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Regional survey on the energy consumption in the tertiary buildings sector

PACA Region

PROJECT TITLE: Enhancing Mediterranean Initiatives Leading SMEs to innovation in building energy efficiency technologies

AXIS: Strengthening innovation capacities

OBJECTIVE: Dissemination of innovative technologies and know-how

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Introduction

1 Sources of data

1.1 Published studies on energy consumption

The following key studies have been used as sources of this survey:

- [1] « *Potentiel d'économies d'énergie des bâtiments de la région PACA* », Energies Demain for Cellule Economique Régionale de la Construction (CERC), April 2012
  This study deals with the analysis of the potential for energy savings in the buildings of the PACA region.
- [10] Vir'Volt audit methodology of commercial buildings

1.2 Available sources of energy data

- [2] Service de l'Observation et des Statistiques (SOeS) - http://www.statistiques.developpement-durable.gouv.fr/
  The SOeS is part of the General Commission for Sustainable Development (CGDD) within the Ministry of Ecology, Sustainable Development and Energy. Its mission is to organize the observation and statistical system for housing, construction, transport, energy, environment and sustainable development, in conjunction with national institutions, European and international stakeholders. SOeS is organized into five units:
    - Sub-Directorate of Energy Statistics
    - Sub-Directorate of Statistics housing and construction
    - Sub-Directorate of Transport Statistics
    - Sub-Directorate of Environmental Information
    - Sub-Directorate of the methods and data for sustainable development
- [3] Observatoire Régional de l'Energie (ORE) - http://ore.regionpaca.fr/
  The Regional Energy Observatory is the result of the meeting twelve major players in the energy field and the air quality in the territory of Provence-Alpes-Côte d'Azur.
  It aims to provide individuals and organizations working on energy issues elements allowing them to better focus on their field operations. It also aims to stimulate the exchange of information by relaying energy-related news and highlights.
- [4] Institut National de la Statistique et des Etudes Economiques (INSEE) - http://www.insee.fr/fr/
  INSEE is a branch of the Ministry of Economy and Finance. It collects, produces, analyzes and disseminates information on the economy and the French society. It contributes to six missions:
    - Collect and produce statistical data

- Analyze
- Broadcast
- Coordinate
- Teach and develop research
- Contribute to the building of an international statistical area

- [5] Observatoire du Conseil Régional du Tourisme PACA (CRT) - http://www.regionpaca.fr/tourisme.html
  Among others, the CRT provides statistical data about the hosting capacity and performances of the tourist-aimed buildings.
- [6] Direction Régionale des Affaires Sanitaires et Sociales (DRASS)
  Among others, the DRASS provides statistical data about the hosting capacity and performances of the healthcare buildings.

1.3 Legislation influencing energy efficiency and use of renewable energy in buildings

- [7] Schéma Régional Climat Air Energie (SRCAE)
  The French law[1] engaging the country in the environment preservation, entitled « Grenelle 2 », foresees that each region elaborates a regional roadmap for climate air and energy. Designed in collaboration between the State and the Region, it aims at defining the orientations and the regional objectives in terms of reduction of greenhouse gases emissions, energy efficiency, renewable energies deployment, air quality and adaptation to the climate change. It starts from a status on the existing situation.
  In the PACA region, the SRCAE was approved by the General Assembly on the 28th of June 2013 and issued by the regional prefect (headmaster) on the 17th of July 2013.
- [8] Decree No. 2012-1530 of 28th December 2012 relating to thermal characteristics and energy performance of the building construction (RT 2012)
  Under the same law as above, this decree forces that application of binding rules regarding the minimum thermal performances of new buildings and new extension of existing buildings. It takes its driving force in the Energy Efficiency of Buildings (EEB) Directive of the European Commission, with some customization to the French context. For instance the maximum authorized primary energy consumption depends on various modulation factors such as the annual solar irradiation, exposure to noise, altitude and building type.
  In addition, the law anticipates the coming regulation for 2020, when all new constructions will have to meet the zero-energy target (production of at least as much renewable energy as primary energy consumed).
- [9] Ordinance of 3rd May 2007 on the thermal characteristics and energy performance of existing buildings (RT existant)
  This regulation gives the minimum performance requirements of new components when

[1] Law n° 2010-788 dated 12th July 2010

changing a structural element of a building or equipment impacting the energy consumption.

2 General review of tertiary sector buildings

2.1 General description of the current status of buildings

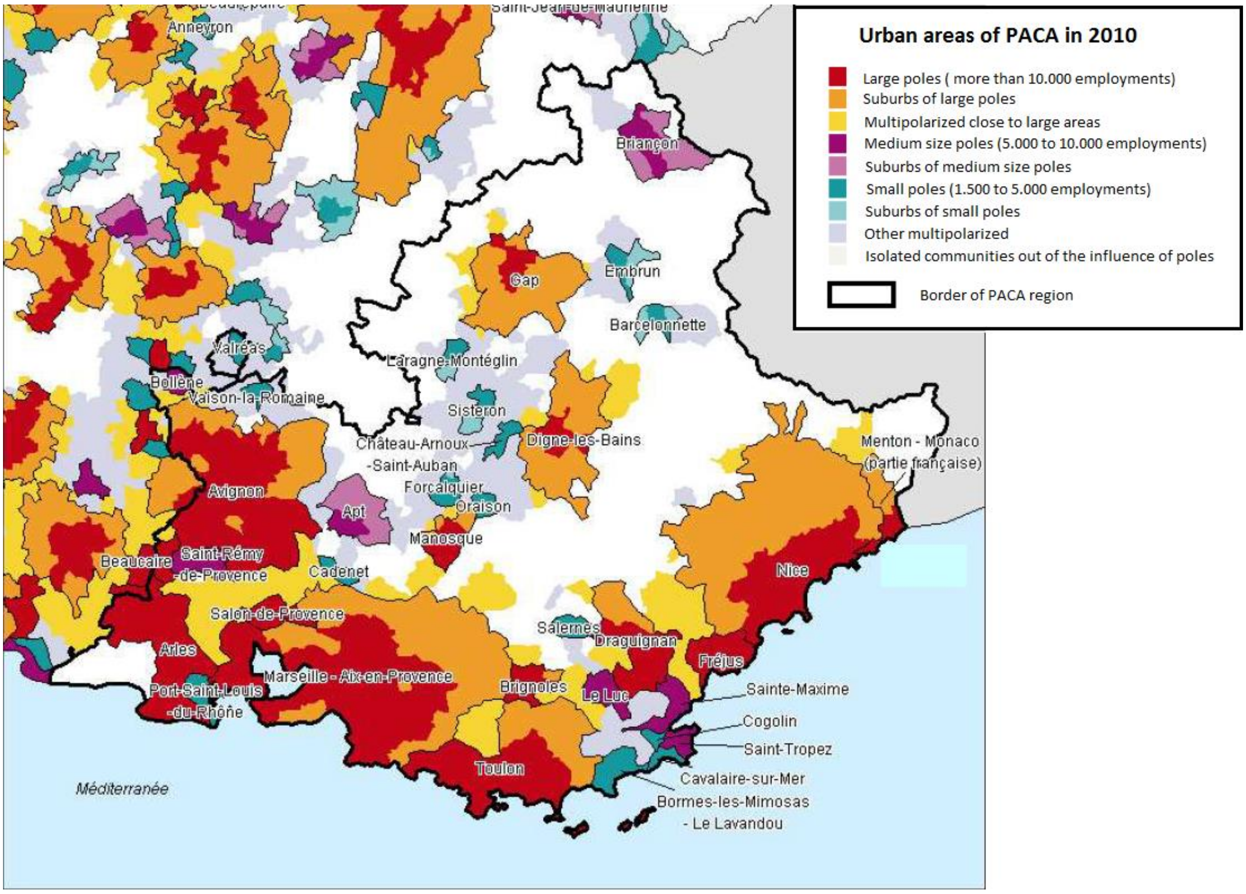
- Specification of typical buildings structure typologies in the region (general description, climate aspects, available indicators, e.g. space per capita or per employee)
- Identification of regional buildings specifics (e.g. according to the age or construction period, size, ownership /private, public/, towns/rural area, etc.)
- Quantification (estimation) of indicators for key types of buildings (split between categories - selected representative building types are listed in Table 1)

