TUIASI

Co-funded by the Erasmus+ Programme of the European Union

MARUEEB

"GHEORGHE ASACHI" TECHNICAL UNIVERSITY OF IASI

Use of renewable energy to increase the energy efficiency in buildings

nZEB solutions

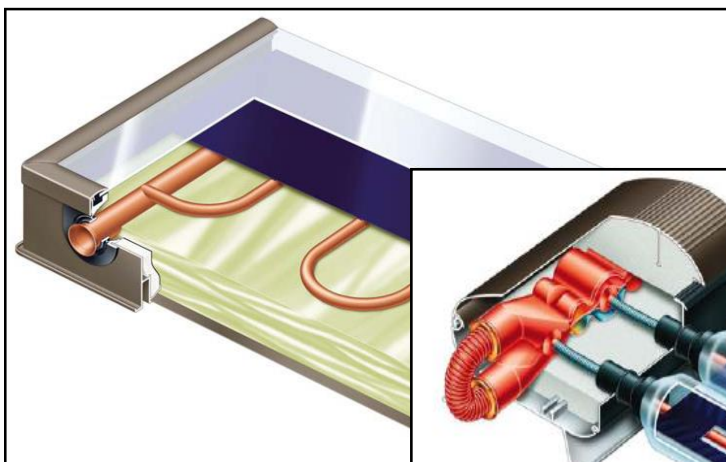
Lecturer. Phd. Marius Balan

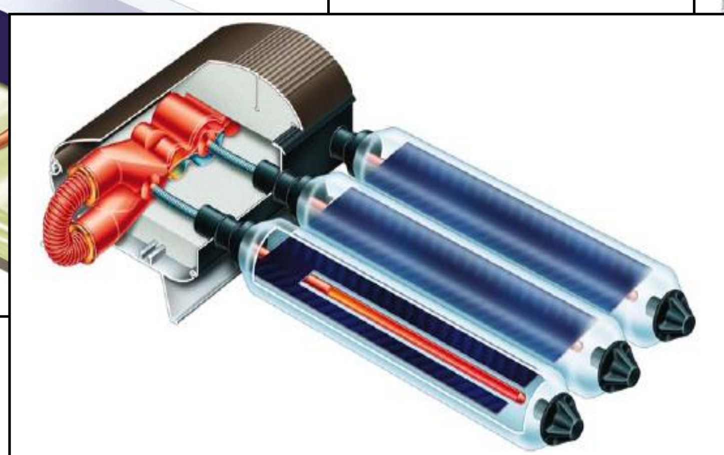
Yerevan, April 17-19

Solar technologies

Solar Energy → Solar Thermal Colectors → MEDIUM TEMPERATURE

- PLAN COLECTORS
- VACUUM COLECTORS
- HEAT PIPES COLECTORS





Solar technologies

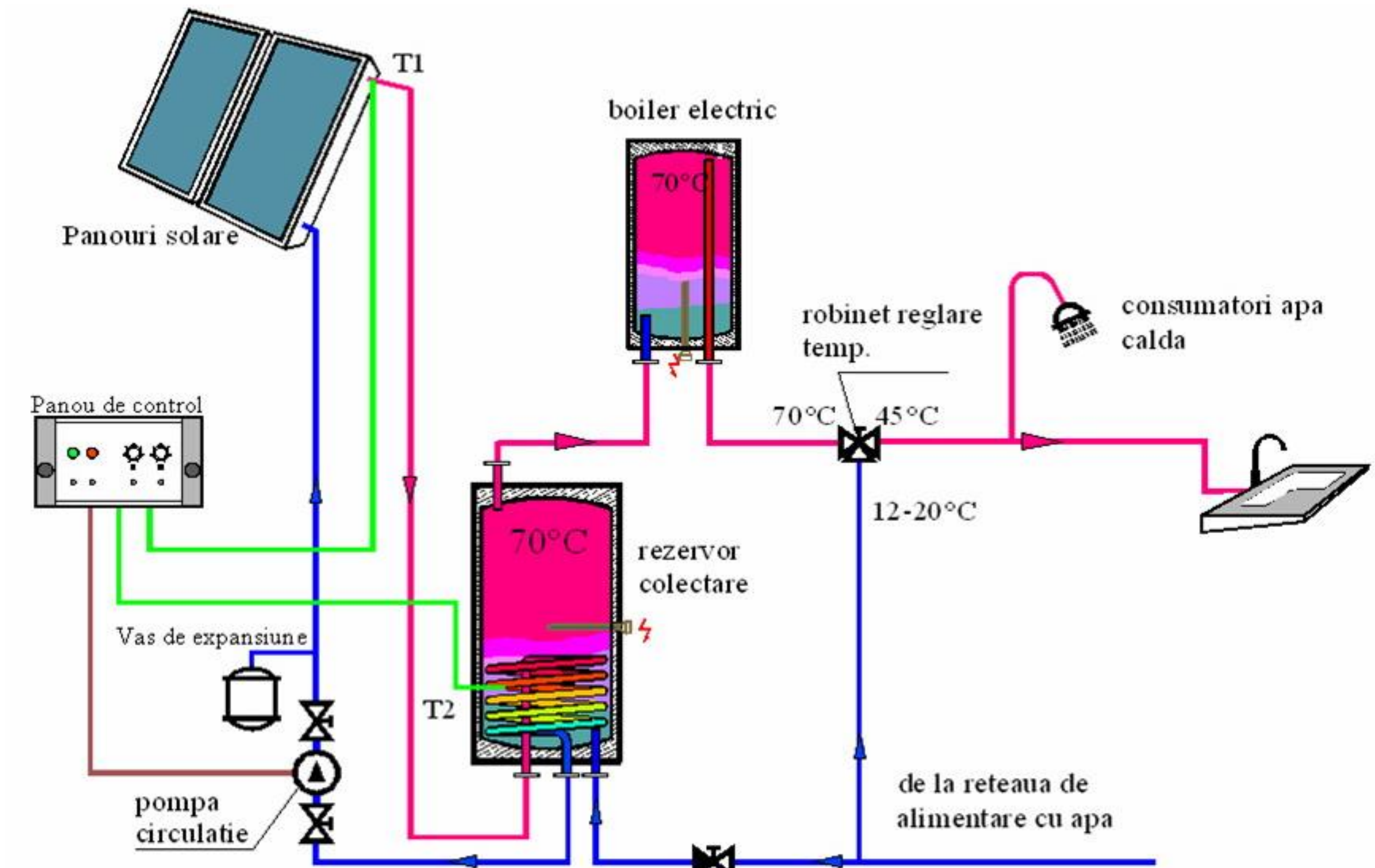
Solar Energy

Solar Thermal Colectors

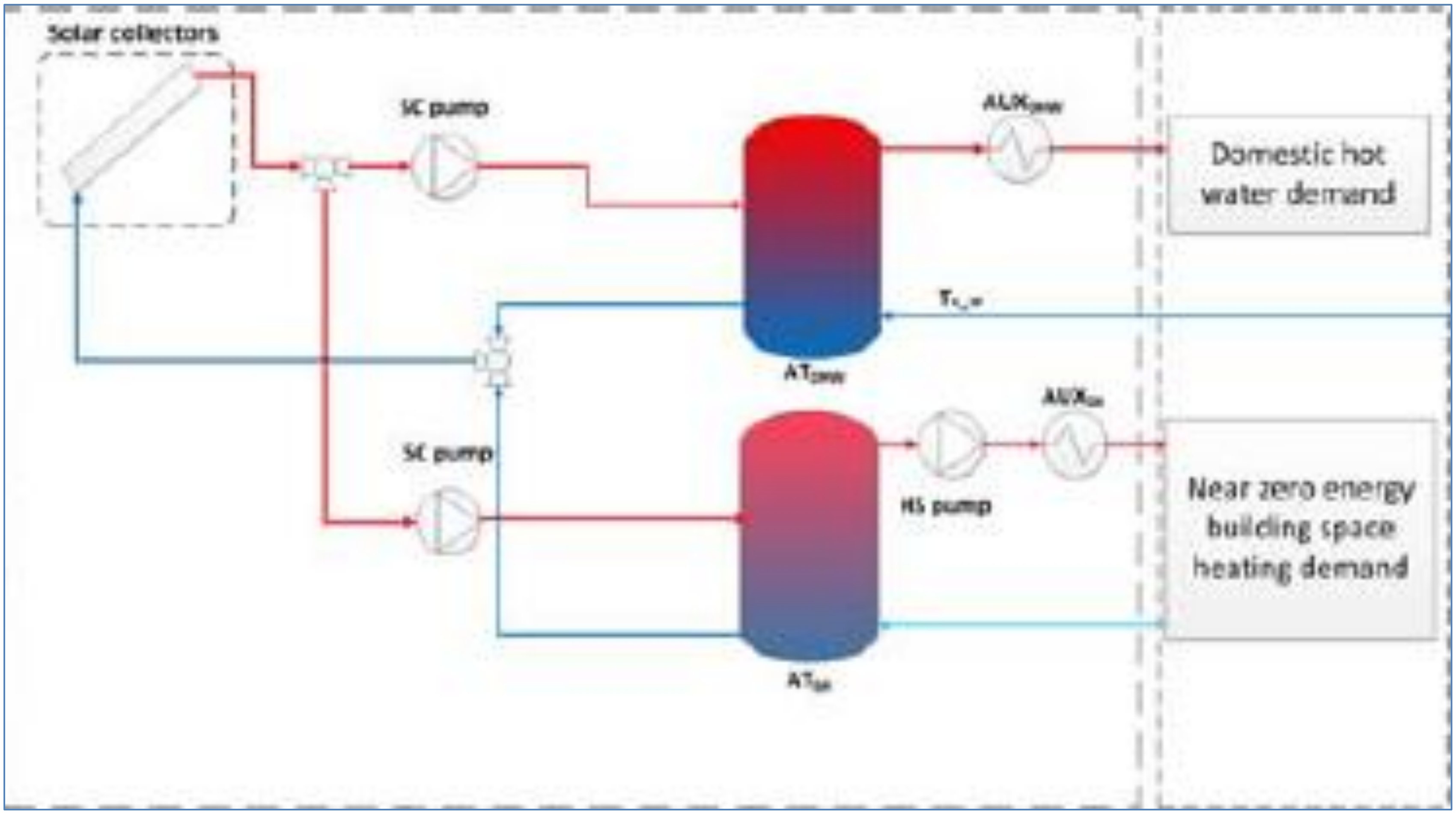
CONCENTRATION OF RADIATION

- SOLAR TOWER
- PARABOLICS
- CONCENTRATION
- PARABOLICS AND STIRLINGS

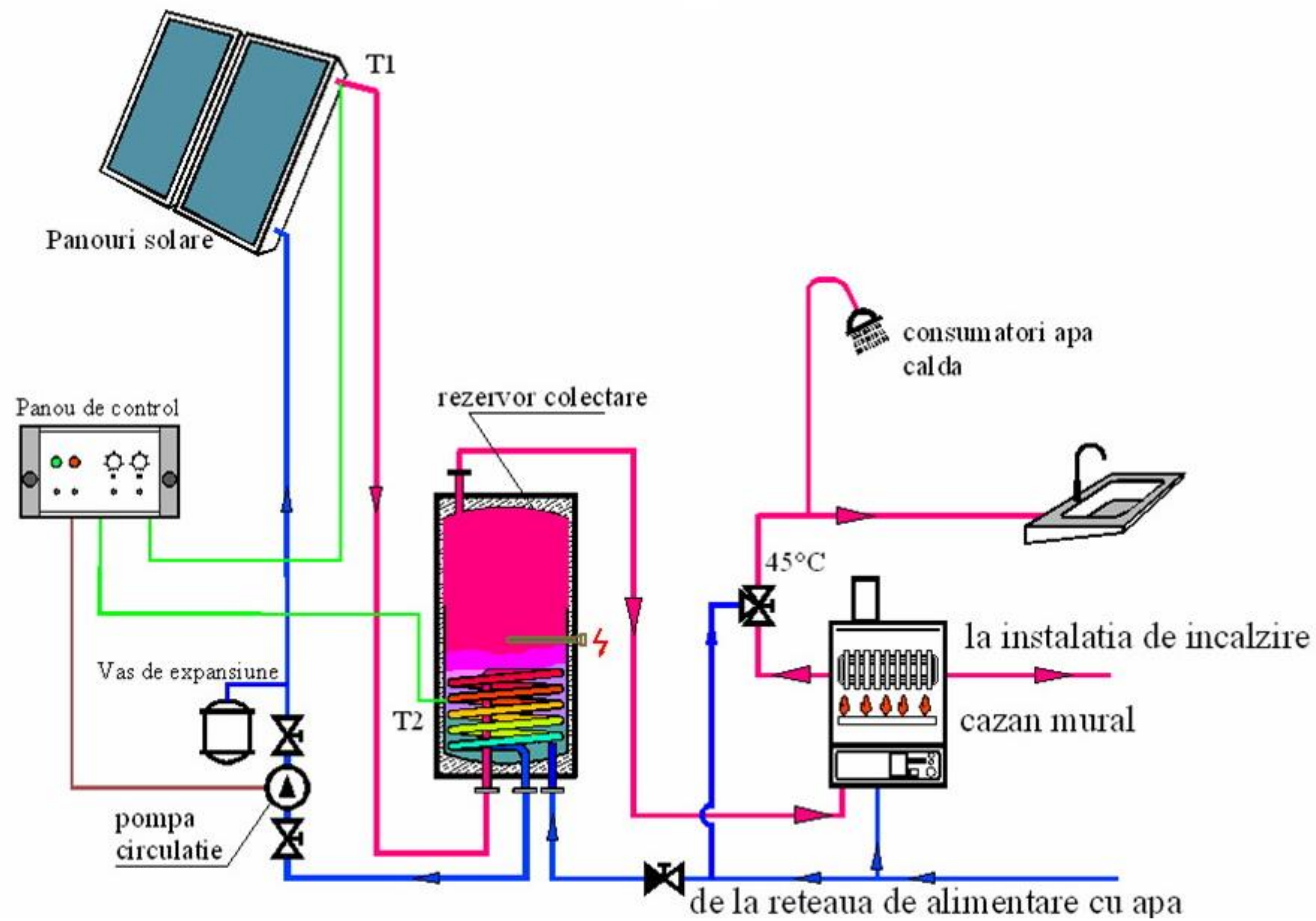
DHW SYSTEM


T1
boiler electric
70°C
Panouri solare
robinet reglare
temp.
consumatori apa
calda
Panou de control
70°C
45°C
12-20°C
70°C
rezervor
colectare
Vas de expansiune
T2
pompa
circulatie
de la reteaua de
alimentare cu apa

