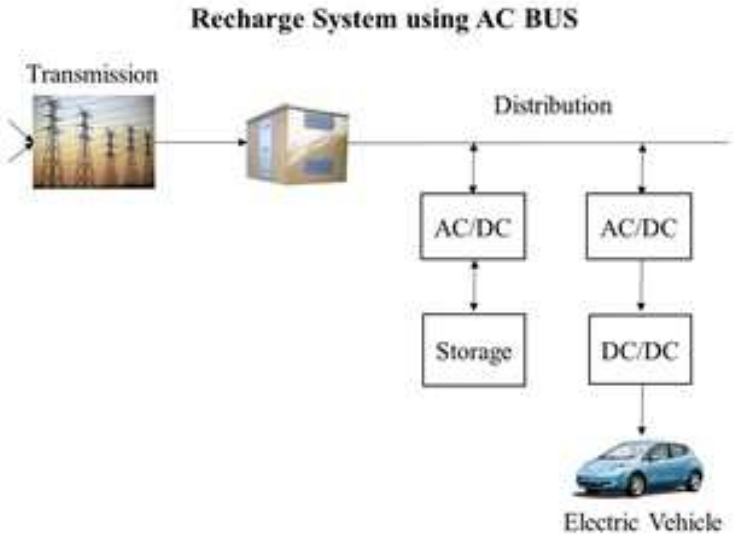


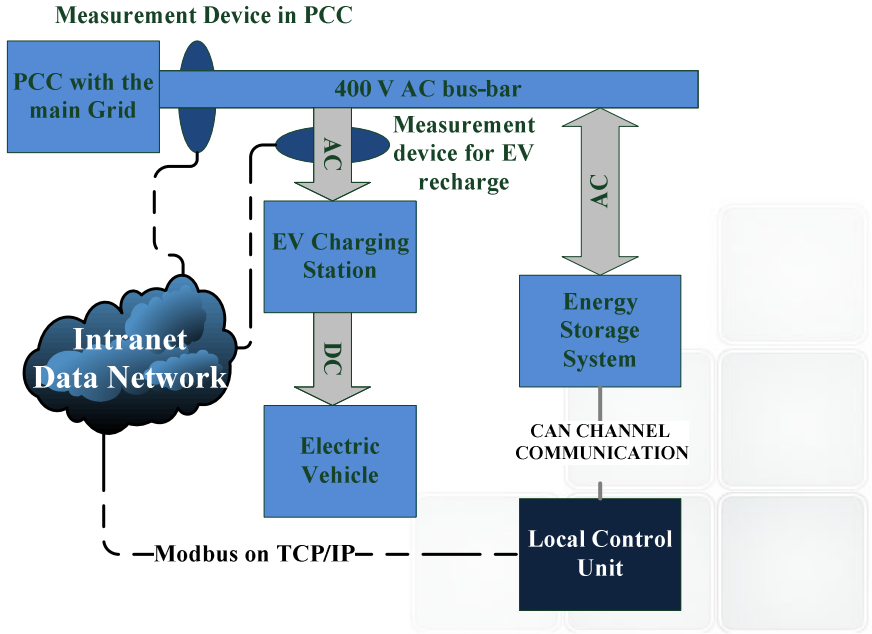
Smart grid in ENEA – C.R Casaccia (Roma)

Energy analysis in real work condition to evaluate
- **Battery effieciency**
- Power converters efficiency
- **Performance of control system**
- Auxiliary consume