2.1.1 Characterization of the tertiary building stock in PACA region

In the PACA region, buildings are very much concentrated on the sea border. Two reasons to that:

- The PACA region is highly attractive for tourists thanks to its warm and sunny climate (300 days of sun a year in average, sea at 24-26°C in summer), the tourists liking to go to the sea shore for their holidays.
- The Alps mountains occupy 3 of the 6 departments of the region, where the construction density is naturally lower than in plains.

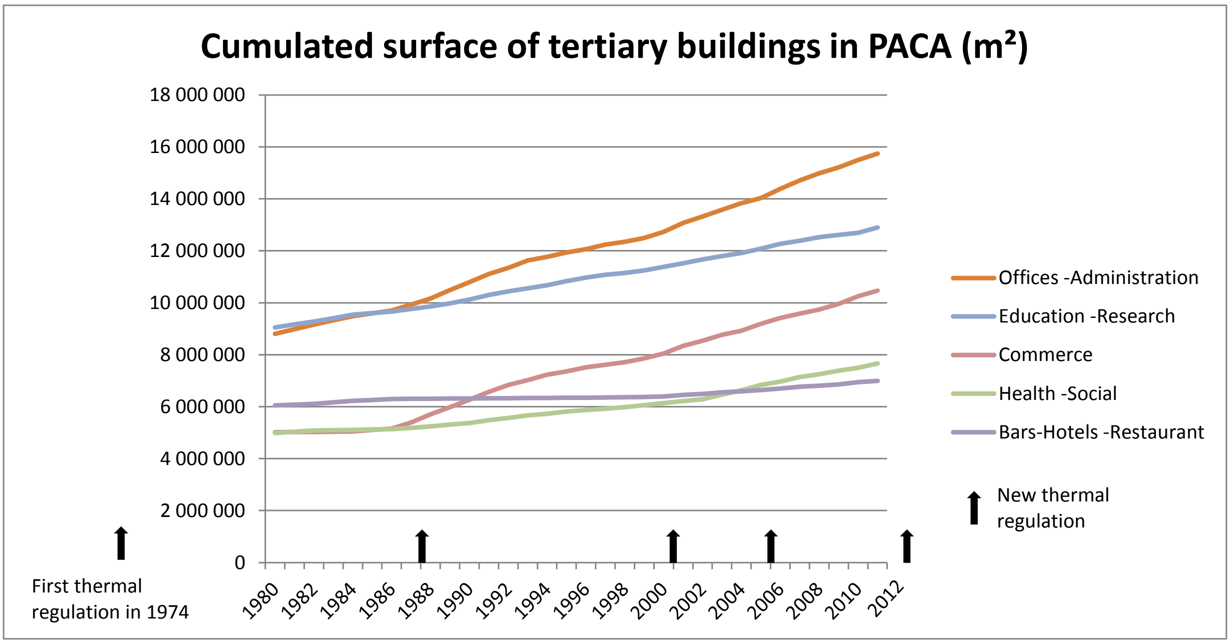
Figure 1 : Urban areas of the PACA region in 2010. Source: IGN-INSEE 2010



The tertiary building stock of the PACA region is rather young. **48% of the buildings were built from 1988 to 2011**, 25% were built between 1975 and 1987, 19% constructed between 1949 and 1974 and 8% built before 1949. The main reasons are the important share of office buildings, most of which being recently constructed with the development of services or deeply renovated under pressure of the successive thermal regulations.

Till 2020, the projections foresee an average **yearly increase of the tertiary building stock of 1,6 %/yr**.

Type of building	Average yearly growth 2010 - 2020
Schools, research, other educational buildings	1,4 %
Hospitals, retirement homes other health/social buildings	1,0 %
Offices, administrative (municipal and other public administrative) buildings	2,4 %
Hotels, restaurants, other tourist buildings	1,5 %
Shopping, retail centres	0,9 %



Source: Capenergies from Sit@del2 database (SOeS) and SES-Enerdata

End of 2012, the tertiary building stock of the PACA region pools heterogeneous economic and public service branches. It spreads over **64 million m²** approximately and is dominated by the segments of **office & administration buildings, education & research and commerce**, which **represent more than 60%** of the total surface.

Figure 2 : Split of the tertiary building surfaces

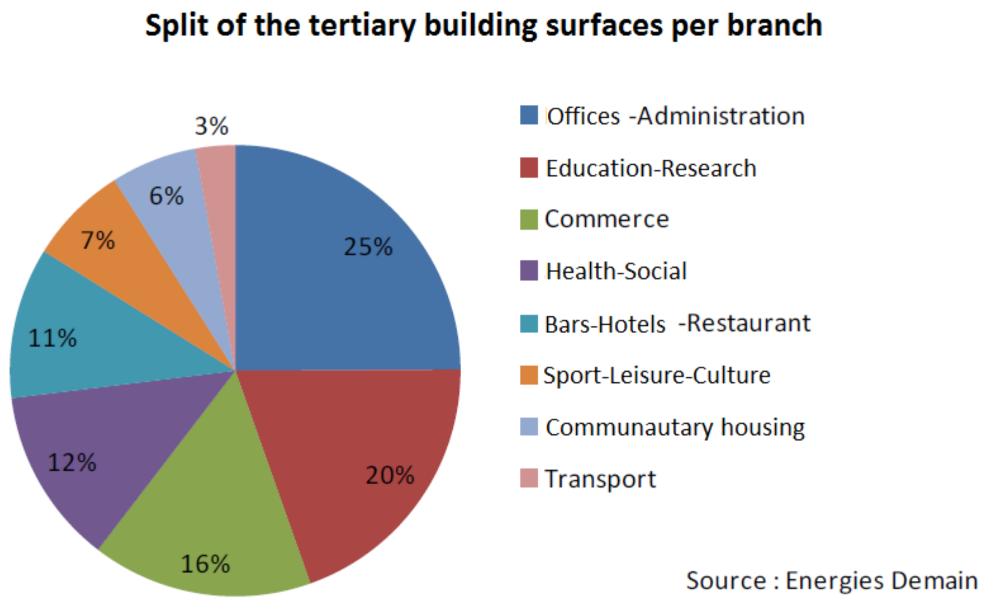


Table 1: Indicators for key types of buildings

Type of building	Indicator	Value	% of total buildings area
Schools, research, other educational buildings	Area Nb Pupils & students	12,80 Mm² 1.070.000	20%
Hospitals, retirement homes other health/social buildings	Area Nb of beds	7,68 Mm² 42.300	12%
Offices, administrative (municipal and other public administrative) buildings	Area	16,00 Mm²	25%
Hotels, restaurants, other tourist buildings	Area Nb of beds	7,04 Mm² 700.000	11%
Shopping, retail centres	Area	10,24 Mm²	16%

Sources: INSEE, Observatoire du CRT PACA

2.1.2 Climate of the PACA region, influencing building design and energy performance

The contribution of natural solar irradiation to the space heating is an important factor of building performance in winter. In summer, protections against excessive solar contribution through glazes are strongly recommended to avoid overheating, due to the Mediterranean south-oriented position of the sea coast.