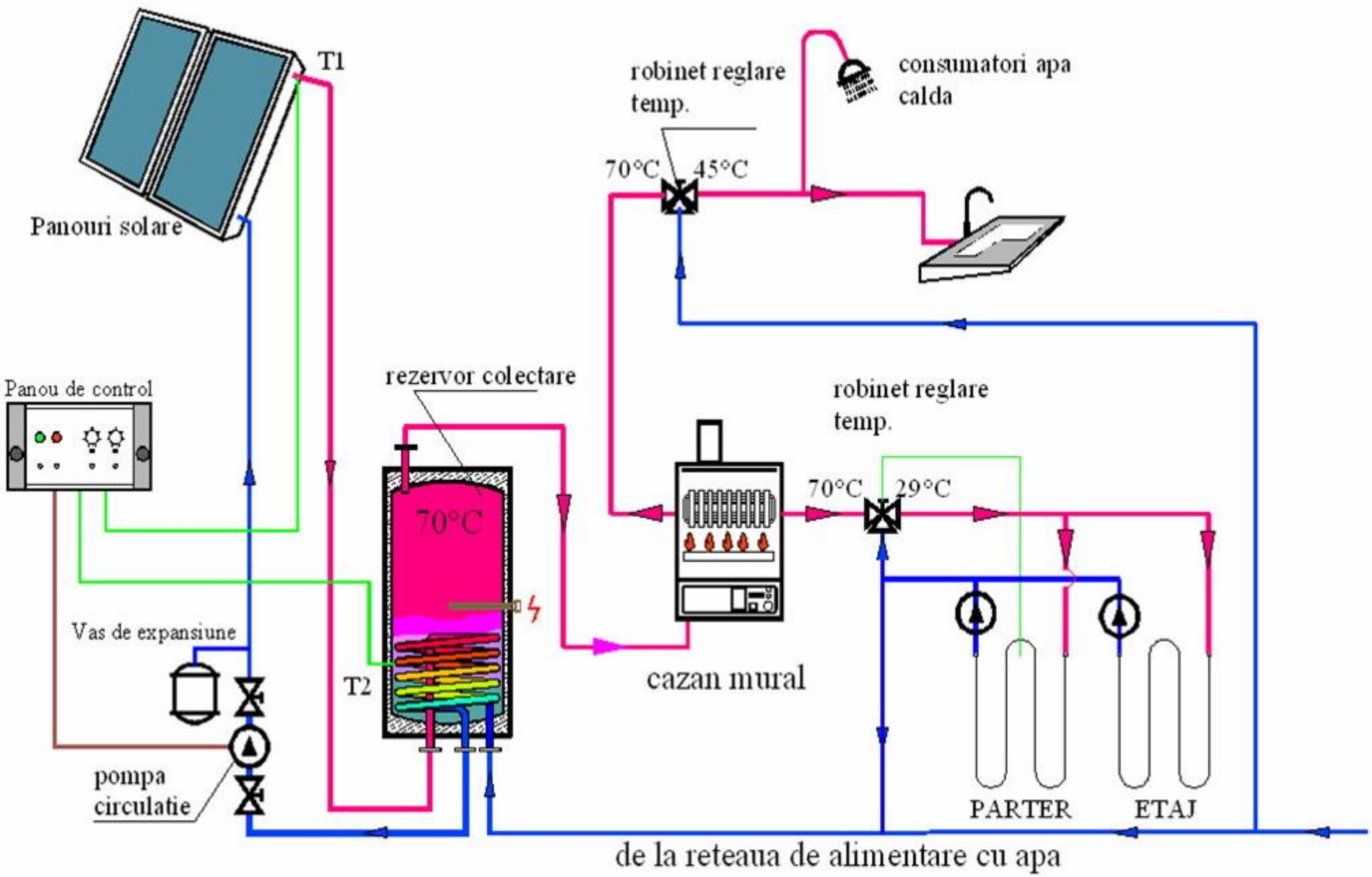
COMBINE HEATING AND HW



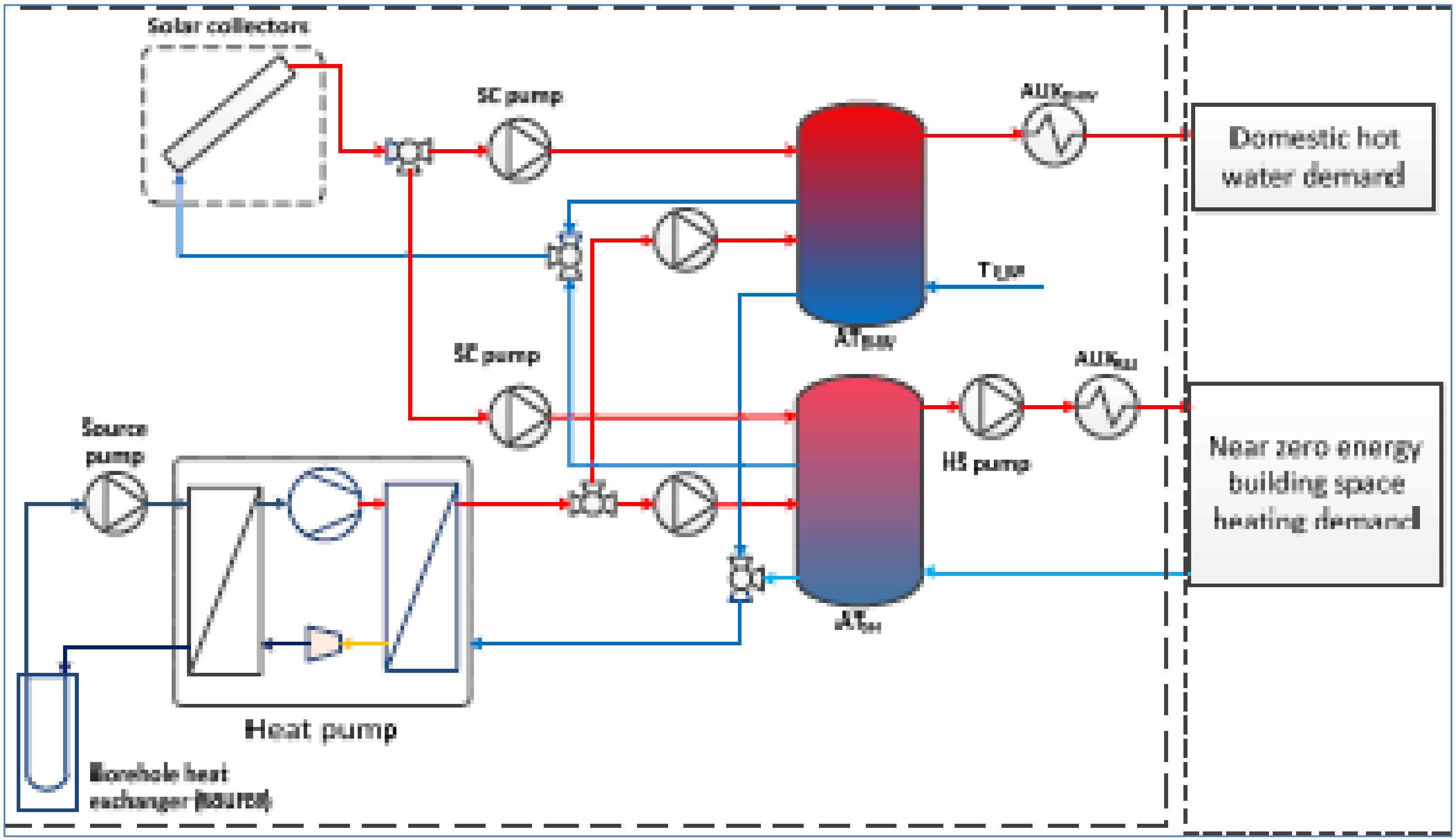
COMBINE HEATING AND HW



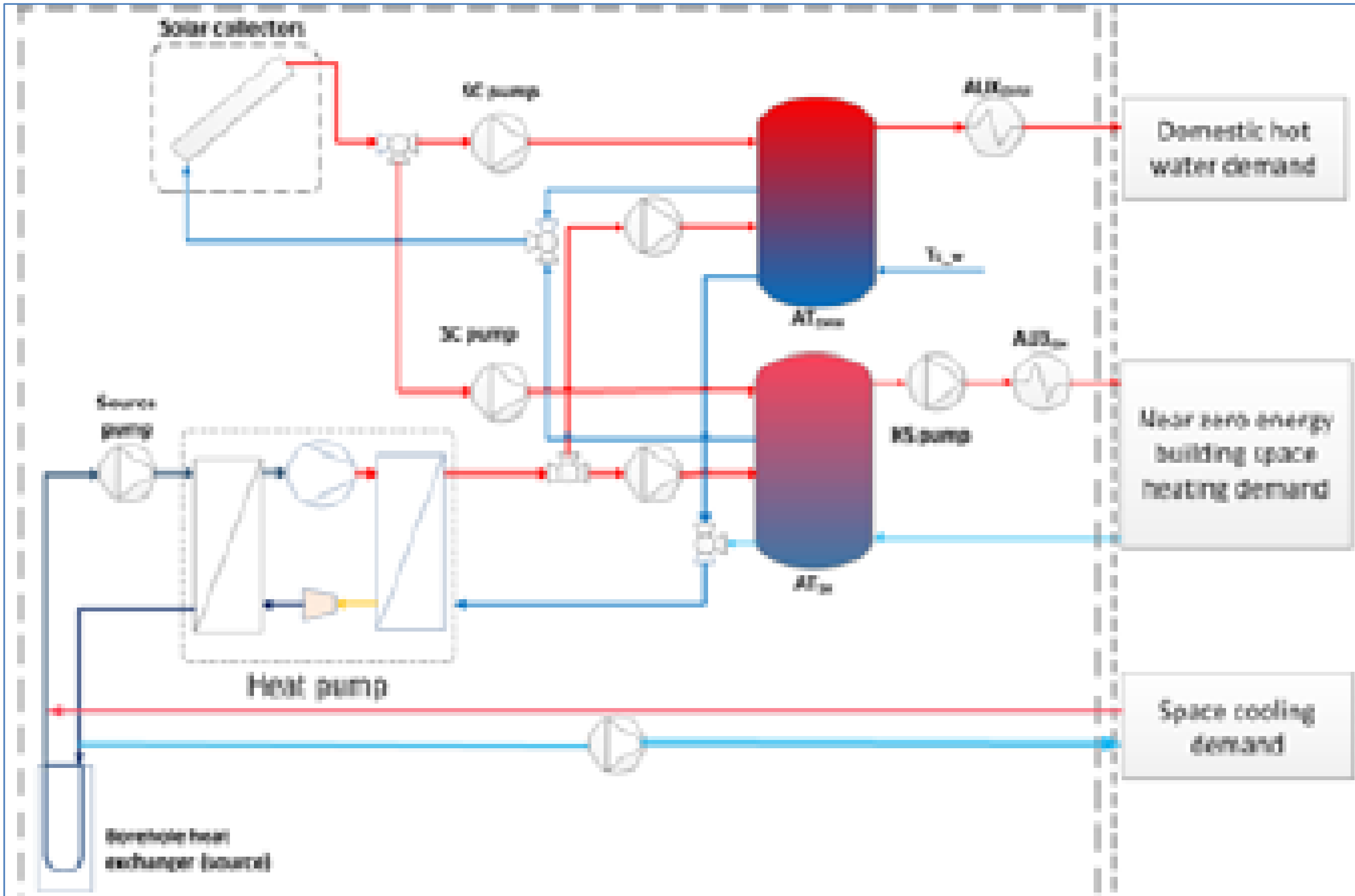
SOLAR SYSTEM WITH BOILER AND RADIANT HEATING



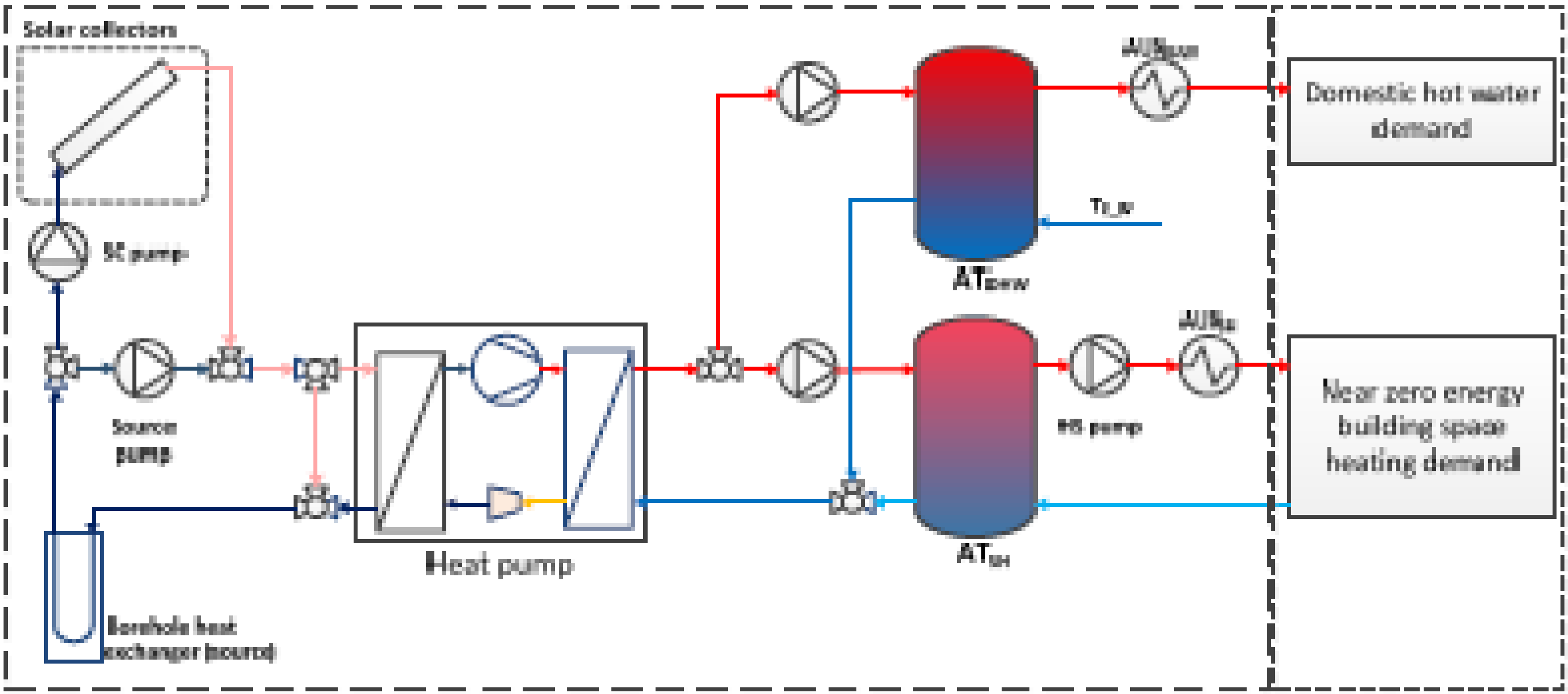
SOLAR SYSTEM WITH GROUND SOURCE HEAT PUMP



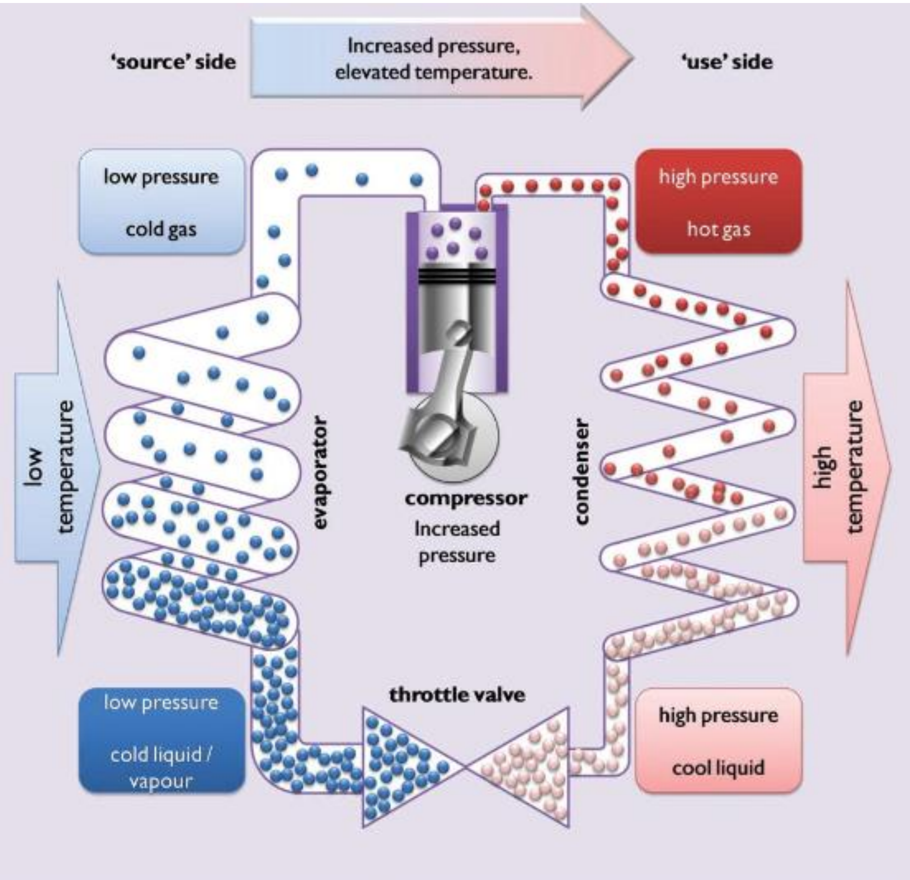
SOLAR SYSTEM WITH GROUND SOURCE HEAT PUMP AND COOLING