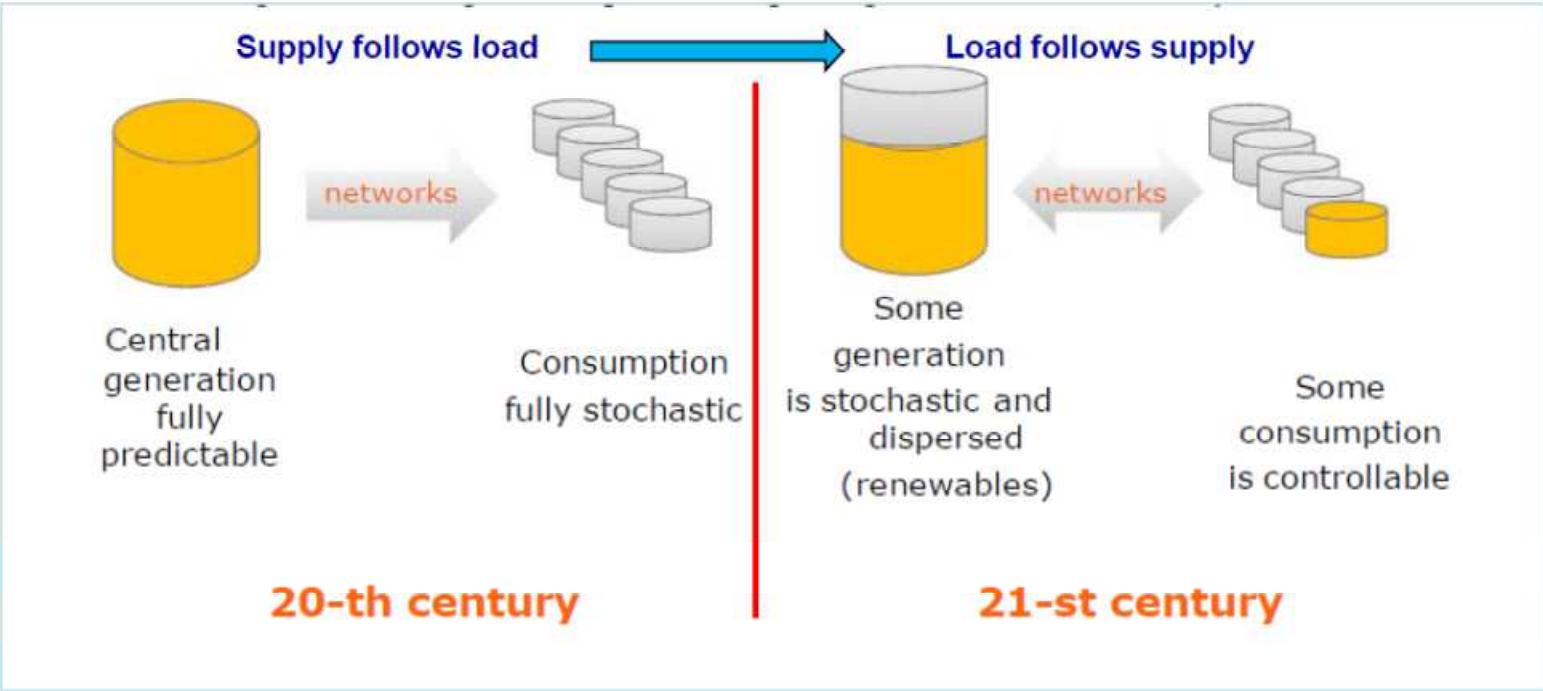


Experimental activity into ENEA main grid in order to test:
-Peak shaving service
- **integration into smart metering system using customized ICT protocols**
- **integration into Electric vehicles fast charging stations**





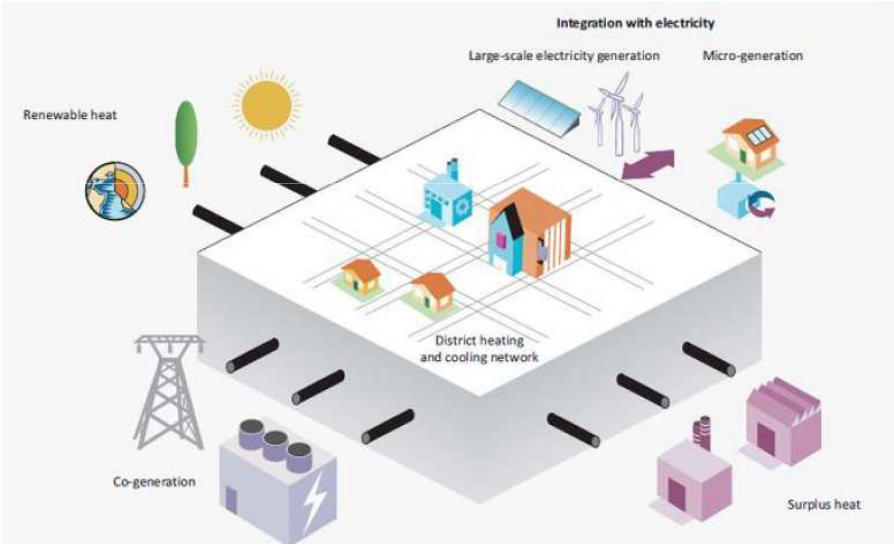
Active demand



Source: The European Electricity Grid Initiative (EEGI): a joint TSO-DSO contribution to the European Industrial Initiative (EII) on Electricity Networks