The PACA region benefits from fairly good annual solar irradiation as depicted on the two maps below:

Figure 3 : Annual horizontal solar irradiation map of Europe

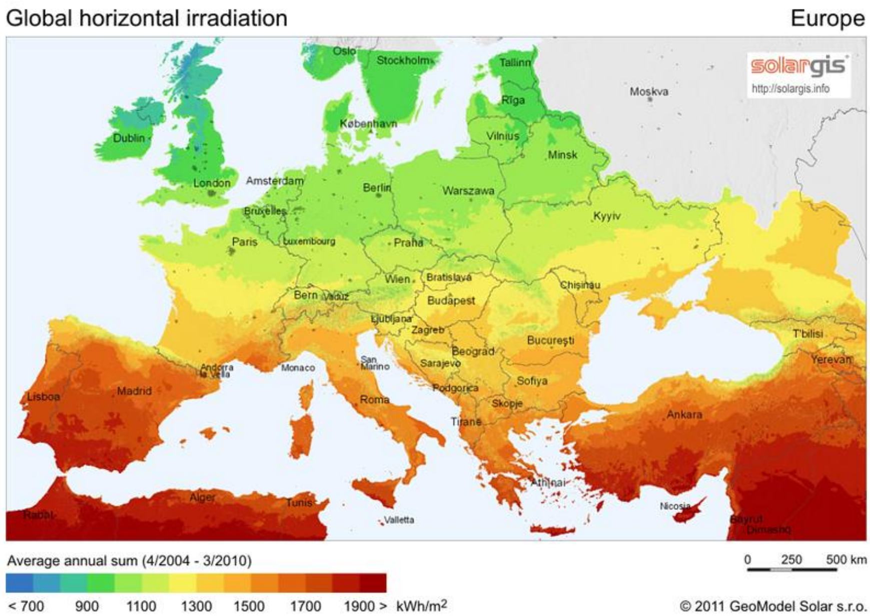
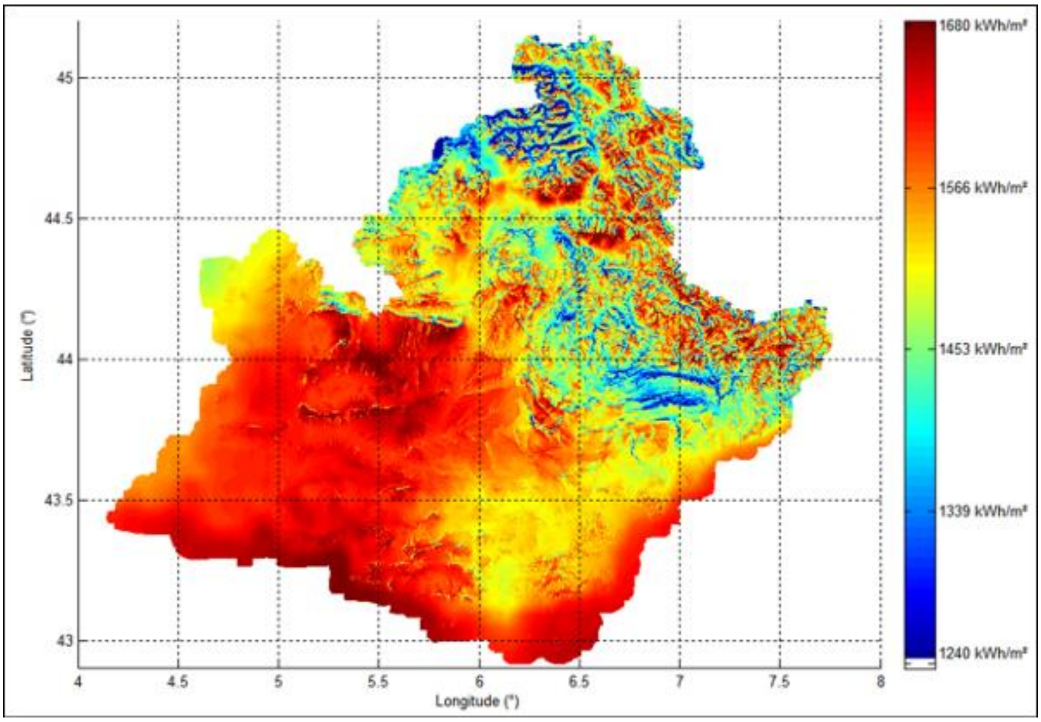


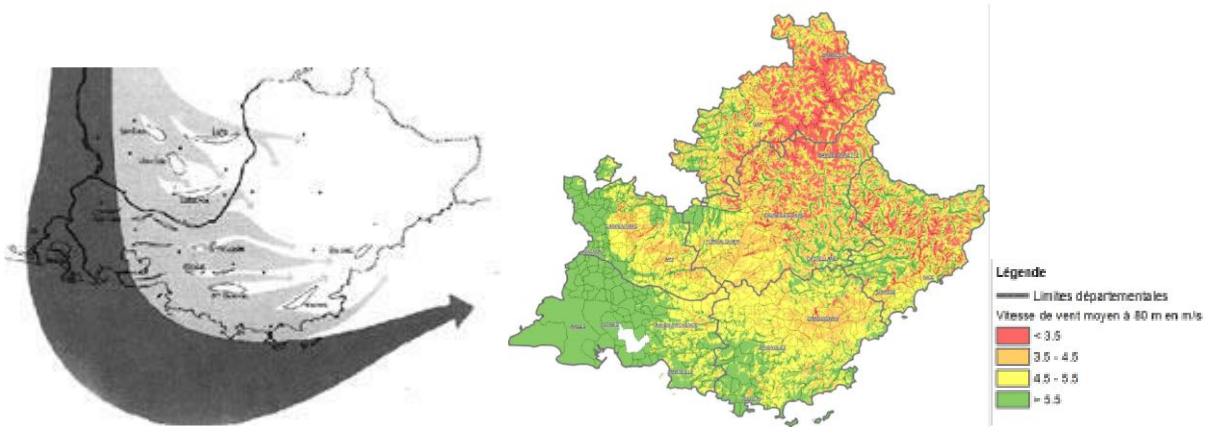
Figure 4 : Annual solar irradiation map of the PACA region



Source: www.atlas-solaire.fr

The wind energy resource is also significant in the PACA region, thanks to the Mistral wind flow running downstream the Rhone valley and U-turning above the Mediterranean Sea back to the Côte d'Azur (east part of the coast).