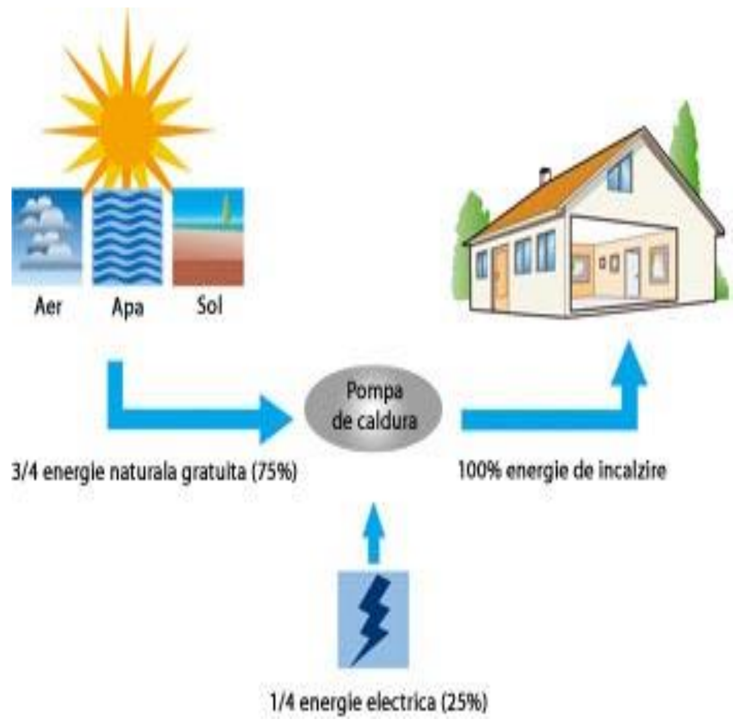


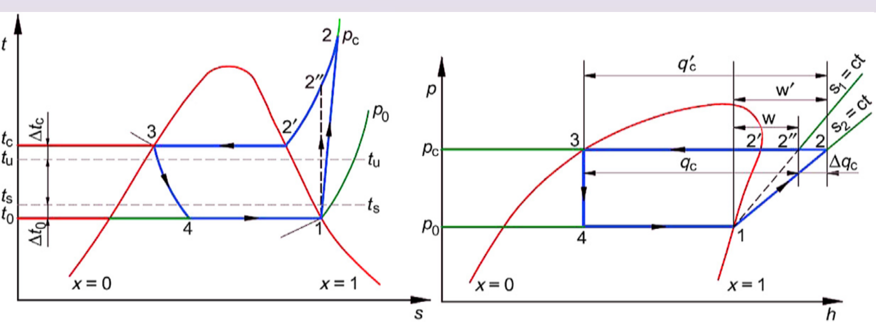
SERIAL SOLAR SYSTEM WITH GROUND SOURCE HEAT PUMP

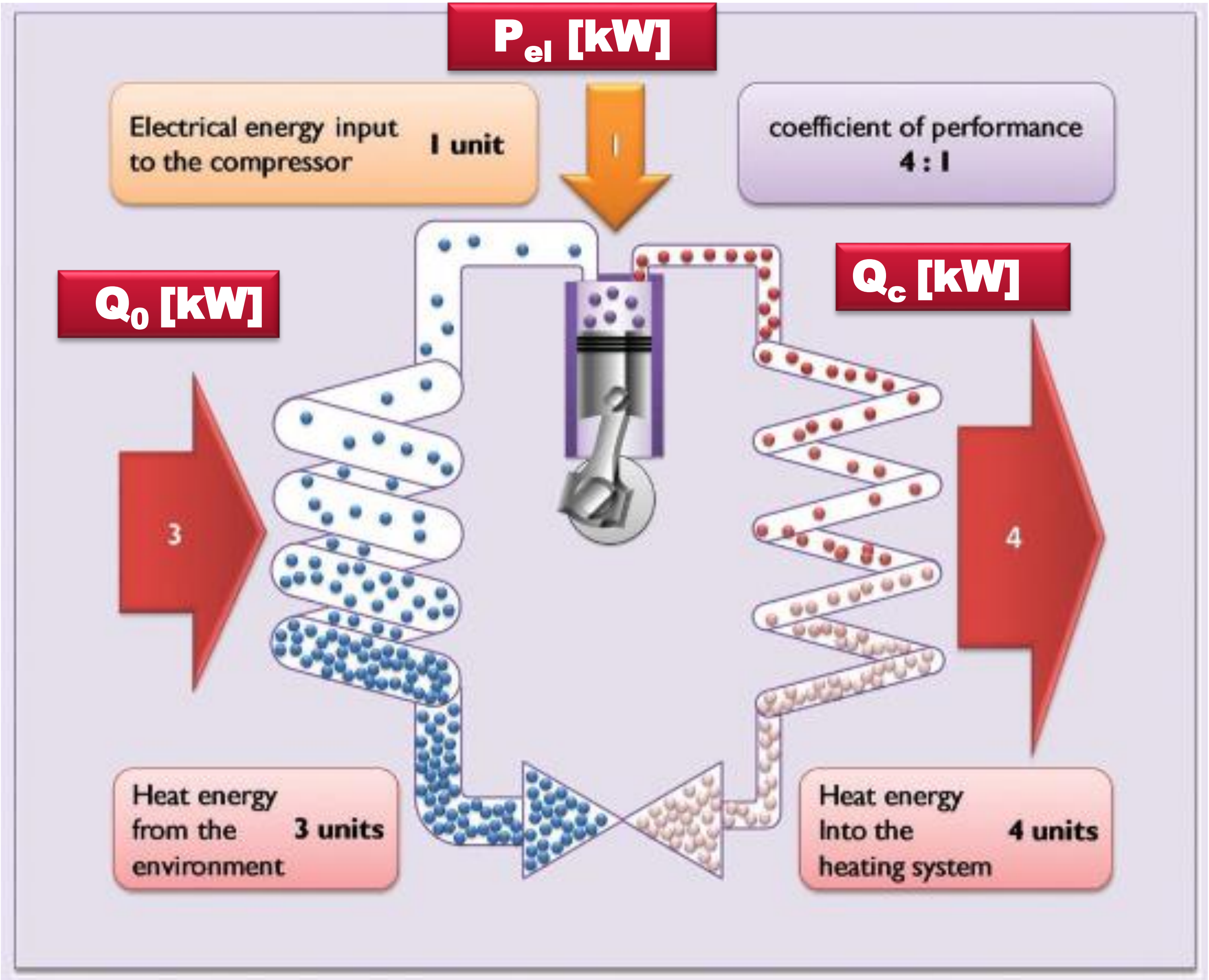


Heat pump


'source' side
Increased pressure, elevated temperature.
'use' side
low pressure
cold gas
high pressure
hot gas
low temperature
evaporator
compressor
Increased pressure
condenser
high temperature
throttle valve
low pressure
cold liquid / vapour
high pressure
cool liquid


Aer
Apa
Sol
Pompa de caldura
3/4 energie naturala gratuita (75%)
100% energie de incalzire
1/4 energie electrica (25%)


t
s
x = 0
x = 1
p
h
q'c
w'
w
qc
Δqc
s1 = ct
s2 = ct


P_{el} [kW]
Electrical energy input to the compressor
1 unit
1
coefficient of performance
4 : 1
Q_0 [kW]
Q_c [kW]
3
4
Heat energy from the environment
3 units
Heat energy Into the heating system
4 units

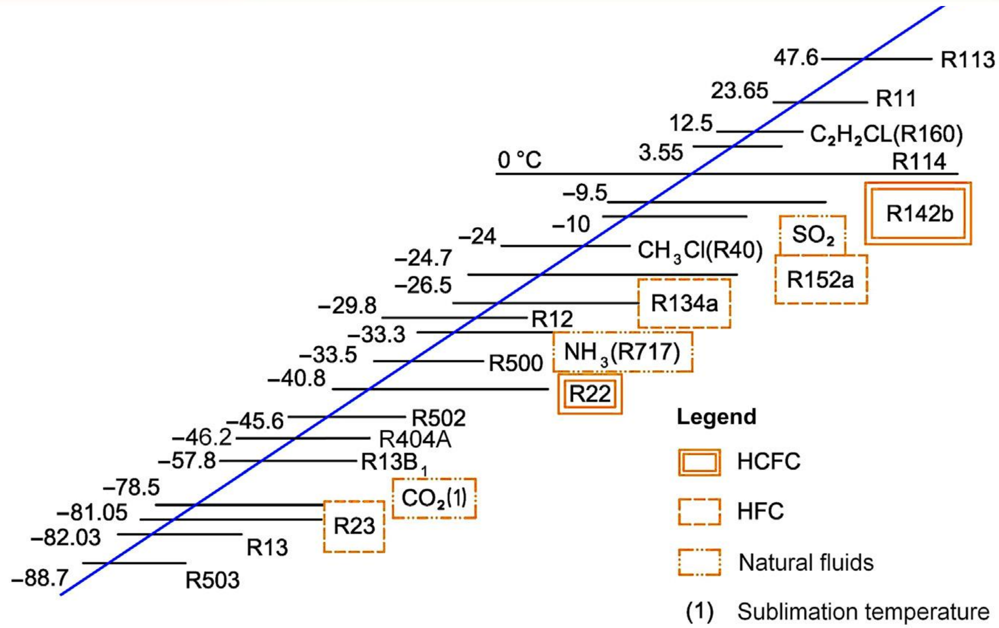
R 407C

0 ODP

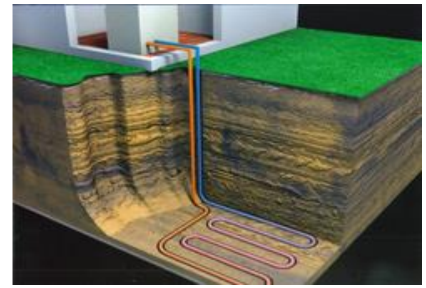
R 410A

0 ODP

Name	Chlorofluorocarbons	Hydrochlorofluorocarbons	Hydrofluorocarbon	Hydrocarbon	Ammonia	Carbon dioxide
Abbreviation	CFC	HCFC	HFC	HC	NH_3	CO_2
Number	R12	R22	R134A, R407C, R410A	R600A, R290	R717	R744
Ozone depleting potential (ODP)	1	0.05	0	0	0	0
Global Warming Potential (GWP)	2,400	1,700	1,500 ±15%	7	0	1
Uses	Domestic fridges	Air conditioning and heat pumps	All types of refrigeration and heat pumps	All types of refrigeration and heat pumps	Large systems	High temperature heat pumps
Status	Banned from 1998	Phased out from 2002 to 2010.	Currently the most common refrigerant.	Used in a few systems, especially smaller ones	Potential future refrigerant	New contender, shows promise for the future.



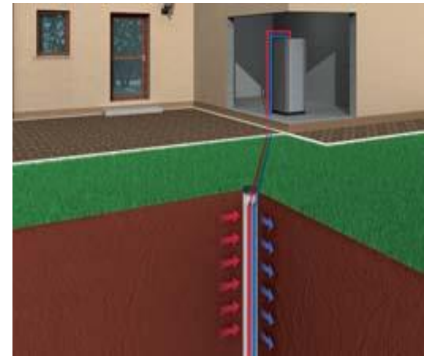
BRINE HEAT PUMP
Orizontal collectors



Tipuri de sol:	valoarea energetica:
Uscat, nisipos	10 W/m^2
Umed, nisipos	15 - 20 W/m^2
Uscat (argilos)	20 - 25 W/m^2
Umed (argilos)	25 - 30 W/m^2
Umed	35 W/m^2

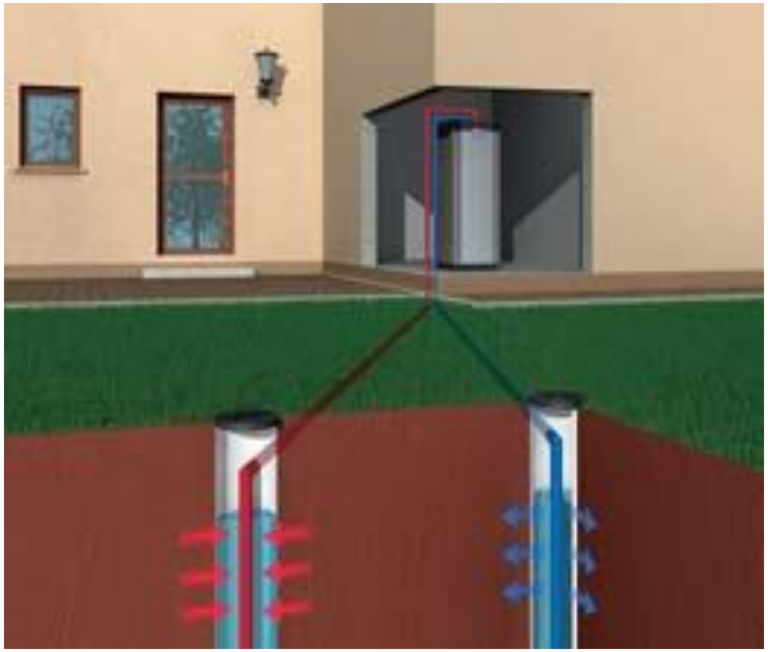
TUIASI
Co-funded by the Erasmus+ Programme of the European Union
MARUEEB

BRINE HEAT PUMP
Vertical collectors

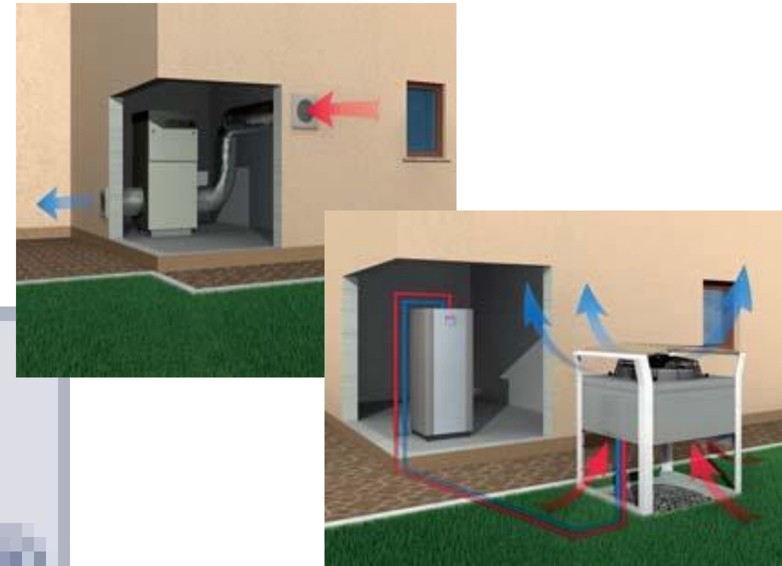


Substrat dur Sediment uscat	20 W/m
Substrat pietros, Sediment saturat cu apa	50 W/m
Roca stabila cu putere termica mare	70 W/m

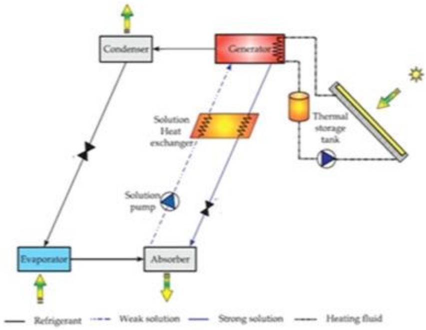
HEAT PUMP WATER TO WATER

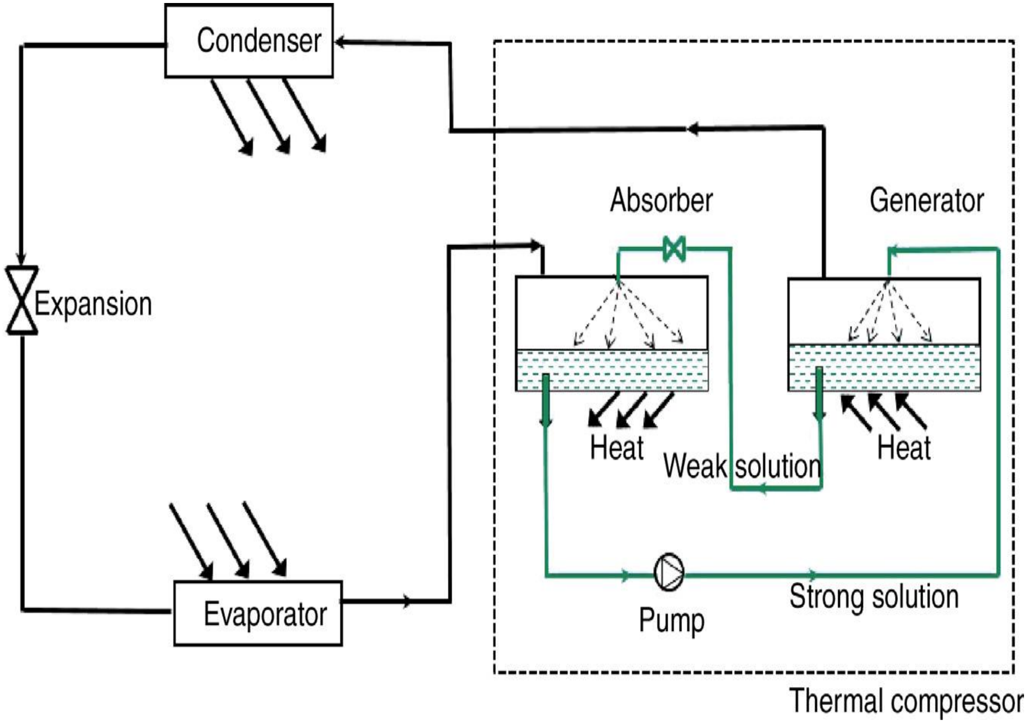


HEAT PUMPS AIR TO WATER



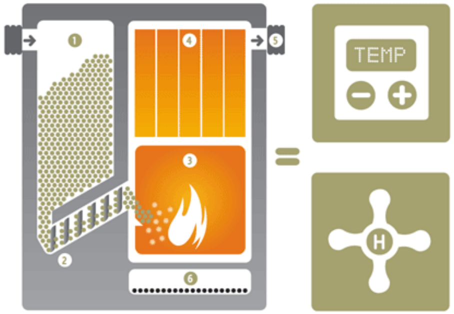
POMPĂ DE CĂLDURĂ CU ABSORBTIE





How does biomass heating work?