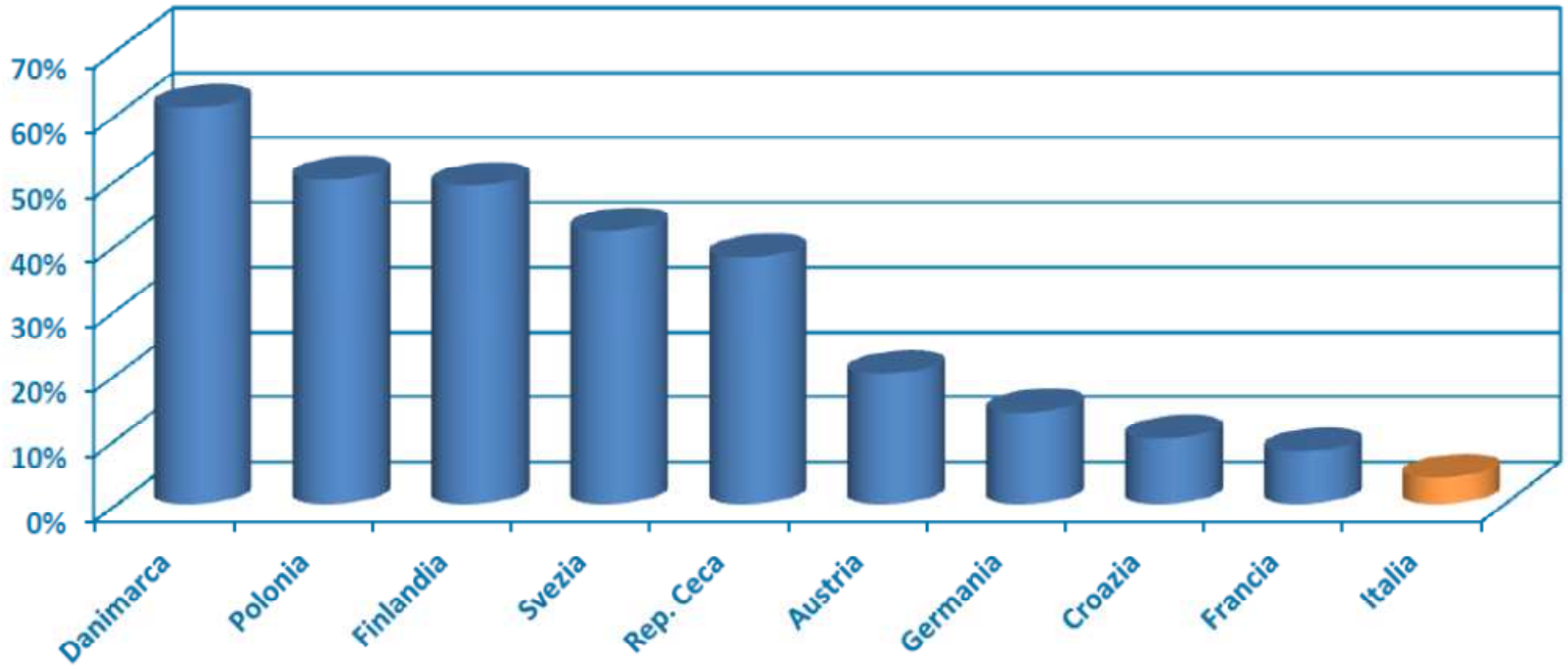
In this way the new scenario is going to implement new rules for the active users connected to the distribution network.