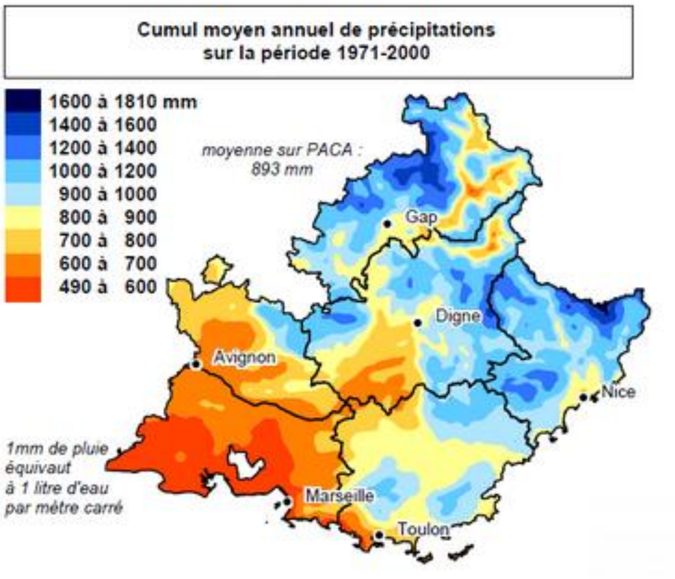
Figure 5 : Annual wind resource map of the PACA region at an altitude of 80 m



Source: Artelia pour l'Observatoire Régionale de l'Energie

Due to the Alps covering almost half the surface of the regional territory, snow falls and very low temperatures have to be taken into account in the local constraints. However the density of the tertiary buildings vanishes with altitude, except for hotels.

Figure 6 : Average annual rain/snow falls in the PACA region between 1971 and 2000



Source : ORE

2.2 Overview of energy consumption

- Description of regional specifics of energy use; heating/cooling degree days (see Eurostat data)
- Distribution of heating types/fuels (Table 2)

2.2.1 Degree-days

The meteo stations of the PACA region give the following degree-days, calculated with the formula below from 30-year averages.

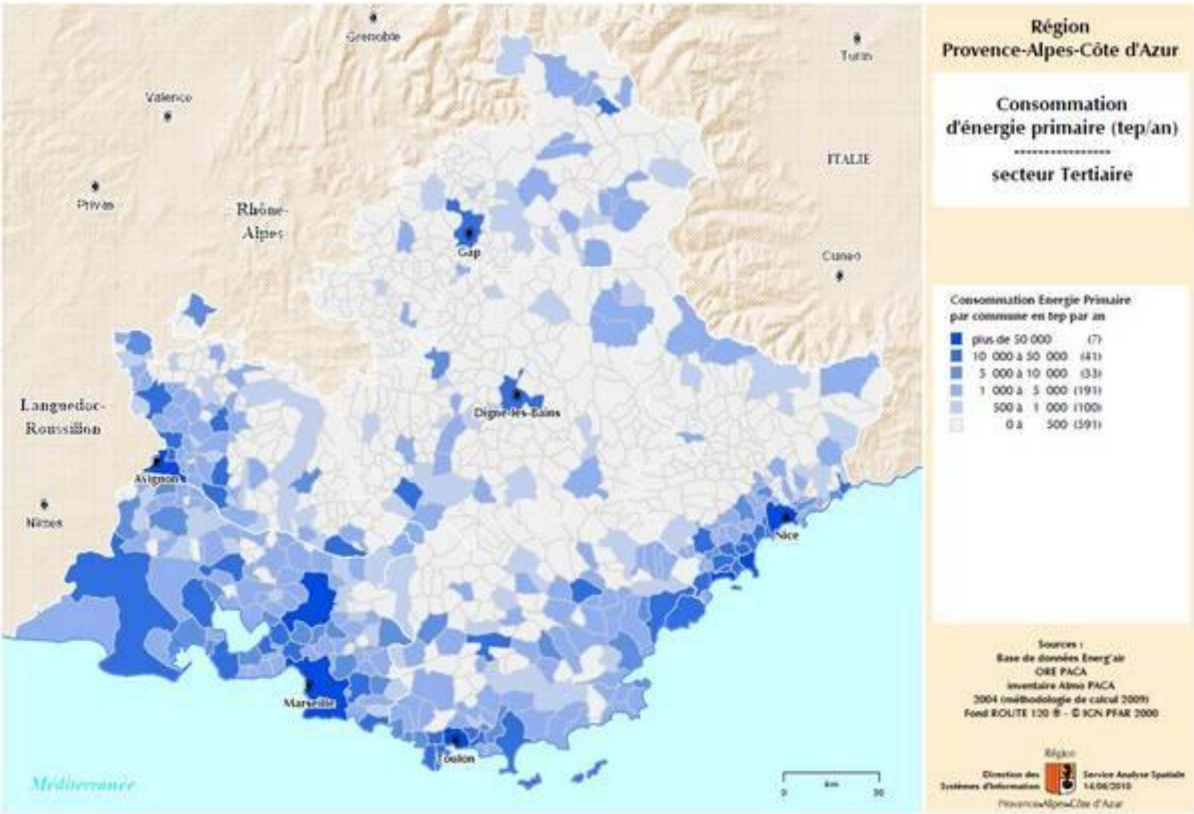
$$(18 - \frac{Tmin + Tmax}{2})$$

	Sept.	Oct.	Nov.	Déc.	Janv.	Fév.	Mars	Avril	Mai	Juin
Montélimar	30	141	297	398	425	332	290	192	87	19
Marignane	7	97	221	323	360	276	240	158	49	4
Toulon	2	48	157	238	275	222	215	135	43	3
Saint-Raphaël	10	84	199	296	326	262	245	168	82	11
Nice	1	56	175	262	291	244	223	149	56	5
Bastia	2	59	156	248	281	241	233	161	62	5
Ajaccio	5	63	168	260	299	249	242	182	80	11

Source: ADEME - U.R.E. Bâtiment : Guide d'audit énergétique 1999

2.2.2 Energy consumption in tertiary buildings of the PACA region

Figure 7: Geographical distribution of the energy consumption in tertiary buildings