Biomass heating is generally wood fuel being burnt to generate hot water or provide space heating.



Different types of wood fuel


Pellets


Chips


Logs

Different types of system

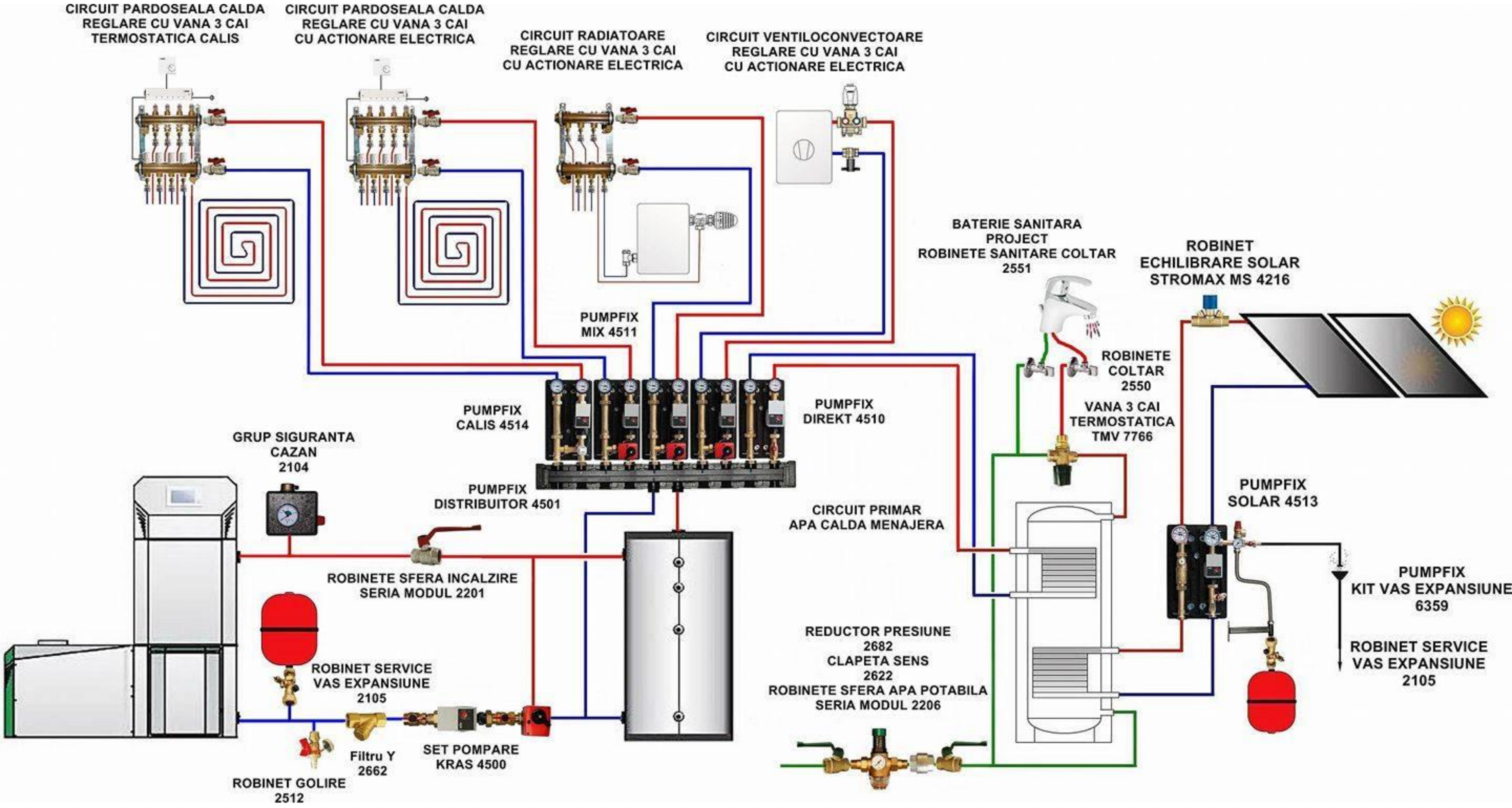

Stoves

Boilers

Biomass heating– the basics

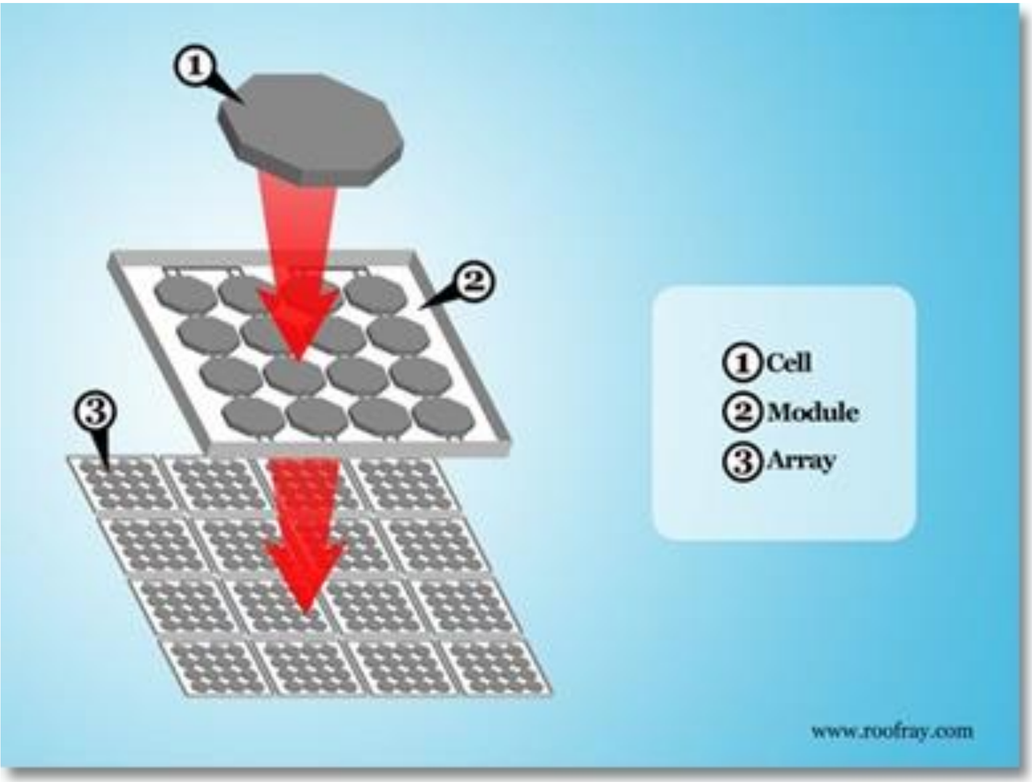
TUIASI Co-funded by the Erasmus+ Programme of the European Union MARUEEB

How does biomass heating work?



Photovoltaic (PV) Hierarchy

- Cell < Module < Panel < Array



Inside a PV Cell

Electron and Current Flow in Solar Cells

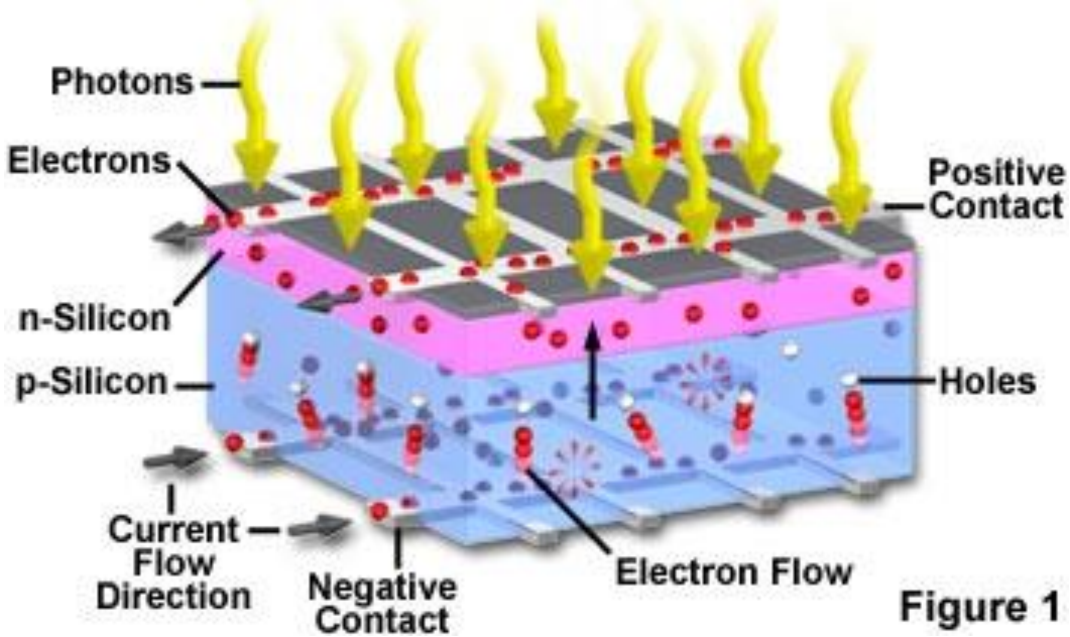
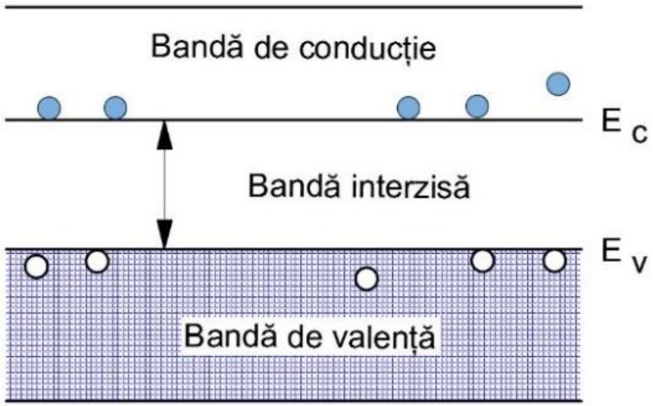


Figure 1



Available Cell Technologies

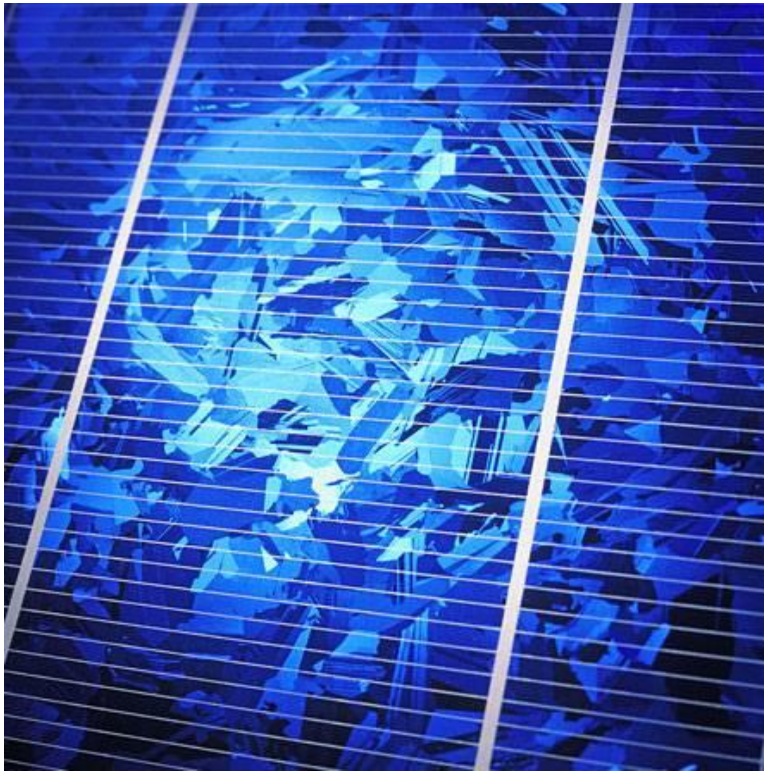
- Single-crystal or Mono-crystalline Silicon
- Polycrystalline or Multi-crystalline Silicon
- Thin film
  - Ex. Amorphous silicon or Cadmium Telluride

Monocrystalline Silicon Modules

- Most efficient commercially available module
- Most expensive to produce
- Circular (square-round) cell creates wasted space on module

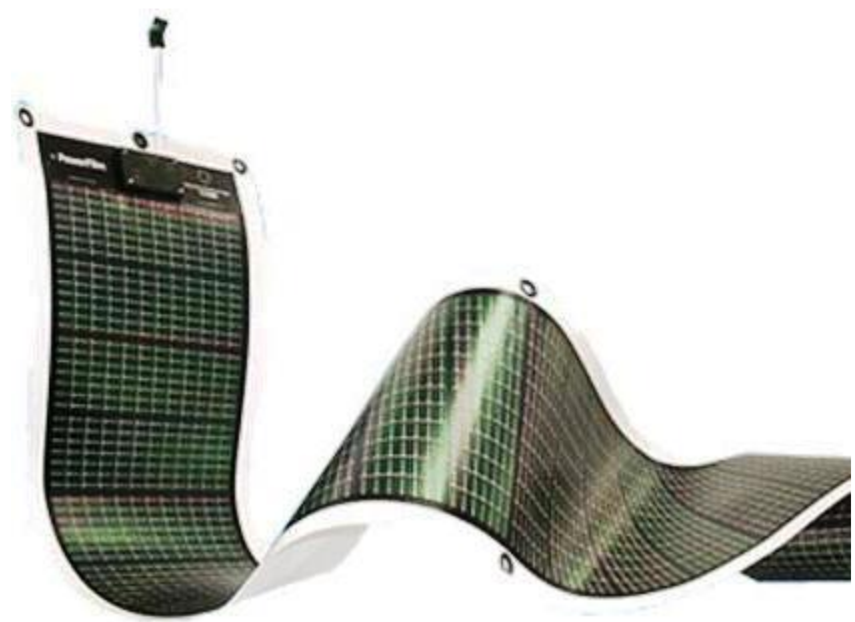
Polycrystalline Silicon Modules

- Less expensive to make than single crystalline modules
- Cells slightly less efficient than a single crystalline
- Square shape cells fit into module efficiently using the entire space



Amorphous Thin Film

- Most inexpensive technology to produce
- Metal grid replaced with transparent oxides
- Can be deposited on flexible substrates
- Less susceptible to shading problems
- Better performance in low light conditions that with crystalline modules

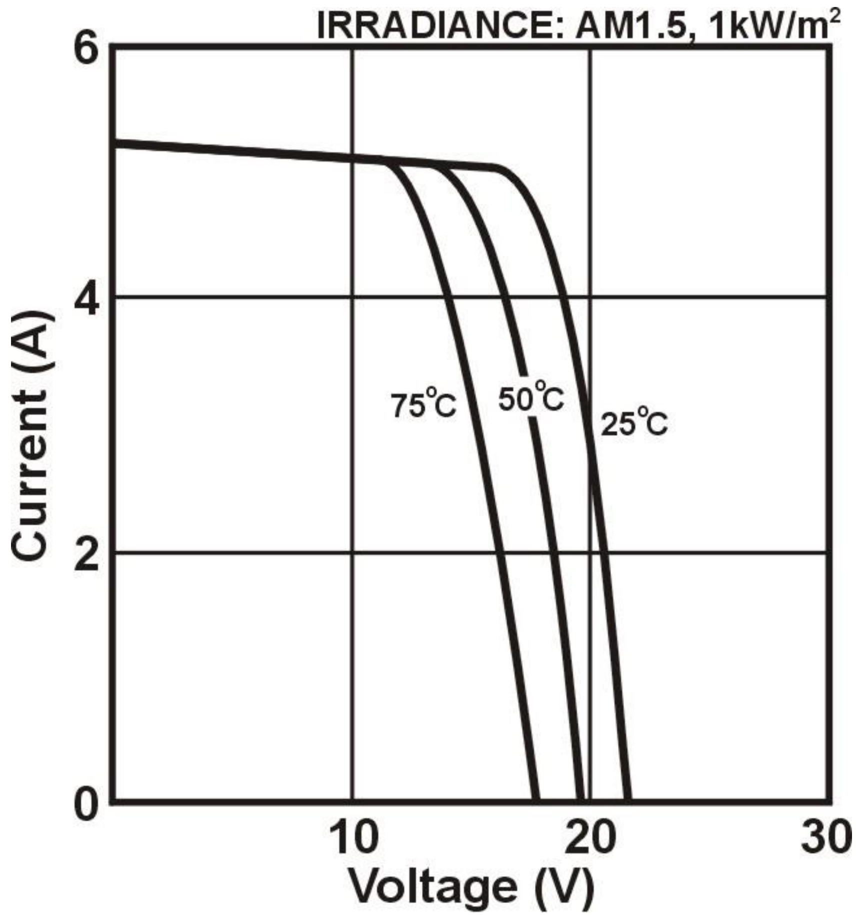


Selecting the Correct Module

- Practical Criteria
  - Size
  - Voltage
  - Availability
  - Warranty
  - Mounting Characteristics
  - Cost (per watt)