Efficiency in thermal grids in Italy



State of district heating in Italy (1)

heating demand supplied by district heating

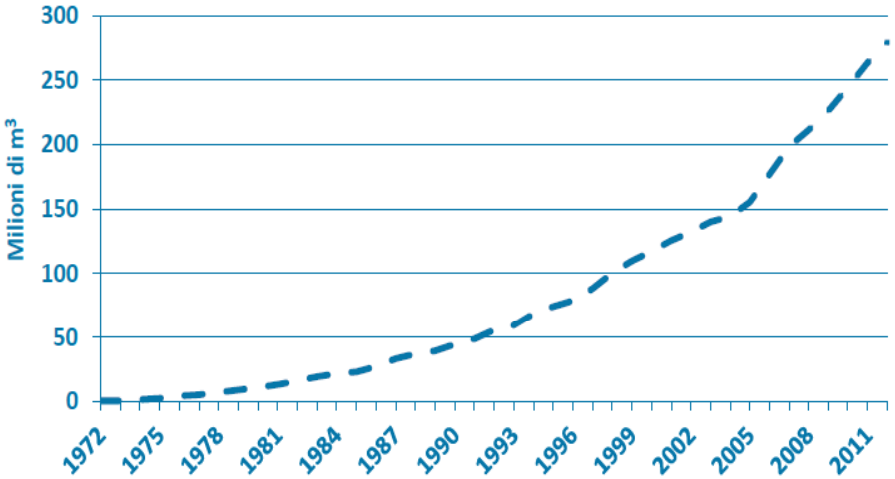


Source: AIRU – www.airu.it

State of district heating in Italy (2)

District heating supplies 4% of the total thermal load in Italy

Trand of heated volume in Italy



average annual growth rate: 7,5% (2006-2011)

Until today 148 District heating are in operation

109 City supplied (2012)

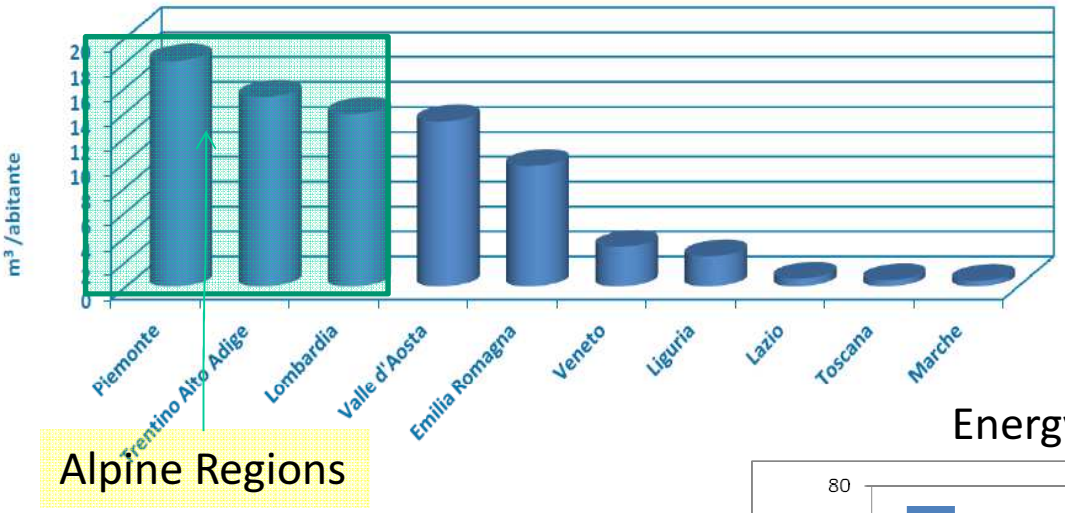
REGIONE	2011	2012	
Lombardia	118,6	125,0	+44,7%
Piemonte	70,7	76,4	+27,3%
Emilia Romagna	37,6	38,5	+13,8%
Veneto	13,8	14,3	+5,1%
Trentino Alto Adige	12,9	14,3	+5,1%
Valle d'Aosta	3,6	3,8	+1,4%
Lazio	3,0	3,2	+1,2%
Liguria	1,5	1,6	+0,6%
Toscana	1,0	1,8	+0,6%
Marche	0,7	0,7	+0,2%
TOTALE ITALIA	263,4	279,4	100%
TOTALE NORD	257,2 (98%)	272,2 (97%)	