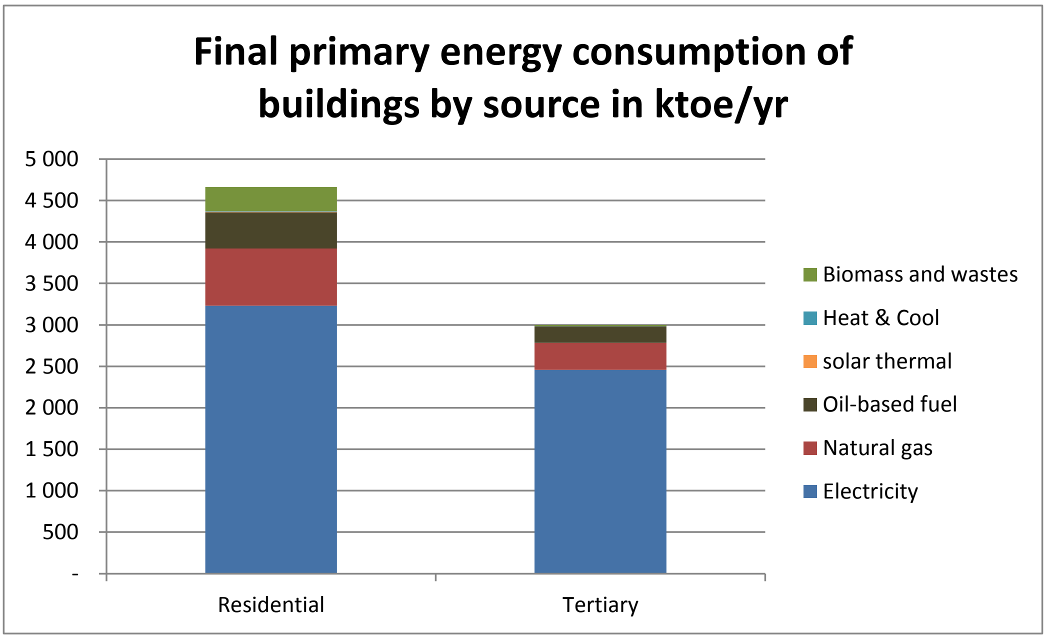


In the PACA region in 2010, the building sector was representing **37% of the final energy consumption**, i.e. 7,6 Mtoe (88,3 TWh), and **23% of the GEG emissions** linked to the final energy consumption, i.e. **12,3 million tCO_2 eq**[2]

[2] Source Energ'Air 2010

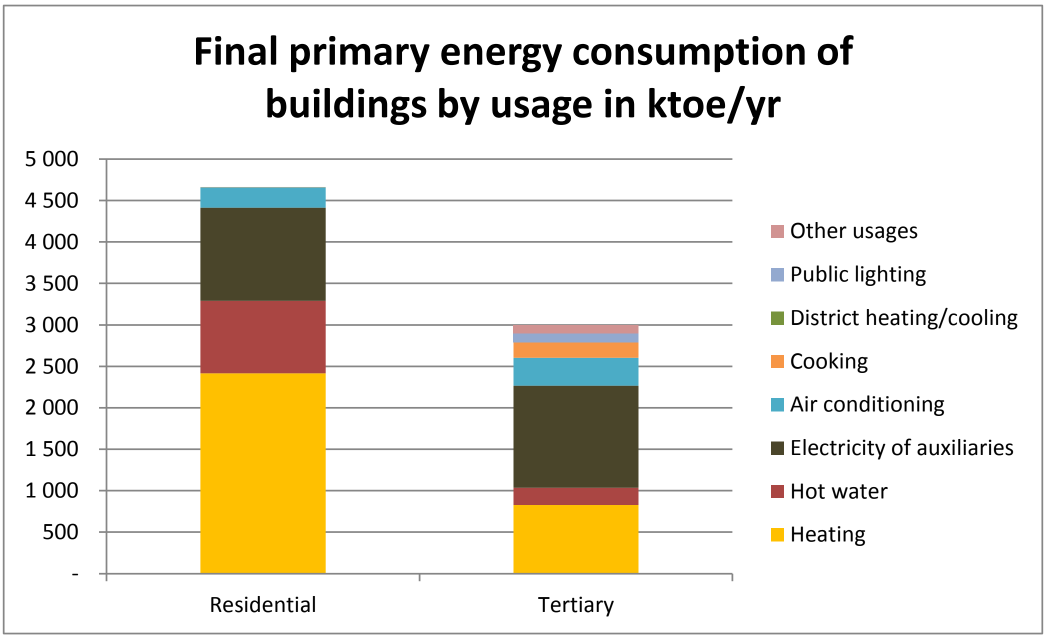
The split of the final energy consumption is estimated to 4,6 Mtoe (53,5 TWh) for the residential segment and 3 Mtoe (34,9 TWh) for the tertiary segment.

Figure 8 : Final primary energy consumption by source in ktoe/yr



Source: Capenergies from database Energ'air - Observatoire Régional de l'Energie Provence-Alpes-Côte d'Azur / inventaire Atmo PACA

Figure 9 : Final primary energy consumption by usage in ktoe/yr



Source: Capenergies from database Energ'air - Observatoire Régional de l'Energie Provence-Alpes-Côte d'Azur / inventaire Atmo PACA

The region is characterised by a large share of electricity in the energy mix (74% overall and 82% in the tertiary segment). Yet, the PACA region has the highest share of hydraulic power and a significant share of the solar photovoltaic power installed in France. The PACA region also ranks 3rd of the wood production regions of France, which leads to a significant share of biomass-fuelled energy production.

The other remarkable points are:

- The main share of the energy consumption is coming from heating and hot water preparation;
- A large share of electrical heating emitters (44% of dwellings);
- A continuous increase of electrical peak loads in winter;
- A continuous increase of electrical peak loads in summer due to a growing demand for cooling;

In the tertiary building segment, the electricity consumption has steeply grown since 1990, in relation to the deployment of auxiliaries (electronic equipment) and air conditioning. Gas consumption increased as well, before stabilizing in the early 2000's, whereas oil consumption slowed down.

Figure 10 : Evolution of the energy consumption in the tertiary building segment, in GWh

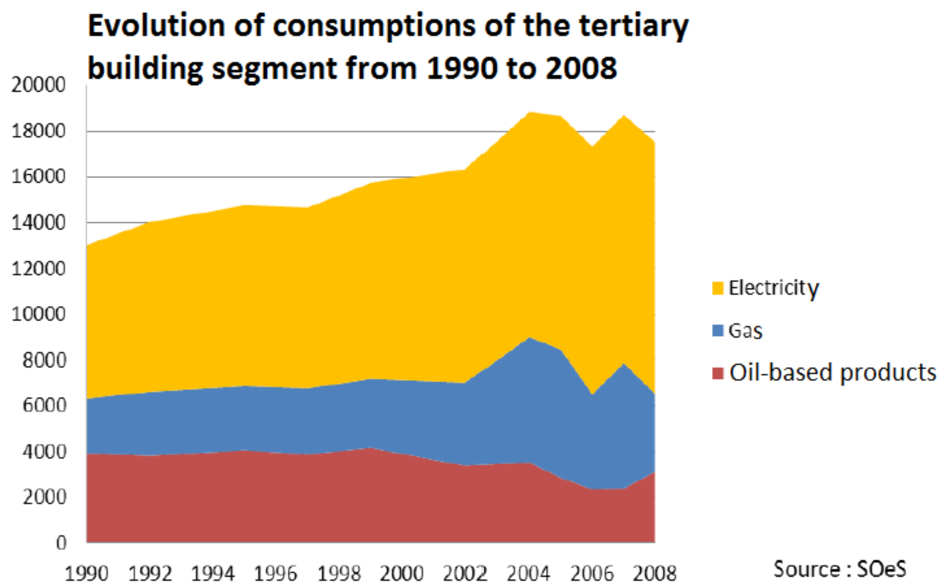


Figure 11 :