Effects of Temperature

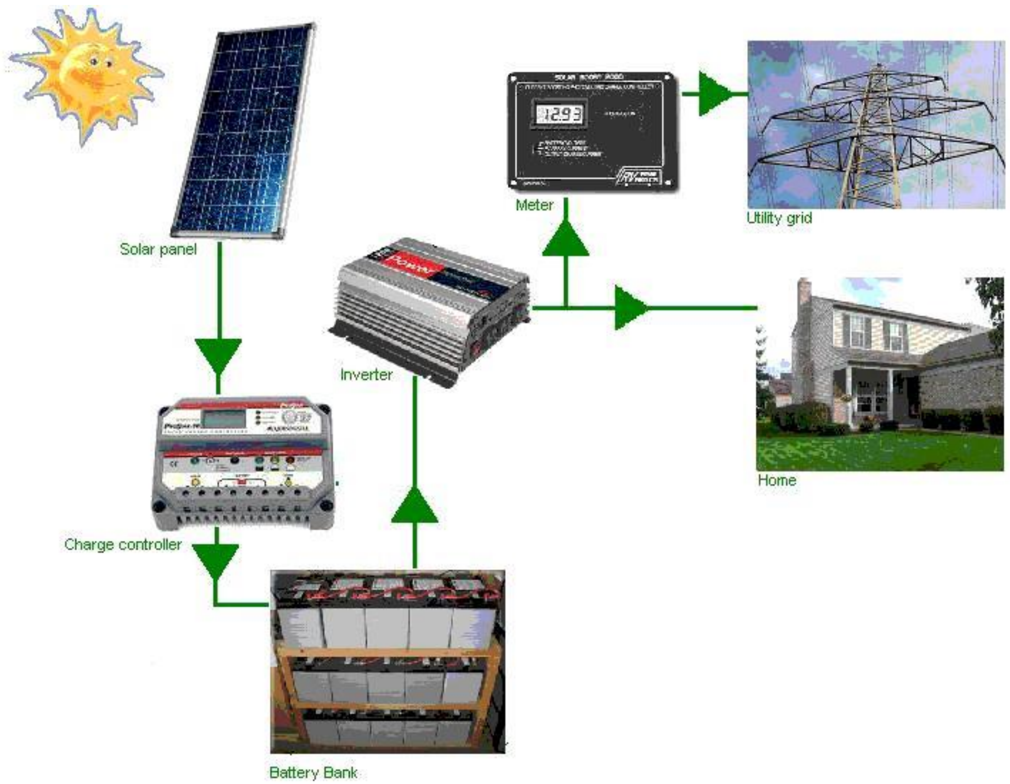
- As the PV cell temperature increases above 25° C, the module V_{mp} decreases by approximately 0.5% per degree C

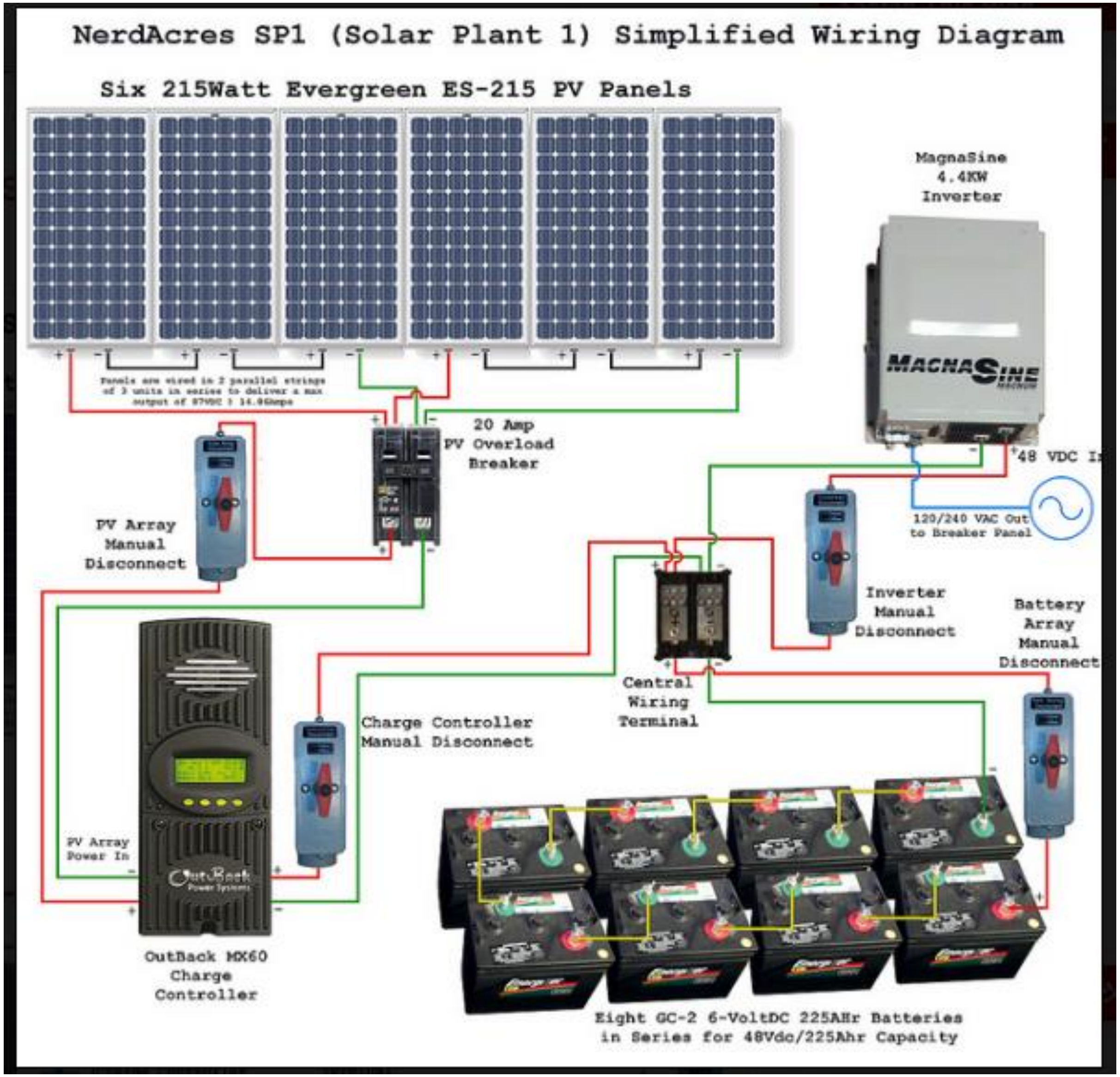


Grid-Tied System

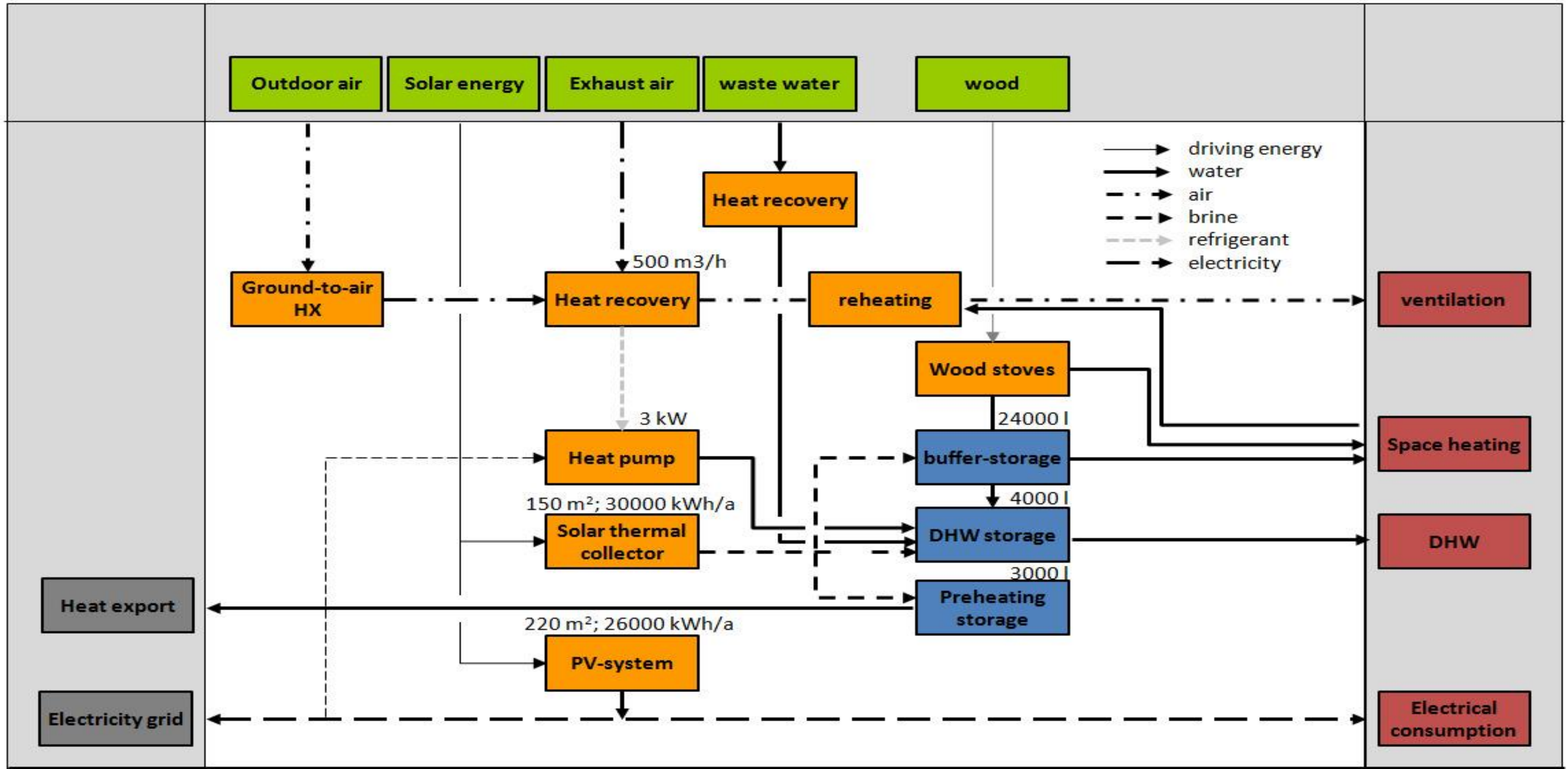
(With Batteries)

- Complexity
  - High: Due to the addition of batteries
- Grid Interaction
  - Grid still supplements power
  - When grid goes down batteries supply power to loads (aka battery backup)





Grid-Tied System
(With Batteries)



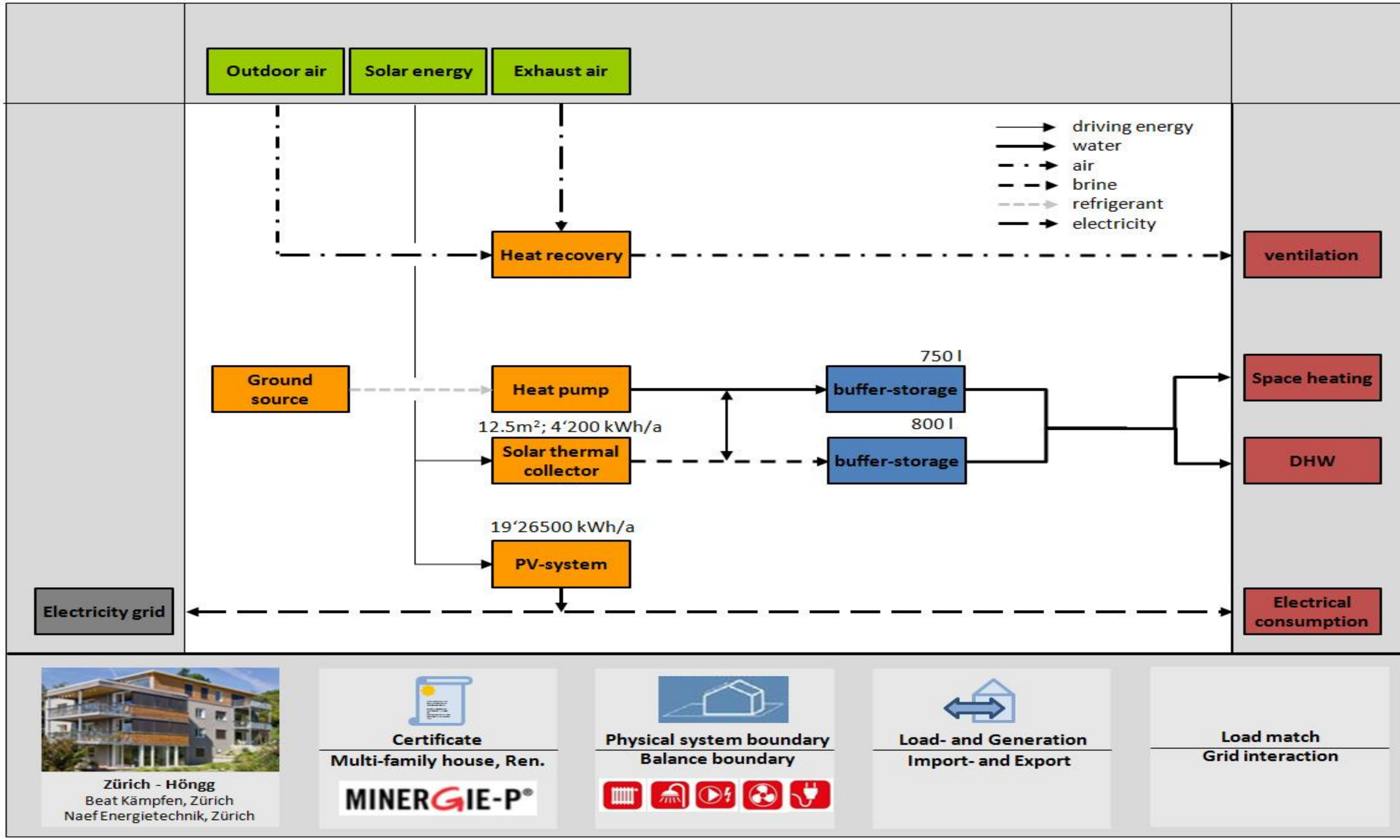
Kraftwerk B
Grab Architekten, Altendorf
Amena, Winterthur

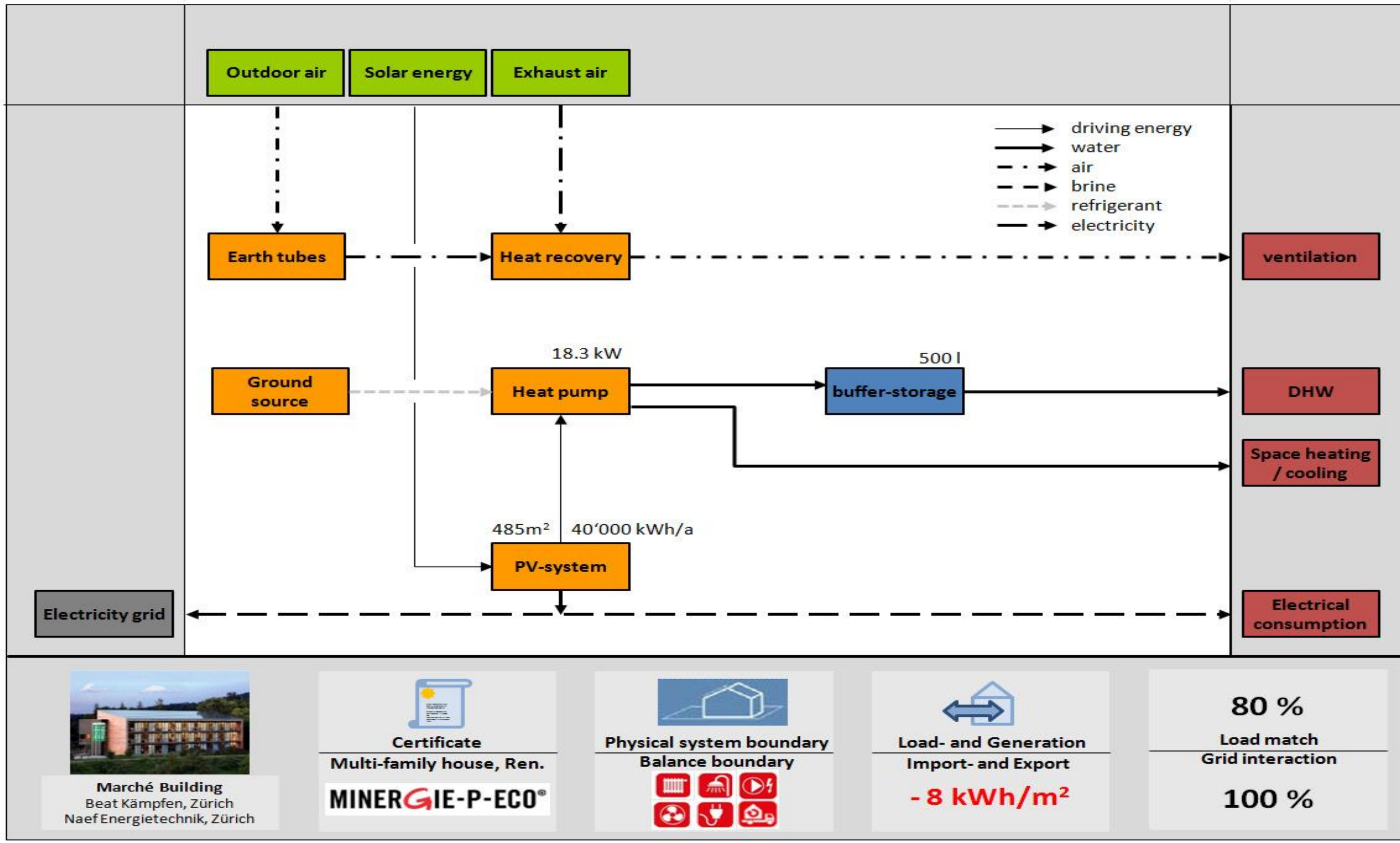
Certificate
Multi-family house, New
MINERGIE-P-ECO®