More than 90% of district heating plants are located in northern Italy

Source: AIRU – www.airu.it

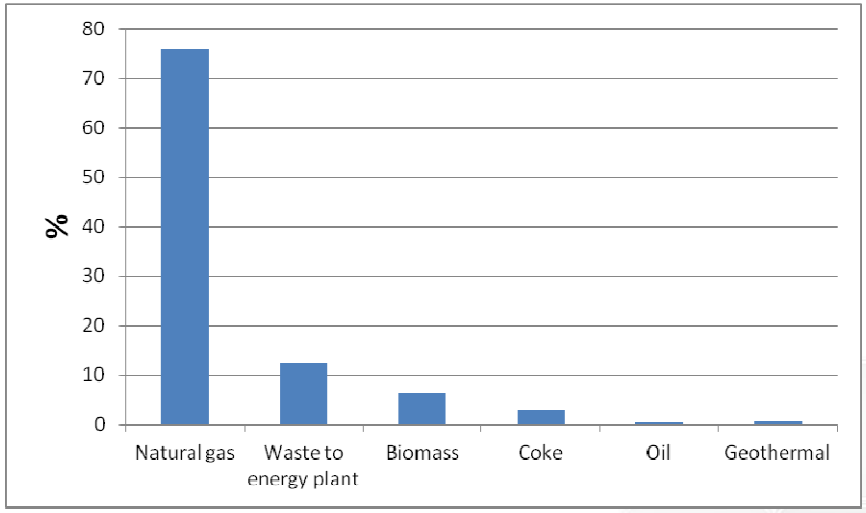
State of district heating in Italy (3)

Ratio of Heated volume per number of inhabitants



Alpine Regions

Energy source used (2011)



Source: AIRU – www.airu.it

Economic incentives for district heating

- Credit tax : 25€/kWht + 21 €/kW (per thermal substation) only for biomass district heating

- Reduced VAT to 10% - only for district heating with renewable energy source or high efficiency CHP

- Energy Efficiency Credit: average value 100 €/TEP (source GME)