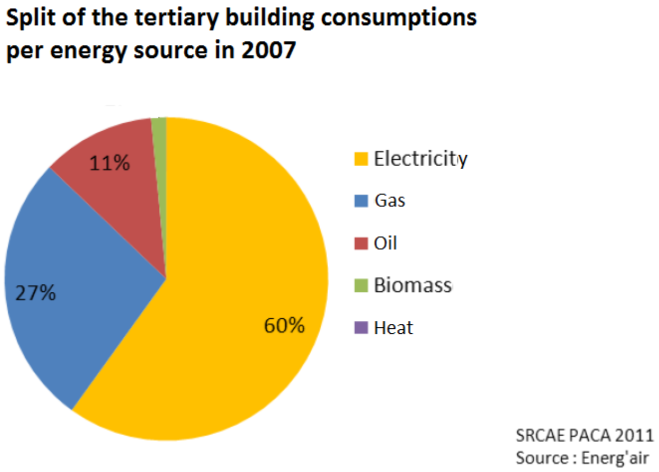
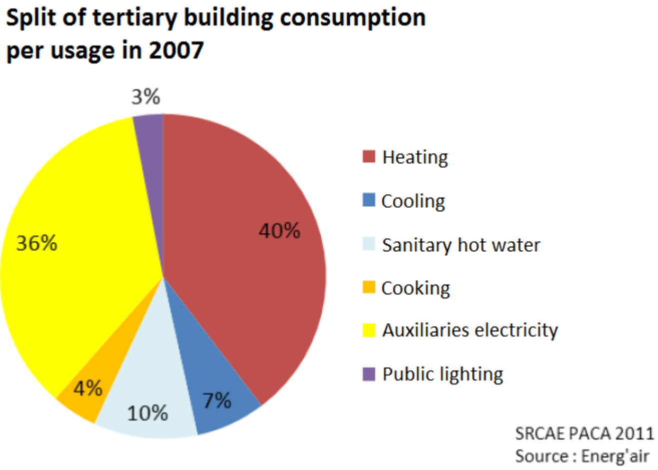


Figure 12 :



Electricity is the main energy source for tertiary buildings representing 60% of the final energy consumption. The market share differs significantly from the French average, especially regarding the electrical space heating, which is 12 points above the national average (36% against 24%).

Space heating accounts for 40% of the overall energy consumption only, since PACA is the warmest region of France. This score is also obtained because the auxiliaries electricity consumption turns to be as high as 36% (e.g. iron and other heavy industries).

Space cooling reaches a pretty high share compared to the national average too, ranging at 7%.

Public lighting, accounted in the tertiary sector, gets a score limited to 3% of the energy consumption. However, for a single city, it can rise up to 18% of the energy bill and 47% of the electricity bill.

The structure of the energy consumptions differs from a branch activity to the other as follows:

Figure 13 : Structure of the energy consumptions in tertiary buildings per activity branch, in GWh

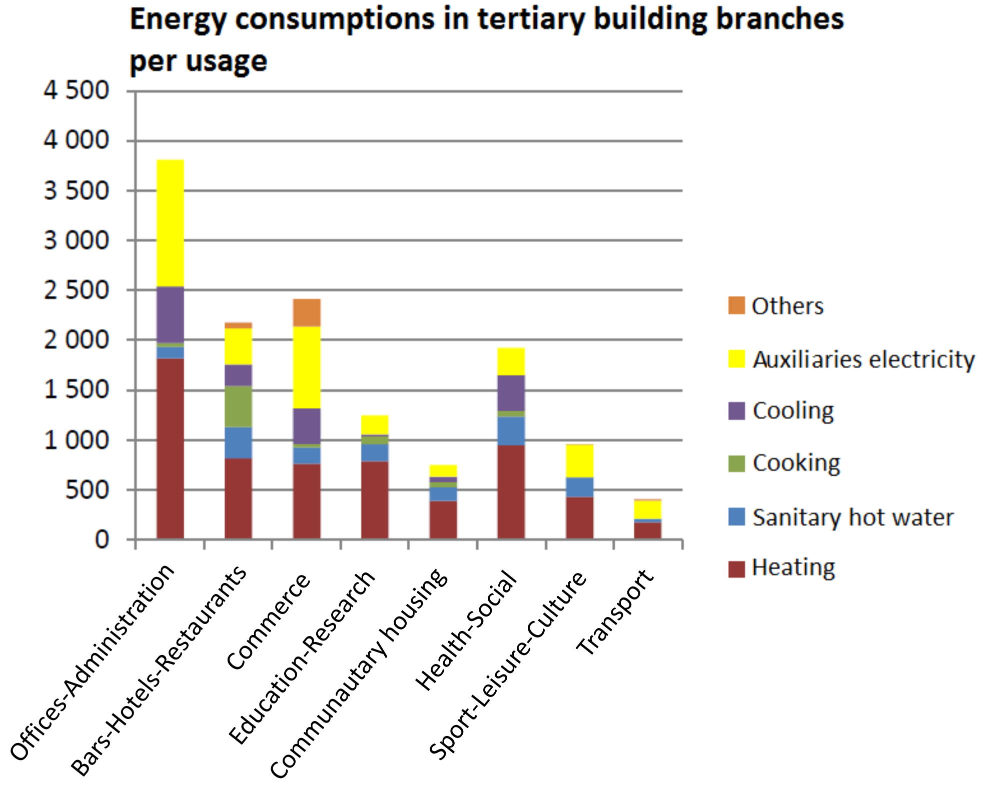


Table 2: Final energy consumption in tertiary buildings per energy source

[ktoe]	**2008**	**2009**	**2010**	**2011**	**Index 2011/2008**
Total final energy consumption	**1520 ktoe**	**1339 ktoe**			
Tertiary sector					
Coal	-	-			
Liquid fuels	315 ktoe	340 ktoe			
Natural gas	292 ktoe	136 ktoe			
RES	298 ktoe	309 ktoe			
District heat	34 ktoe	34 ktoe			
Electricity	10988 GWh	10427 GWh			

- Final tertiary buildings energy use, structure (share) of final energy consumption for tertiary sub sectors

Table 3: Final energy consumption in tertiary sector and share of total energy use per building type (sub sector)

	Total (sub sector) [GWh]	% (of total sectors)	Specific energy use [kWh/m^2 a]
Schools, research, other educational buildings	1240	7,0%	97
Hospitals, retirement homes other health/social buildings	1960	11,1%	255
Offices, administrative (municipal and other public administrative) buildings	3810	21,6%	238
Hotels, restaurants, other tourist buildings	2180	12,4%	309
Shopping, retail centres	2430	13,8%	237

3 Energy analysis of building types

3.1 Current energy consumption

3.1.1 Primary school

Short description of the typical Primary school building *(Age of construction, size, current status, total number in region, etc.)* Construction: 1969 + 1988 (2 buildings) Orientation: B1: South – B2: East Size : 3800 m² Renovations: roof in 2004 2 levels + 1 undergroung Ceiling height: 2.70m Total education surface in PACA: 12 025 000 m²	
Building heating area (m^2)	**3400 m²**

Energy consumption of the building from 1969					
Electricity (MWh)		**181**			
Fuels, district heat, RES (MWh)		**450 NG**			
TOTAL (MWh)		**631**			
Specific energy consumption for heating (kWh/m^2)		**118,6**			
Specific electricity consumption (kWh/m^2)		**47,85**			
	Heating	Cooling (VAC)	Hot water	Lighting	Other
Share in energy consumption [%]	**71%**	**6%**	**2%**	**12%**	**9%**
Remarks on data quality (e.g. estimated, model, real) Data from energy audit 2008					