Physical system boundary
Balance boundary

Load- and Generation
Import- and Export
+ 2 kWh/m²

70 %
Load match
Grid interaction
30 %


Outdoor air
Solar energy
Exhaust air
driving energy
water
air
brine
refrigerant
electricity
Heat recovery
ventilation
750 l
Ground source
Heat pump
buffer-storage
Space heating
12.5m²; 4'200 kWh/a
800 l
Solar thermal collector
buffer-storage
DHW
19'26500 kWh/a
PV-system
Electricity grid
Electrical consumption
Zürich - Höngg
Beat Kämpfen, Zürich
Naef Energietechnik, Zürich
Certificate
Multi-family house, Ren.
MINERGIE-P®
Physical system boundary
Balance boundary
Load- and Generation
Import- and Export
Load match
Grid interaction


Outdoor air
Solar energy
Exhaust air
driving energy
water
air
brine
refrigerant
electricity
Earth tubes
Heat recovery
ventilation
18.3 kW
500 l
Ground source
Heat pump
buffer-storage
DHW
Space heating / cooling
485m²
40'000 kWh/a
PV-system
Electricity grid
Electrical consumption
Marché Building
Beat Kämpfen, Zürich
Naef Energietechnik, Zürich
Certificate
Multi-family house, Ren.
MINERGIE-P-ECO®
Physical system boundary
Balance boundary
Load- and Generation
Import- and Export
- 8 kWh/m²
80 %
Load match
Grid interaction
100 %

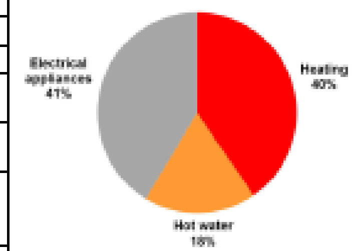
TUIASI

Co-funded by the Erasmus+ Programme of the European Union

MARUEEB

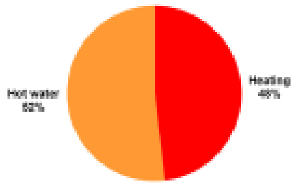
Austria

Project aim:	The house is built to meet the *passive house* standard, using solar thermal panels. The main focus was on the use of environmental building materials like straw, wood and loam rendering and a high contribution by the owner to the construction of the building.				
Building address:	Am Eichengrund 16, 8111 Judendorf-Straßengel				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Single-family house with a small integrated office				
Building size:	160 m^2 net floor area, 216 m^2 gross floor area				
Building envelope construction:	The walls and the roof are made of 70 cm straw bales between wood frame construction, the windows have triple glazing and the floor consists of 50 cm foam-glass gravel fill under a concrete base plate.				
Building envelope U-values:	Wall	0.065 W/m^2.K			
	Window	0.86 W/m^2.K			
	Roof/ceiling to the attic	0.065 W/m^2.K			
	Cellar ceiling/ground slab	0.11 W/m^2.K			
Building service systems:	The house is heated by a wood-pellet stove. It has a mechanical ventilation system with 86% heat recovery. The demand of hot water is mostly covered by solar panels.				
Included renewable energy technologies:	Heating system with wood pellets and solar thermal panels (8 m^2) for DHW production.				

Final energy use:	Calculated	X	Calculation method:	OIB 2011
	Measured		Monitored in year:	Not yet monitored. Finished in 2014.
	Heating		16.0 kWh/m^2.year	
	Hot water		7.3 kWh/m^2.year	
	Cooling		0.0 kWh/m^2.year	
	Ventilation		incl. in electrical appliances	
	Lighting		incl. in electrical appliances	
	Electrical appliances (household electricity)		16.4 kWh/m^2.year	
	Total		39.7 kWh/m^2.year	
Primary energy use/CO_2 emissions:	Total primary energy		85.9 kWh/m^2.year	
	Total CO_2 emissions		10.4 kg/m^2.year	
Renewable energy contribution ratio:	About 48% of the total final energy			
Improvement compared to national requirements:	About 42%		Compared to:	Maximum final energy demand according to OIB 2011
Experiences/ lessons learned:	The challenge with this house was using straw in the building construction. The owner wanted to significantly contribute to the construction of the building. Thus, at the end, his degree of satisfaction and personal fulfilment satisfaction with the house is very high.			
Costs:	The building costs were about 300,000 € (1,875 €/m^2 net floor area) but this does not include the work of the house owner.			
Funding:	Subsidies of the Styrian government including a bonus for building a passive house and for the *klima:aktiv* declaration.			
Marketing efforts:	*klima:aktiv* declaration			
Links to further information:	http://strohundlehm.at			

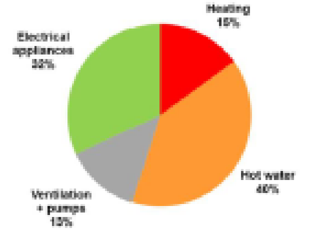
Austria

Project aim:	The complex is built to meet the *passive house* standard. The main focus was to offer a mix of various common spaces (like service areas, a nursery, and student and senior dwellings) in a central location and a lot of open areas. This report only describes the multi-family section of the complex.				
Building address:	Klosterwiesgasse 101-103 and Münzgrabenstr. 84, 8010 Graz				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Multi-family apartment building				
Building size:	21,000 m² net floor area				
Building envelope construction:	The house has a massive construction with insulated brick walls. The roof and the cellar ceiling consist of reinforced concrete, the windows have triple glazing.				
Building envelope U-values:	Wall	0.18 W/m².K			
	Window	0.8 W/m².K			
	Roof/ceiling to the attic	0.11 W/m².K			
	Cellar ceiling/ground slab	0.11 W/m².K			
Building service systems:	The house is heated by district heating. It has a mechanical ventilation system with 75% heat recovery. The demand of hot water is partially covered by 700 m² solar thermal panels on the roof.				
Included renewable energy technologies:	Solar thermal panels (700 m²) are used for heating the hot water and as support for heating. A heat pump is used as preheating of the incoming air of the mechanical ventilation system.				

Final energy use:	Calculated	X	Calculation method:	OIB 2007
	Measured		Monitored in year:	-
	Heating		14.4 kWh/m².year	
	Hot water		15.7 kWh/m².year	
	Cooling		0.0 kWh/m².year	
	Ventilation		incl. in heating	
	Lighting		Unknown	
	Electrical appli-ances (household electricity)			
	Total		30.1 kWh/m².year	
Primary energy use:	Total:		45.8 kWh/m².year	Primary energy factor of district heating: 1.52
Renewable energy contribution ratio:	About 52% of the total final energy			
Improvement compared to national requirements:	About 43%		Compared to:	Maximum final energy demand according to OIB 2007
Experiences/ lessons learned:	The satisfaction of the residents is very high. The infrastructure and the equipment are good and the mix of use is well accepted. The swimming pool with wellness area on the top floor, which is free to use for all residents, is a large plus.			
Costs:	The building costs were about 57 million € for the entire estate.			
Funding:	Subsidies of the Styrian government including a bonus for building a passive house and for the *klima:aktiv* declaration.			
Marketing efforts:	*klima:aktiv* declaration			
Awards:	Award for Architecture and Sustainability			
Links to further information:	http://www.klimaaktiv.at/bauen-sanieren/staatspreis/staatspreis2012 http://www.zement.at/Service/literatur/fileupl/05_12_wohnanlage_messequartier_graz.pdf			

Belgium

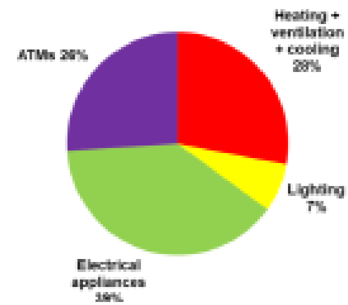
Project aim:	Research about the affordability of NZEB-dwellings: Passive building envelope, 100% renewable energy coverage of the primary energy use for heating, DHW and electrical auxiliary use.				
Building address:	Zultseweg 7, 8790 Waregem, Flanders, Belgium				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	7 individual dwellings with a small private garden and a large communal garden.				
Building size:	Total dwelling size (gross): 194 m² for the corner houses and 188 m² for the central houses. Heated floor area: ca. 150 m²				
Building envelope construction:	The building consists of brick walls and concrete floor slabs. All walls have a thickness of 14 cm, plus 24 cm of mineral wool for the outer walls. The roof is a wooden construction with 36 cm of mineral wool. The target for air tightness is 1.5 vol/h or 2.5 m³/hm² at 50 Pa pressure difference. The windows have a wooden frame and triple glazing.				
Building envelope U-values:	Wall	0.12 - 0.13 W/m².K			
	Window	0.78 W/m².K ($U_{glazing}$ = 0.6 W/m².K)			
	Roof/ceiling to the attic	0.13 W/m².K			
	Cellar ceiling/ground slab	0.10 W/m².K			
	Wall between 2 dwellings	0.35 W/m².K			
	Roof window	1.01 W/m².K ($U_{glazing}$ = 0.5 W/m².K)			
Building service systems:	Heating: gas boiler (12 kW) with floor heating in the kitchen and living area. The bedrooms are not equipped with a separate heating. In the bathroom, an electric towel dryer with thermostat will be installed. DHW: gas boiler (same as above) with 200 liter buffer storage. Ventilation: mechanical, supply of fresh air in dry rooms, exhaust in wet rooms, with heat recovery (min. 85%) Cooling: a number of measures were part of the design to make active cooling unnecessary, including a big structural louvre on the south façade. Lighting: up to buyers/tenants. All communal lighting will be according to BREEAM standards.				

Included renewable energy technologies:	All possible renewable energy technologies where studied (heat pumps, biomass boilers, PV panels, solar thermal panels and collective installations of all these technologies for the 7 dwellings. A Life Cycle Cost Analysis study led to 3 possible and more or less equal choices in renewable energy systems: 1. a collective biomass boiler for the 7 dwellings 2. an optimally insulated dwelling with participation in renewable energy systems in the region (no production on site). 3. gas boiler + PV system (3.8 kW_p): for a number of practical reasons mainly linked to the preference of the real estate developer, this was the implemented solution.			
Final energy use:	Calculated	X	Calculation method:	VE (Virtual Environment)
	Measured		Monitored in year:	Monitoring over 3 years will start when construction is finished
	Heating	8.5 kWh/m².year		
	Hot water	22.0 kWh/m².year		
	Cooling	0.0 kWh/m².year		
	Ventilation + pumps	7.0 kWh/m².year		
	Lighting	incl. in electrical appliances		
	Electrical appli-ances (household electricity) incl. lighting	(18.0 kWh/m².year) -> not taken into account in calcula-tion of NZEB energy		
	PV production	-22.0 kWh/m².year		
	Total gas	30.5 kWh/m².year		
	Total electricity	-15.0 kWh/m².year		
	Total final energy	15.5 kWh/m².year		
Primary energy use:	Gas	31 kWh/m².year	Primary energy factor: 1	
	Grid electricity	18 kWh/m².year	Primary energy factor: 2.5	
	PV production	-55 kWh/m².year	Primary energy factor: -2.5	
	Total	-6 kWh/m².year		
Renewable energy contribution ratio:	59% of the total final energy (112% of primary energy)			
Improvement com-pared to national requirements:	78%	Compared to:	Current requirement is E60 + PV production of 7 kWh/m².year habitable space: this building is E13 + PV production of 22 kWh/m².year	
Costs:	Difference in initial investment cost (CAPEX) compared to current legislation (E60 + RE): • Reference building = 242,000 € • NZEB (with collective biomass heating) = reference + 6% (14,500 €) • NZEB (with participation and condensing boiler) = reference + 6% (14,300 €) • NZEB (with PV and condensing boiler) = reference + 8% (18,900 €) Difference in net present value (NPV) over 30 years according to current legislation: • NZEB (with collective biomass heating) = reference - 7,100 € • NZEB (with participation and condensing boiler) = reference - 7,300 € • NZEB (with PV and condensing boiler) = reference - 11,000 €			
Marketing efforts:	• BREEAM Excellent certificate will be obtained for the design and the post construction phase • The project is widely known in the Belgian press • Series of lectures about the project and lessons learned for architects, developers, constructors, etc.			
Awards:	A BREEAM Excellent for both the design and post-construction phases.			
Links to further information:	www.deduurzamewijk.be (NL/FR)			

Belgium

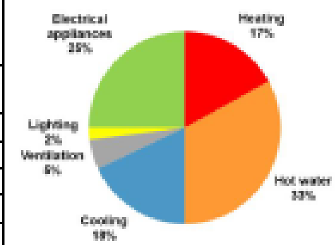
Project aim:	The initial aim for the project was a low-energy bank office, whose concept could be used as an example for other KBC bank offices. During the building process, the aim became to build a (Nearly) Zero Energy bank office.				
Building address:	Edingsesteenweg, 1755 Gooik				
Building type:	Residential	Non-residential	Public	New	Renovated
		X		X	
	Office building				
Building size:	265 m² net floor area				
Building envelope construction:	The building has high insulation and triple-glazed windows. The natural stone façade has 23 cm of extruded polystyrene (XPS), the green roof 20 cm of polyurethane (PUR) and the floor is on ground with 20 cm of XPS.				
Building envelope U-values:	Wall	0.20 W/m².K			
	Window	0.87 W/m².K			
	Roof/ceiling to the attic	0.13 W/m².K			
	Cellar ceiling/ground slab	0.18 W/m².K			
Building service systems:	The same philosophy of sustainable construction has been extended to the technical installations of the building. Therefore, concrete core activation, among others, is applied as the most important delivery system for heating and cooling. The lighting is completely operated by presence detection and daylight-based control.				
Included renewable energy technologies:	The necessary cold and heat is integrally generated by borehole thermal energy storage (BTES) in combination with a heat pump. A photovoltaic installation on the roof ensures the production of the necessary electricity.				