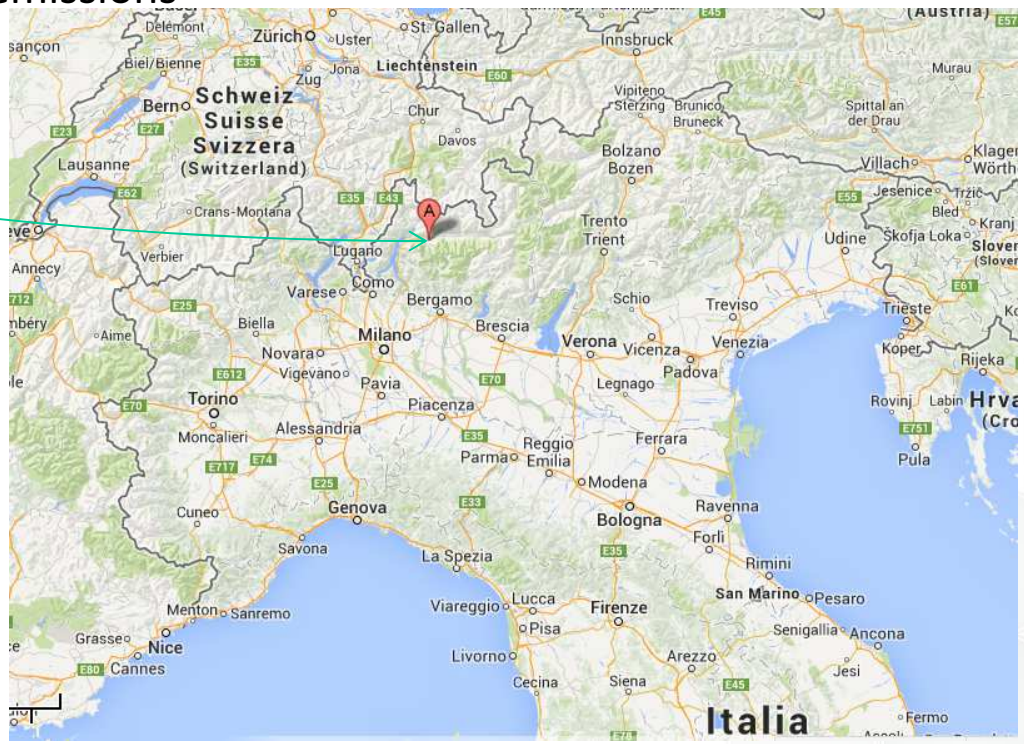
Source: AIRU

District heating: Some examples of best practices

- **Ferrara** (Center of Italy): thermal power supplied by geotermal source and waste to energy plant

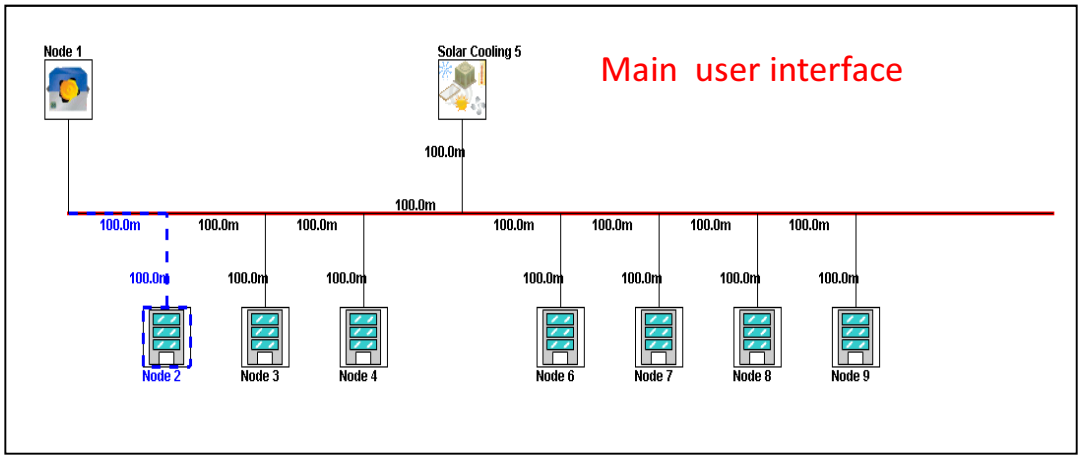
Pinerolo (northern Italy -Torino): thermal power supplied by 3 **biogas** CHP

Morbegno (northern Italy –Sondrio – Alpine area): thermal power supplied by 4 gas combustion engine combined and a heat pump in order to optimize the working cycle and reduce CO2 emissions

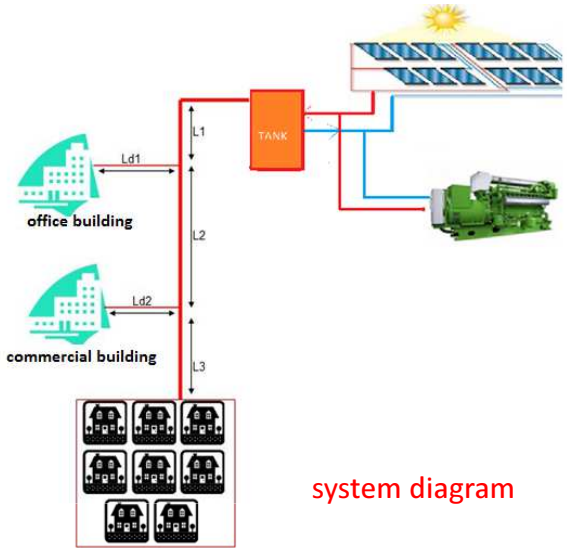


Source: AIRU

District heating in ENEA – C.R Casaccia (Roma)



Main user interface



system diagram

In ENEA we are developing a new platform software in order to simulate the small-scale district heating in time domain.

The new software is able to evaluate the energy and economic performances of a hybrid energy generation plant (CHP, solar palnts. Heat punp)

Project carried out by University of Rome Sapienza and ENEA, within the framework of “R&D activities of general interest for the National Electric System”, funded by Italian Ministry of Economic Development (MSE)

thanks for your attention !

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