Short description of the energy related systems
Envelope: *(Insulation of walls, roof, quality of windows, etc.)* Walls: Non-insulated concrete 15 cm estimated. Um ($W/m^2.K$) = 3,7 Windows: simple-glazed, wood frame. Um ($W/m^2.K$) = 4,9 Floors: non-insulated concrete 20 cm Roof: Plaster plates fixed on wood timbers, buffer space under tiles
HVAC systems: *(Types of systems installed, age, efficiency, specifics, etc.)* Ventilation: Natural and good (absence of moisture) SHW: local electric boilers 50 L – 10 years – consumption estimated to 100 m^3/yr Heating: Central gas boiler 250 kW – 40 years – 71% yield - appropriate substations but no balancing valves Cooling: Server room 20m^2 cooled by air/air split system 5 kW – 10 years Office equipment: About 100 units. Estimated total consumption: 11.890 kWh/yr Auxiliaries: Fans, pumps, cooking: Estimated total consumption: 10.090 kWh/yr
Energy management status in the buildings: *(Rate: always, usually, rarely, no)* Heating system control using a central control system Heating regulation: 20°C during occupation; 16°C during inoccupation; and shut down in summer vacations.

Trained energy manager employed in the building	Regular collection of energy consumption and cost data (bills)	Analysis of consumption (performance calculation, targets, etc.)	IT Energy management system installed (metering and on line collection of data)
Always	Usually	Usually	Rarely

Potential for energy savings/refurbishment *(Rate: high, medium, low)*					
Envelope insulation	Windows replacement	Heating	Cooling (VAC)	Lighting	Other (specify)
High	High	High	Low	Medium	Low With low energy pumps
Comments: Typically, primary schools need important insulation of walls, slabs and roofs. They face comfort issues due to overheating in summer in some rooms and cold feeling in some others. Heating systems should be often replaced by more efficient ones, since they are ageing. Most often, measures have already been taken to mitigate electricity consumption of lights.					

Potential application of the pilot technologies from EMILIE project *(Rate: very applicable, likely applicable, not applicable)*			
Solar heating & cooling	HVAC optimisation	Energy management	PCM
likely applicable	Very applicable	Very applicable	likely applicable
Comments: PACA is a sunny region all over the year; Since hot water consumption is low, solar heating and cooling truly have potential. However, most of the schools are closed 2 months in summer, which negatively impact the relevance of solar cooling. Many old schools are ventilated naturally. Yet, when renovation works are implemented, tightness is necessarily addressed, which raises the need for a forced ventilation system. Most recent buildings since 1989 (second thermal regulation) do have a forced ventilation system.			

Potential introduction of renewable energy sources (RES) in buildings *(Specify: solar, biomass, heat pump…)* *(Rate: very applicable, likely applicable, not applicable)* Solar: PV very applicable; SHW very applicable; Heating likely applicable (cost issue), cooling likely applicable in schools that are opened in summer for various activities like leisure centers. Biomass: very applicable, especially in mountain and non-coastal areas Heat pumps: very applicable, especially on the coastal strip Wind: likely applicable at large scale, unlikely applicable at small scale
Comments: There is a real potential for solar heating of sanitary water and even the dish washer in schools which include a canteen. However, the closure of most of them in summer impinges this potential. In such a situation, a coupling with a large PCM storage could be an option. Since many schools will be deeply renovated in the years ahead, double-flow ventilation units will often be introduced to mitigate the risk of moisture generation implied by the improved air tightness. Building automation for a better energy management is also foreseen as an important factor of CO_2 emission cuts. More and more renovation projects include the creation or the connection to a heating network. This network could be fed with biomass or solar energy a renewable source. Similarly, more and more schools receive a photovoltaic roof, in order to take advantage of the state incentives.

3.1.2 Hospitals

Short description of the typical healthcare building *(Age of construction, size, current status, total number in region, etc.)* Construction: 1955 + 2011 (new building) Orientation: South-West Size : 24.000 m² (1955) + 55.000 m² (2011) Ceiling height: 3 m 550 beds Total healthcare surface in PACA: 7 723 000 m²	 
Building heating area (m²)	**71.400 m²**
Energy consumption of the building	
Electricity (MWh)	**8.300**
Fuels, district heat, RES (MWh)	**18.400 Gas**
TOTAL (MWh)	**26.700**
Specific energy consumption for heating (kWh/m²)	**228**
Specific electricity consumption (kWh/m²)	**387**

	Heating	Cooling (VAC)	Hot water	Lighting	Other
Share in energy consumption [%]	61%	4%	7,3%	10%	17,7

Remarks on data quality (e.g. estimated, model, real) Data from energy audit 2012 including computed estimations

Short description of the energy related systems

Envelope: *(Insulation of walls, roof, quality of windows, etc.)* <u>Old building:</u> Walls: Non-insulated concrete 15 cm estimated. Um (W/m².K) = 3,7 Windows: simple-glazed, wood frame. Um (W/m².K) = 4,9 Floors: non-insulated concrete 20 cm Roof: Plaster plates fixed on wood timbers, buffer space under tiles <u>New building:</u> Walls: Concrete 20 cm with inner insulation 15 cm of mineral wool + shadowing elements Windows: Double-glazed low emissivity with PVC frame Floors: Concrete slab 20 cm including 20 cm insulation underneath when connected to a buffer volume Roof: Terrace slab including 10 cm insulation

HVAC systems: *(Types of systems installed, age, efficiency, specifics, etc.)* <u>Old building:</u> Ventilation: Natural and good (absence of moisture accept where rain infiltration could be seen) SHW: Centralized production + loop, consuming 0,8 GWh/yr of gas Heating: Central cogeneration 80% yield share with new building's Cooling: Technical rooms cooled by air/air split systems and air/water systems from 1999 to 2011 totalling 1,9 MW Laundry common to both buildings: 2 Vapour generators powering 3,5 T/h each, consuming 1.7 GWh/yr of gas Electrical auxiliaries & equipment: Fans, pumps, cooking, surgery equipment: Estimated total consumption: 2.040 MWh/yr <u>New building:</u> Ventilation: Double flow SHW: Centralized production + loop, consuming 1,3 GWh/yr of gas Heating: Central cogeneration 80% yield share with old building's Cooling: Technical rooms cooled by air/air split systems and air/water systems from 1999 to 2011 totalling 1,9 MW Electrical auxiliaries & equipment: Fans, pumps, cooking, surgery equipment: Estimated total consumption: 5.920 MWh/yr
Energy management status in the buildings: *(Rate: always, usually, rarely, no)* Buildings equipped with a control unit for heating and cooling

Trained energy manager employed in the building	Regular collection of energy consumption and cost data (bills)	Analysis of consumption (performance calculation, targets, etc.)	IT Energy management system installed (metering and on line collection of data)
Always	Always	Always	Usually

Potential for energy savings/refurbishment *(Rate: high, medium, low)*					
Envelope insulation	Windows replacemen t	Heating	Cooling (VAC)	Lighting	Other (specify)

Medium	Medium	Medium	High	High	Medium

Comments:

During the last decades, hospitals have been put under particular scrutiny, as they are state-funded high-consumption buildings. Thus, tremendous efforts have been made to audit the healthcare establishments and to trigger deep renovation works. In many places, old buildings have even been destroyed and new ones have been erected, in conjunction of territorial redesign of the global healthcare infrastructure.