Final energy use:	Calculated		Calculation method:	
	Measured	X	Monitored in year:	2013
	Heating		14.9 kWh/m².year	
	Hot water		incl. in electrical appliances	
	Cooling		incl. in heating	
	Ventilation		incl. in heating	
	Lighting		33.2 kWh/m².year	
	Electrical appliances		41.1 kWh/m².year	
	Cash dispensers		27.2 kWh/m².year	
	Total		116.4 kWh/m².year	
	PV generated electricity		-89.7 kWh/m².year	
Primary energy use:	Grid electricity		291.0 kWh/m².year	Primary energy factor: 2.5
	PV electricity		-224.3 kWh/m².year	Primary energy factor: -2.5
	Total		66.7 kWh/m².year	
Renewable energy contribution ratio:	77% of the total final energy			
Improvement compared to national requirements:	99%		Compared to:	Maximum primary energy use (maximum energy level 100). This building is energy level 1.
Experiences/ lessons learned:	This is clearly a success story. The overall consumption of the building is almost fully covered by photovoltaic panels and the users are very pleased with the indoor climate. The originally installed fixed sun blinds did not prevent reflections on the computer screens. New sun blinds have been installed, which together with the good orientation of the building solved the problem.			
Costs:	Total cost: 1,411,903 € (5,328 €/m²), which includes construction, technical installation, furniture, cleaning, etc.			
Marketing efforts:	Internal communication via Intranet (about 14,000 employees) Big posters on the windows of the new building Newspaper article *"Het Laatste Nieuws"* concerning the opening (published on 13 December 2012)			
Awards:	2020 Challenge 2013			
Links to further information:	http://ingenium.be/benl/site/references-detail.aspx?vPK=339&k=&page=33 http://www.2020challenge.be/project.asp?id=66 http://www.architectura.be/nl/newsdetail.asp?id_tekst=4337&content=Publiekswinnaar%202020%20Challenge%20-%20KBC%20Nulenergiekantoor			



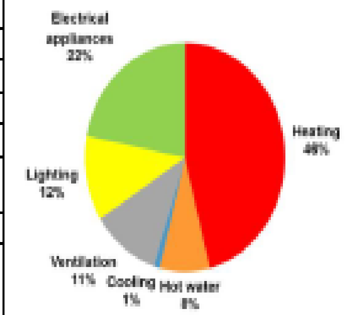
Croatia

Project aim:	The building was planned and constructed to meet the requirements for energy performance class A with less than 15 kWh/m².year for heating.				
Building address:	Zvonimira Goloba 1, 48 000 Koprivnica				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Multi-family house				
Building size:	1,539 m² net usable floor area (28 apartments, basement, ground floor and three floors with a ground area of 612 m²)				
Building envelope construction:	The structural walls are reinforced concrete, 20 cm thick, or brick masonry block 25 cm thick. The building envelope is thermally insulated with stone wool of 20 cm thickness for concrete walls and 15 cm for brick walls. The roof is flat, made out of 20 cm concrete and thermally insulated with 30 cm of XPS. The PVC windows are made with triple low e-coated glazing filled with argon, mounted according to RAL installation. (RAL is a German quality assurance association of windows and front door producers, which publish guidelines for correct window installations.)				
Building envelope U-values:	Wall	0.19 W/m².K (concrete wall) - 0.22 W/m².K (brick wall); allowed U_{max} = 0.45 W/m².K			
	Window	0.99 W/m².K; allowed U_{max} = 1.80 W/m².K			
	Roof/ceiling to the attic	0.10 W/m².K; allowed U_{max} = 0.30 W/m².K			
	Cellar ceiling	0.21 W/m².K; allowed U_{max} = 0.50 W/m².K			
	Ground slab	0.13 W/m².K; allowed U_{max} = 0.50 W/m².K			
Building service systems:	Heating and cooling are provided by an underfloor system using the same pipes for both heating and cooling. Heating is generated by a compact heat pump with COP = 2.8 (90%) or by boilers using natural gas (10%). Each apartment has its own energy meters. The ventilation system runs constantly to supply 0.5 air changes per hour of the entire volume of the apartment. The waste air heat is taken through a high performance energy recuperation system. Hot water is primarily generated by solar thermal collectors, and, if necessary, complemented by gas boilers.				

Included renewable energy technologies:	Solar energy for centralised DHW preparation: solar thermal collectors on the roof of the building, connected to the DHW storage tank with a volume of 4,000 liter. The system is designed to use primarily solar energy for hot water generation, with gas boilers as support.			
Final energy use:	Calculated	X	Calculation method:	HRN EN ISO 13790/PHPP 2009
	Measured		Monitored in year:	-
	Heating	14.95 kWh/m².year (~ 10% gas boiler, 90% el. heat pump)		
	Hot water	29.10 kWh/m².year (50% solar energy)		
	Cooling	15.65 kWh/m².year		
	Ventilation	4.17 kWh/m².year		
	Lighting	1.69 kWh/m².year		
	Total	65.56 kWh/m².year		
	Electrical appliances (household electricity)	21.54 kWh/m².year		
Primary energy use:	Electricity	78.95 kWh/m².year		Primary energy factor: 3
	Natural gas	17.65 kWh/m².year		Primary energy factor: 1.1
	Total	96.30 kWh/m².year		
Renewable energy contribution ratio:	22% (solar thermal energy) of the total final energy			
Improvement compared to national requirements:	78%	Compared to:	Maximum heating energy demand allowed for new buildings	
Experiences/ lessons learned:	Positive: A higher quality than prescribed by the national legislation with the aim of improving quality of life, including renewable energy, and considering environmental protection is possible at an affordable price for the users. Problematic: The project showed insufficient experience of the workforce regarding the application of new technology (e.g. RAL installation of windows), quality of works (e.g., airtightness of the envelope) and a lack of information on how the building service system works under real conditions. The users showed insufficient awareness and a lack of knowledge of using such systems.			
Costs:	Costs of land, design, construction and supervision amount to 11,485,000.00 HRK (~ 1,500,000.00 €) for 1,644.00 m² (28 apartments). There were no additional costs for the A⁺ energy class type of building compared to a standard quality building.			
Funding:	The City of Koprivnica, the investor of the project, has also spent funds in a public awareness campaign, yet the money spent was relatively modest compared to the media attention that followed the construction and promotion.			
Marketing efforts:	The two multifamily buildings 'Sporne hiže', energy class A⁺, are unique in Croatia. Marketing efforts were aimed at informing the public of the advantages of low-energy buildings through public lectures, debates, articles in print media and broadcasts on TV.			
Awards:	• ManagEnergy award winner, 'The bold new face of Koprivnica' (European Commission, EACI, Sustainable energy week 24.-28. June 2013.); • Recognition for best practice in local government in the energy efficiency category (IN PLUS, Association of Croatian cities)			
Links to further information:	www.apos-koprivnica.hr			

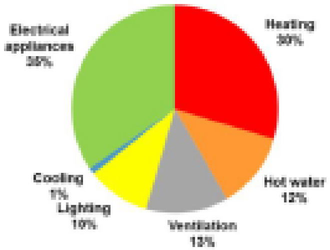
Estonia

Project aim:	The first Estonian NZEB, primary energy consumption is 60% better than the established current national requirement, and smart building automation systems are in use also.					
Building address:	Turu plats 2, Rakvere, Estonia					
Building type:	Residential	Non-residential	Public		New	Renovated
		X			X	
	Office building					
Building size:	2,170 m² gross floor area					
Building envelope construction:	Double façade, load-bearing structure of prefabricated concrete elements with polyurethane insulation. Typical roof construction with hollow-core slab and 500 mm insulation. Windows are made with wooden-aluminium frames and triple glazing.					
Building envelope U-values:	Wall	0.07 W/m².K				
	Window	0.8 W/m².K				
	Roof/ceiling to the attic	0.08 W/m².K				
	Cellar ceiling/ground slab	0.14 W/m².K				
Building service systems:	Heating is generated by the local district heating system and delivered by low-temperature radiators. The building has mechanical supply-extract ventilation systems with heat recovery (Variable Air Volume (VAV) and Constant Air Volume (CAV) systems). Hot water is also generated by the district heating. To prevent overheating, the building uses a high-temperature passive cooling system based on open energy piles connected to the ground water. The cooling delivery system consists of chilled beams in rooms.					
Included renewable energy technologies:	Energy piles are connected to the ground water for passive cooling and a 33.8 kW photovoltaic system.					

Final energy use:	Calculated	X	Calculation method:	National standard and dynamic simulation tool
	Measured		Monitored in year:	-
	Heating	39.4 kWh/m².year		
	Hot water	6.9 kWh/m².year		
	Cooling	0.6 kWh/m².year		
	Ventilation	9.8 kWh/m².year		
	Lighting	10.5 kWh/m².year		
	Electrical appliances	19.1 kWh/m².year		
	Total	86.3 kWh/m².year		
	PV generated electricity	-13.3 kWh/m².year		
Primary energy use:	District heating	41.7 kWh/m².year		Primary energy factor: 0.9
	Electricity	56.2 kWh/m².year		Primary energy factor: 2
	Total	97.9 kWh/m².year		
Renewable energy contribution ratio:	23% of the total final energy			
Improvement compared to national requirements:	60%		Compared to:	Minimum requirement for energy performance is 160 kWh/m².year (defined in the Estonian energy act *"Minimum requirements for energy performance of August 2012"*)
Experiences/ lessons learned:	Due to the financial constraints, several conceptual changes were made during the planning process in order to remain within budget, and initial expectations had to be lowered. This meant that some of the technical solutions were replaced with cheaper and less effective ones.			
Costs:	Costs include planning and construction. Additional equipment and monitoring appliances are also included. The additional costs compared to a regular building are estimated to be around 5-10%.			
Funding:	The funding is provided by EU regional funds for the development of regional competence centres in Estonia. The main co-funder of the project is the Rakvere Municipality. Additional contributions are expected from private sector.			
Marketing efforts:	The building will be used as a test and demonstration building for intelligent and automated building systems and is expected to serve as a test base for regional and national research institutions.			
Links to further information:	http://www.rakveretarkmaja.ee/			

Finland

Project aim:	The building was designed based on an architectural competition for zero-energy buildings organised by Saint-Gobain ISOVER in co-operation with the architect association SAFA, *Rakennuslehti* magazine, VTT and WWF.					
Building address:	Housing fair (2013) area in Hyvinkää, Finland					
Building type:	Residential	Non-residential	Public		New	Renovated
	X				X	
	A two-storey single-family house					
Building size:	Floor area: 195.5 m² + 21 m² storage space					
Building envelope construction:	Wall insulation with Saint-Gobain Isover Vacupad vacuum insulation product (0.007 W/m.K). The roof includes 700 mm of mineral wool and the floor is insulated with 400 mm of Styrofoam XPS on a concrete slab based construction. The windows are triple glazed.					
Building envelope U-values:	Wall	0.09 W/m².K				
	Window	0.75 W/m².K				
	Roof/ceiling to the attic	0.06 W/m².K				
	Cellar ceiling/ground slab	0.09 W/m².K				
	Doors	0.6 - 0.75 W/m².K				
Building service systems:	Mechanical ventilation system with heat recovery unit with 80% efficiency. Since the set-point temperature against freezing of the heat exchanger was -10°C, the yearly heat recovery efficiency rate resulted in 76% for the ventilation system. Heating energy is generated by a ground source heat pump and distributed by a low-exergy floor-heating system with clinker surfaces and a maximum surface temperature of 26°C. Lighting is designed to be LED and all household equipment is designed to have the best energy label classification A++.					
Included renewable energy technologies:	The main heating source is the ground source heat pump, but solar heat can also provide a share of the heating. In addition, the building has a fire place capable of storing heat in its thermal mass. The ground source heat pump's Seasonal Performance Factor (SPF) is 3.5 for space heating and 2.5 for DHW generation. The solar thermal collector system (6 m²) is faced southerly with an angle of 15-30 degrees. The surface area of the photovoltaic system is 80 m² on the southern façade of the roof and at the same angle as the solar thermal collectors. The PV system consists of 72 Copper Indium Selenide (CIS)-type thin-film modules. The system has 3 inverters, each rated for 3 kW power.					

Final energy use:	Calculated	X	Calculation method:	IDA Indoor Climate and Energy according the Finnish Building Code
	Measured		Monitored in year:	-
	Heating		11.3 kWh/m².year	
	Hot water		4.6 kWh/m².year	
	Cooling		0.2 kWh/m².year	
	Ventilation		4.8 kWh/m².year	
	Lighting		4.0 kWh/m².year	
	Electrical appliances (incl. outdoor lighting and car heating)		13.2 kWh/m².year	
	Total		40.4 kWh/m².year	
Primary energy use:	Electricity		68.7 kWh/m².year	
	Total		68.7 kWh/m².year	Primary energy factor: 1.7
Renewable energy contribution ratio:	100% of the total final energy (annual balance)			
Improvement compared to national requirements:	66%		Compared to:	Maximum primary energy value of the Finnish building regulation: 160 kWh/m².year. This does not include the 13.2*1.7 kWh/m².year primary energy for electrical appliances.
Experiences/ lessons learned:	The building performance is monitored in detail. The first preliminary results show promising results and further analysis shall be carried out to evaluate the holistic picture about the building performance in real use.			
Funding:	Saint Gobain Isover *Rakennustuotteet* funded the project.			
Marketing efforts:	The building is part of the *Hyvinkää* housing exhibition area.			
Awards:	The building won the architectural competition organised by Saint-Gobain ISOVER in co-operation with the architect association SAFA, *Rakennuslehti* magazine, VTT and WWF. There were 81 contestants in total.			
Links to further information:	http://www.isover.fi/passiivitalo/seurantakohteet/villa-isover-asuntomessut-2013-hyvinkaa/villa-isoverin-esittely (in Finnish)			

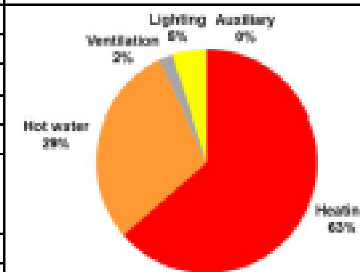
TUIASI

Co-funded by the Erasmus+ Programme of the European Union

MARUEEB

France

Project aim:	To produce a French NZEB.				
Building address:	143 avenue de la Rochelle - 79000 Niort				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Single-family house				
Building size:	158 m² net floor area				
Building envelope construction:	The building has brick walls insulated with mineral wool on the inside. The ceiling, made of reinforced concrete, has a mineral-wool insulation.				
Building envelope U-values:	Wall	0.205 W/m².K			
	Window	1.45 W/m².K			
	Roof/ceiling to the attic	0.138 W/m².K			
	Cellar ceiling/ground slab	0.138 W/m².K			
Building service systems:	Heating is provided by a gas-condensing boiler and delivered by a floor-heating system. DHW is generated by solar thermal collectors and supported by the boiler. A single-flow ventilation system with humidity sensors was installed to maintain the quality of the indoor air.				
Included renewable energy technologies:	Nearly 4 m² of solar thermal collectors were installed on the roof to cover part of the DHW consumption.				
Final energy use:	Calculated	X	Calculation method:	National standard (*méthode Th-BCE*)	
	Measured		*Monitored in year:*	-	
	Heating	20.80 kWh/m².year			
	Hot water	9.50 kWh/m².year			
	Cooling	0.00 kWh/m².year			
	Ventilation	0.65 kWh/m².year			
	Lighting	1.70 kWh/m².year			
	Electrical appli-ances (household electricity)	unknown			
	Auxiliary energy	0.15 kWh/m².year			
	Total	32.80 kWh/m².year			
	Solar thermal energy contribution	7.70 kWh/m².year			

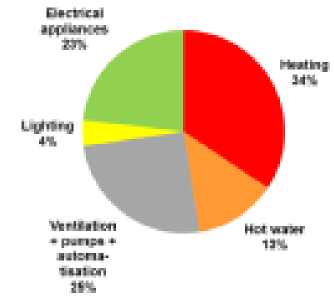


Primary energy use:	Electricity	6.50 kWh/m².year	Primary energy factor: 2.58
	Gas	30.30 kWh/m².year	Primary energy factor: 1
	Total	36.80 kWh/m².year	
Renewable energy contribution ratio:	21% of the total final energy		
Improvement compared to national requirements:	21%	Compared to:	Maximum primary energy use according to RT2012 (46.90 kWh/m².year).

Germany

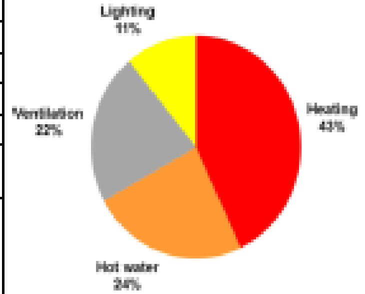
Project aim:	This pilot building generates its own energy and makes it available to the users and the electric vehicles. Excess energy is fed back into the grid or stored in a battery. An annual positive energy balance is required for primary and final energy use.				
Building address:	Fasanenstraße 87a, 10623 Berlin				
Building type:	Residential	Non-residential	Public	New	Renovated
	X			X	
	Single-family house with 2 floors				
Building size:	203 m² useful floor area ('A_N', with A_N=0.32*V_{gross}), 138 m² living area				
Building envelope construction:	The floor, the walls and the roof are made of timber panels filled with up to 52 cm of cellulose insulation. The windows have triple glazing. Thermal bridges have been minimised. Photovoltaic modules cover the roof and the façade. All house elements can be separated and moved to another location or be disposed of once the lifetime of the building has expired.				
Building envelope U-values:	Wall	0.11 W/m².K			
	Window	0.70 W/m².K			
	Roof/ceiling to the attic	0.11 W/m².K			
	Cellar ceiling/ground slab	0.11 W/m².K			
Building service systems:	The house is heated by a central heating system with an air-to-water heat pump and floor heating. A balanced mechanical ventilation system with 80% heat recovery and a building energy management system with touch pads are installed. The PV systems on the roof and facades generate electricity that is used by the building, fed into the grid or stored in a battery. The battery, with a capacity of 40 kWh, is made of 7,250 single second-hand battery cells formerly used in electric cars.				
Included renewable energy technologies:	The air-to-water heat pump uses ambient energy from the outside air. Two large photovoltaic fields are installed: 98 m² monochrystalline PV modules on the roof and 73 m² thin-film modules on the façade.				
Final energy use:	Calculated		Calculation method:	DIN V 18599, *Effizienzhaus Plus-Rechner* [Efficiency house plus calculator]	
	Measured	X	Monitored in year:	2012/2013	

Final energy use (cont.):	Heating	20.8 kWh/m².year	
	Hot water	8.1 kWh/m².year	
	Cooling	0.0 kWh/m².year	
	Ventilation incl. pumps and automatisation	15.3 kWh/m².year	
	Lighting	2.6 kWh/m².year	
	Electrical appli-ances (household electricity)	14.3 kWh/m².year	
	Total	61.1 kWh/m².year	
	E-mobility	19.6 kWh/m².year	
	PV energy gener.	- 65.6 kWh/m².year	
	thereof self-used	- 32.3 kWh/m².year	
	thereof fed-in	- 33.3 kWh/m².year	
	Electr. from grid	28.8 kWh/m².year	
	Electricity surplus	- 4.5 kWh/m².year	
Primary energy use:	Electr. from grid	69.1 kWh/m².year	Primary energy factor: 2.4 (PEF 2014)
	Electr. fed-in	-93.2 kWh/m².year	Primary energy factor: 2.8 (PEF 2014)
	Total	- 24.1 kWh/m².year	
Renewable energy contribution ratio:	107% of the total final energy		
Improvement compared to national requirements:	78%	Compared to:	Maximum primary energy use according to EnEV 2009. (Household equipment, e-mobility not taken into account. PV generated electricity accounted up to monthly electricity use).
Experiences/ lessons learned:	The test family enjoyed living in the house without having a bad conscience because of using conventional energy. As the ventilation system was not manually controlled, it introduced warm external air into the rooms in summer, which became a problem. The measurements show that the goal of the efficiency house plus has been achieved, but only 25% of the electricity used for e-mobility could be covered.		
Costs:	The costs of the house are rather high, with 1,080,000 € for construction and 566,000 € for the building service systems. This is partly due to the high ambition (plus energy) and the ability to divide the house into different materials in the event of deconstruction. There is a network of efficiency houses plus with more than 20 buildings of the same energy performance level. These houses show that the additional costs compared to a regular new building can be decreased by about 50,000 €.		
Funding:	Research program *"Efficiency house plus"*. The Federal Building Ministry (BMUB) supports the construction of buildings which produce significantly more energy than required for their operation. The pilot projects are assessed by a scientific support program. The goals are to improve energy management in modern structures and further develop necessary building envelope and renewable energy components.		
Marketing efforts:	- Network of more than 20 efficiency house plus pilot projects - The house can be visited and is used for events - BMUB website includes videos, a blog by the users, actual monitoring results, etc. - Official opening by Chancellor Angela Merkel		
Awards:	The design by architect Werner Sobek won the architectural competition for the BMUB pilot project. Case highlighted in February 2014 on EU's BUILD UP portal.		



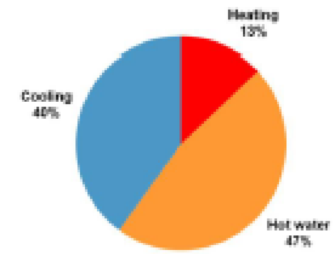
Ireland

Project aim:	First A2 rated post primary school				
Building address:	Colaiste Choilm, O'Moore Street, Tullamore, Co. Offaly				
Building type:	Residential	Non-residential	Public	New	Renovated
			X	X	
	Post primary school completed in 2011				
Building size:	4,681 m² useful floor area				
Building envelope construction:	Overall U-value is 0.36 W/m².K - 50% better than the current building regulations Air tightness of 3 m³/h per m² at 50 Pa				
Building envelope U-values:	Wall	0.09 W/m².K			
	Window	1.5 W/m².K			
	Roof/ceiling to the attic	0.18 W/m².K			
	Cellar ceiling/ground slab	0.19 W/m².K			
	Doors	2.19 W/m².K			
Building service systems:	Biomass boiler and combined heat and power system based on natural gas with low-temperature hot water radiators for heating Automatic ventilation openings fitted with airtight automatic shut-off and linked to CO_2 sensors Building control strategies designed to minimise energy use Improved energy monitoring and management awareness Use of LED-based external lights with improved controls Improved water conservation measures				
Included renewable energy technologies:	Biomass heating Combined heat and power system based on natural gas Photovoltaic electricity production.				

Final energy use:	Calculated	X	Calculation method:	Non Domestic Energy Assessment Procedure (NEAP)
	Measured		Monitored in year:	2011
	Heating		32.89 kWh/m².year	
	Hot water		1.00 kWh/m².year	
	Cooling		0.00 kWh/m².year	
	Ventilation		3.10 kWh/m².year	
	Lighting		15.55 kWh/m².year	
	Electrical appliances		Unknown	
	Total		52.54 kWh/m².year	
Primary energy use:	Natural gas		31.36 kWh/m².year	Primary energy factor: 1.1
	Biomass		33.90 kWh/m².year	Primary energy factor: 1.1
	Electricity		18.65 kWh/m².year	Primary energy factor: 2.7
	Total		81.91 kWh/m².year	
Renewable energy contribution ratio:	~ 40% of the total final energy			
Improvement compared to national requirements:	50%		Compared to:	Improved insulation levels. U-value for the building is 0.36 W/m²K which is 50% better than the current building regulations.
Experiences/ lessons learned:	The school is a research and demonstration project to improve the quality of teaching spaces and notably reduce the school's environmental impact. Over 21 sustainable design aspects were reviewed. Extensive automated monitoring systems establish energy consumption profiles and user patterns. The design incorporates passive, active, and renewable techniques.			
Costs:	Total project: 5.3 million € 255,000 € for additional energy efficiency measures			
Funding:	Department of Education and Skills			
Marketing efforts:	All new primary schools are built to Building Energy Rating (BER) A3 or better. Building is featured in SEAI Energy USE in Public Sector publication.			
Awards:	The Department of Education and Skills energy programme commenced in 1997 and is recognised at national and international levels for excellence in design and specifications. Top prize at 2012 Green Awards.			
Links to further information:	http://www.education.ie/en/Press-Events/Press-Releases/2012-Press-Releases/20%20April,%202012%20-%20Department%20of%20Education%20and%20Skills%20wins%20top%20prize%20at%202012%20Green%20Awards.html			

Italy

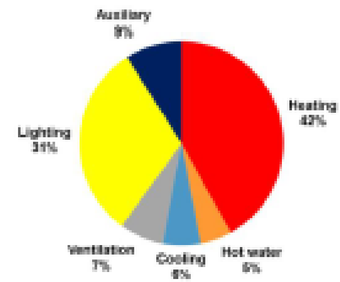
Final energy use:	Calculated	X	Calculation method:	According to EU Directive 2002/91/CE, 16/12/2002, UNI/TS 11300:2008 and CASACLIMA protocol
	Measured		Monitored in year:	2013 (data not yet available)
	Heating		4.60 kWh/m^2.year	
	Hot water		16.68 kWh/m^2.year	
	Cooling		14.00 kWh/m^2.year	
	Ventilation		in use but not measured	
	Lighting		Unknown	
	Electrical appliances (household electricity)		Unknown	
	Total		35.28 kWh/m^2year	
	PV generated electricity		Unknown	
Costs:	Total costs were 1,465 €/m^2 gross floor area including demolitions.			
Marketing efforts:	This very low-energy building was designed and built according to the Bolzano CASACLIMA protocol and the official CASACLIMA golden certification was obtained for the first time in the territory of Region Abruzzo.			
Awards:	Golden CASACLIMA certificate Special mention of "*Premio SOSTENIBILITA' 2013*" of Modena Sustainable Energy Agency AESS			



Project aim:	Best Current Practice according to ITACA protocol, certification in Italian national class A+ (21.3 kWh/m^2.year); emissions reduced by 15 times compared to the required limits.					
Building address:	Via S. Demetrior ss 216, Località S. Gregorio - L'Aquila					
Building type:	Residential	Non-residential	Public		New	Renovated
	X				X	
	Single-family house with 3 storeys					
Building size:	173 m^2 net floor area					
Building envelope construction:	Wood and wood-fibre walls with chalk lining, reinforced (1% steel) concrete lower walls, insulation of linen fibre. The windows have triple glazing.					
Building envelope U-values:	Wall	Upper: 0.120 W/m^2.K; lower: 0.126 W/m^2.K				
	Window	0.89 W/m^2.K				
	Roof/ceiling to the attic	0.09 W/m^2.K				
	Cellar ceiling/ground slab	0.12 W/m^2.K				
Building service systems:	Systems include a 10 kW reversible geothermal heat pump for heating and cooling, solar thermal panels, a ventilation system with heat recovery and integrated electrical heaters, PV panels with 8.5 kW_p and fixed and adjustable shades.					
Included renewable energy technologies:	Solar thermal panels, PV panels (thin-film), geothermal heat pump					

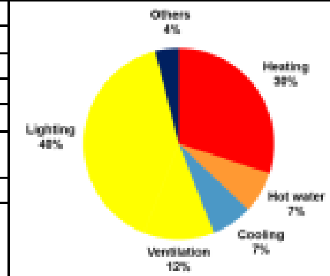
Luxembourg

Project aim:	NZEB and HQE ("Haute Qualité Environnementale - Certivéa") certification.					
Building address:	163 rue de Kiem - L-8030 Strassen Luxembourg					
Building type:	Residential	Non-residential	Public		New	Renovated
		X			X	
	Office building					
Building size:	3,200 m² net floor area					
Building envelope construction:	Concrete structure. External insulation of the building with a minimum 24 cm mineral wool for external walls. The windows have triple glazing.					
Building envelope U-values:	Wall	0.13 W/m².K				
	Window	0.82 W/m².K				
	Roof/ceiling to the attic	0.11 W/m².K to the outside 0.18 W/m².K to unheated zone				
	Cellar ceiling/ground slab	0.19 W/m².K to unheated zone				
Building service systems:	Heating is based on a biomass (pellet) boiler. Heating and cooling distribution through concrete core activation. Cooling is generated by a scroll compressor with a hybrid water chiller combined with free chilling during the night. All zones are equipped with CO_2-sensors to regulate the hygienic air stream.					
Included renewable energy technologies:	Pellet boiler included. The roof is fully covered with PV (938 m² and 138 kW_p).					

Final energy use:	Calculated	X	Calculation method:	*Règlement grand-ducal du 5 mai 2012 modifiant*
	Measured		Monitored in year:	-
	Heating	31.8 kWh/m².year		
	Hot water	3.9 kWh/m².year		
	Cooling	4.5 kWh/m².year		
	Ventilation	5.3 kWh/m².year		
	Lighting	23.4 kWh/m².year		
	Electrical appliances	unknown		
	Auxiliary	6.7 kWh/m².year		
	Total	75.6 kWh/m².year		
	PV production	37.6 kWh/m².year		
Primary energy use:	Pellets (wood)	1.8 kWh/m².year		Primary energy factor: 0.07
	Gas	10.7 kWh/m².year		Primary energy factor: 1.12
	Electricity	105.9 kWh/m².year		Primary energy factor: 2.66
	Total	118.5 kWh/m².year		(PV production not deducted)
Renewable energy contribution ratio:	84% of the total final energy (94% of the total electricity)			
Improvement compared to national requirements:	62%		Compared to:	*Règlement grand-ducal du 5 mai 2012 modifiant* (version of 2010, Class D) Primary energy compared to reference building national calculation method (without PV).
Costs:	9 million € (2,813 €/m²) incl. VAT for construction, without costs for consultancies, land and auxiliaries.			
Funding:	Equity and bank loans.			
Marketing efforts:	Awards and participations (Fiabci International Award, Green Awards, *Bauhärepräis OAI*), press articles as NZEB, visited by the Minister of Economy, Luxembourg, for the inauguration of the building.			
Awards:	*"Prix d'excellence Fédération Internationale des professions immobilières FIABCI Luxembourg"* in Sustainable Building category			
Links to further information:	http://www.groupe-schuler.lu			

Norway

Project aim:	Demonstrate the possibility of transforming a typical 1980s office building into a plus-energy office building, generating more energy during its lifetime than what was used during the production of materials, construction, operation and demolition. The project is aiming for a BREEAM-NOR 'Outstanding' classification, the highest classification in BREEAM-NOR. It will also fulfil all requirements in the Norwegian passive house standard for non-residential buildings, NS 3701.				
Building address:	Kjørboveien 18 - 20, 1337 Sandvika, Norway				
Building type:	Residential	Non-residential	Public	New	Renovated
		X			X
	Office building				
Building size:	5,200 m² net floor area				
Building envelope construction:	Old structural elements in concrete were kept, highly insulated timber frame walls and charred wood cladding added to maintain the aesthetics of the old black glass façade. Use of tailor-made aluminium-framed openable windows with triple glazing. The design airtightness of the building envelope is 0.50 air changes per hour at 50 Pa (tests have shown actual results of 0.3 air changes per hour). Exposed concrete for high internal inertia is used. Low emitting materials reduce ventilation demand for indoor air quality control.				
Building envelope U-values:	Wall	0.13 W/m².K			
	Window	0.80 W/m².K			
	Roof/ceiling to the attic	0.08 W/m².K			
	Cellar ceiling/ground slab	0.14 W/m².K			
	Thermal bridge value (normalised)	0.02 W/m².K			
Building service systems:	Electricity is covered by solar panels on roof. Geothermal heat pumps, for heating, cooling and hot water. Own heat pump to re-use heat from the cooling of server parks as heating. Exterior sunscreen automated system. Innovative ventilation system with extremely low pressure drop over the components and in the ventilation ducts. Components with high pressure drop, such as the heat recovery unit, are bypassed when not in use. The system utilises displacement ventilation, demand-controlled lighting and better use of daylight.				

Included renewable energy technologies:	Solar cell park (1,400 m²) on flat roof, delivering more than 200,000 kWh/m².year, or 41 kWh/m².year. Geothermal heat pump with 10 wells. Connected to district heating as a back-up solution.			
Final energy use:	Calculated	X	Calculation method:	NS 3031
	Measured		Monitored in year:	-
	Heating	5.9 kWh/m².year		
	Hot water	1.4 kWh/m².year		
	Cooling	1.3 kWh/m².year		
	Ventilation	2.3 kWh/m².year		
	Lighting	7.7 kWh/m².year		
	Electrical appliances	unknown		
	Others	0.8 kWh/m².year		
	Total	19.4 kWh/m².year		
Primary energy use:	Electricity	28.3 kWh/m².year		There are no official national primary energy factors available yet. However, the project has calculated a life-cycle-based primary energy factor for the electricity by balancing the grid electricity and the PV produced electricity as an average over 60 years at 1.46.
	Total	28.3 kWh/m².year		
Renewable energy contribution ratio:	100% of the total final energy. The building has been designed to generate a surplus of 18.4 kWh/m².year, with operational energy (excluding equipment computers, servers, etc.) and embodied energy in materials being taken into account.			
Improvement compared to national requirements:	80%	Compared to:	National minimum requirements for net energy use defined in TEK10: *"Regulations on technical requirements for building works"*. http://www.dibk.no/globalassets/byggeregler/regulations_on_technical_requirements_for_building_works.pdf	
Experiences/ lessons learned:	High focus on integrating architecture and technical systems, embodied energy, options for the re-use of materials and construction elements, high level of energy efficiency (building envelope and innovative ventilation solutions). Effort was put into designing an optimised energy supply system for on-site production of thermal energy and electricity. The project is expected to be an important demonstration project for plus-energy buildings worldwide. The building has been occupied since 2014; therefore, measured values are not yet available.			
Costs:	Construction costs were 114 million NOK (13.86 million €, or 2,665 €/m²). The project was developed in cooperation between the Powerhouse-Alliance and the Research Centre on Zero Emission Buildings (ZEB).			
Funding:	14.9 million NOK (1.81 million €) in funding from the national support program for upgrade of existing buildings (ENOVA).			
Marketing efforts:	New tenant was part of the design team.			
Awards:	BREEAM-NOR 'Outstanding'			
Links to further information:	www.powerhouse.no www.zeb.no			

TUIASI

Co-funded by the Erasmus+ Programme of the European Union

S.l. dr. ing. **Marius-Costel Balan**
Universitatea Tehnica "Gheorghe Asachi" din Iasi, Facultatea de Constructii si Instalatii, Departament Ingineria Instalatiilor
Str. Prof. dr. doc,Dimitrie Mangeron nr. 13
Tel : 0232 701 350
IASI-700050
ROMANIA
Mobil: +40 766 588 168
+40 747 051 340
e-mail: balanmariuscostel@gmail.com
marius.balan@tuiasi.ro

Thank you!

IPSA SCIENTIA POTESTAS EST

Co-funded by the Erasmus+ Programme of the European Union