Potential application of the pilot technologies from EMILIE project

(Rate: very applicable, likely applicable, not applicable)

Solar heating & cooling	HVAC optimisation	Energy management	PCM
Very applicable	Very applicable	Very applicable	Likely applicable

Comments:

Most often, healthcare buildings are flat-roofed and multi-storey, which is a favourable configuration for installing solar panels.

For hygienic reasons, there is still a challenge in the optimization of the HVAC systems (performance vs consumption) and sanitary water monitoring.

The lack of experience with PCM materials and heat storage using them does not allow to rate more than "likely".

Potential introduction of renewable energy sources (RES) in buildings

(Specify: solar, biomass, heat pump…)

(Rate: very applicable, likely applicable, not applicable)

Solar: PV very applicable but not much deployed; SHW very applicable; Heating likely applicable (cost issue); cooling very applicable

Biomass: very applicable, especially in mountain and non-coastal areas, although the impact of fumes on health remains an issue for hospitals

Heat pumps: very applicable, especially on the coastal strip

Wind: unlikely applicable at small scale

Comments:

Hospitals need a high level of reliable regarding energy supply, which explains that they cannot depend on the electricity network. All such buildings have fuel, gas or rarely biomass boilers or cogenerators. When they do not have a cogenerator, they are equipped with a genset electrical rescue power supply.

3.1.3 Public administrative buildings

<table>
<tr><td colspan="2">Short description of the typical administrative building
(Age of construction, size, current status, total number in region, etc.)
Construction: 1987
Orientation: North-East
Size : 20.000 m²
Total surface in PACA : 15 238 000 m²</td><td colspan="4"></td></tr>
<tr><td colspan="2">Building heating area (m^2)</td><td colspan="4">± 19.000 m²</td></tr>
<tr><td colspan="6">Energy consumption of the building</td></tr>
<tr><td colspan="2">Electricity (MWh)</td><td colspan="4">4494</td></tr>
<tr><td colspan="2">Fuels, district heat, RES (MWh)</td><td colspan="4">1123</td></tr>
<tr><td colspan="2">TOTAL (MWh)</td><td colspan="4">5617</td></tr>
<tr><td colspan="2">Specific energy consumption for heating (kWh/m^2)</td><td colspan="4">107</td></tr>
<tr><td colspan="2">Specific electricity consumption (kWh/m^2)</td><td colspan="4">67 (without cooling)</td></tr>
<tr><td></td><td>Heating</td><td>Cooling (VAC)</td><td>Hot water</td><td>Lighting</td><td>Other</td></tr>
<tr><td>Share in energy consumption [%]</td><td>38%</td><td>37%</td><td>1%</td><td colspan="2">24%</td></tr>
<tr><td colspan="6">Remarks on data quality (e.g. estimated, model, real) Building heated area not exactly known and data includes non-heated areas</td></tr>
<tr><td colspan="6">Short description of the energy related systems</td></tr>
</table>

Envelope:

(Insulation of walls, roof, quality of windows, etc.)

Walls : concrete 20 cm + 8-10 cm inner insulation + plaster plates

Windows: double-glazed, aluminium frame. Uw ($W/m^2.K$) = ± 2.3

Floors: non-insulated concrete slabs 20 cm

Roof: concrete slabs 20 cm + 7-8 cm effigreen insulation

Aesthetic design and construction work quality leads to several abnormal comfort disagreements.

HVAC systems:

(Types of systems installed, age, efficiency, specifics, etc.)

Oversized gas boilers – 21 years old

5 distribution zones: heating floor, ventilated convectors, radiators, splits) of which 3 only are thermally controlled.

3 cooling units: 2 being 20 years old and 1 rented following a break down. To be substituted in 2013

Energy management status in the buildings:

Existing remote supervision and control system, though not well maintained.

(Rate: always, usually, rarely, no)

Trained energy manager employed in the building	Regular collection of energy consumption and cost data (bills)	Analysis of consumption (performance calculation, targets, etc.)	IT Energy management system installed (metering and on line collection of data)
rarely	rarely	rarely	rarely

Potential for energy savings/refurbishment

(Rate: high, medium, low)

Envelope insulation	Windows replacement	Heating	Cooling (VAC)	Lighting	Other (specify)
low	medium	high	high	low (management of switch-off)	Low energy motors

Comments:			
Potential application of the pilot technologies from EMILIE project *(Rate: very applicable, likely applicable, not applicable)*			
Solar heating & cooling	HVAC optimisation	Energy management	PCM
not applicable (classified site)	likely applicable	likely applicable	not applicable
Comments: The above answers address the studied building, which is located in a classified area (historical district) and oriented to the north as the main orientation. Generally, administrative/office buildings are located in city centers which are often historical classified areas where it is almost impossible to introduce solar panels.			
Potential introduction of renewable energy sources (RES) in buildings *(Specify: solar, biomass, heat pump…)* *(Rate: very applicable, likely applicable, not applicable)* Hardly applicable or highly integrated like in the Renewable Energy House of Brussels.			
Comments:			

3.1.4 Hotels

Short description of the typical hotel building *(Age of construction, size, current status, total number in region, etc.)* Construction: 1920 Orientation: East / South-East Size : 2100 m² Last renovation: 2001 4 levels + 1 undergroung Ceiling height: 3 m 43 rooms Family-owned Total hotels surface in PACA: 6 624 000 m²	
Building heating area (m^2)	**2020 m²**

Energy consumption of the building					
Electricity (MWh)	**91**				
Fuels, district heat, RES (MWh)	**386**				
TOTAL (MWh)	**447**				
Specific energy consumption for heating (kWh/m^2)	**112**				
Specific electricity consumption (kWh/m^2)	**45**				
	Heating	Cooling (VAC)	Hot water	Lighting	Other
Share in energy consumption [%]	51%	10%	26%	9%	4%
Remarks on data quality (e.g. estimated, model, real) Data form energy diagnosis + interviews					
Short description of the energy related systems					

Envelope: *(Insulation of walls, roof, quality of windows, etc.)* Walls : White stone 33 cm + 8 cm inner insulation + plaster plates Windows: double-glazed, PVC frame. Uw (W/m².K) = ± 1.4 Floors: non-insulated concrete slabs 20 cm Roof: Plaster plate ceiling fixed on wood timbers + non insulated buffer space under roof
HVAC systems: *(Types of systems installed, age, efficiency, specifics, etc.)* Ventilation: Natural with electrical extraction in bathrooms SHW: Centralized production + loop from gas boilers + accumulation tank 1000 L Heating: Centralized production from gas boiler 186 kW dated 2001- 46% yield + gas burner mounted on an old coal boiler. Cooling: Ciat DYNACIAT LG LGP 700 kW + Drycooler Ciat EUROPA 2 9K42 - estimated consumption: 45 MWh/yr Electrical auxiliaries & equipment: Fans, pumps, cooking - estimated consumption: 17 MWh/yr
Energy management status in the buildings: No supervision or control system *(Rate: always, usually, rarely, no)*

Trained energy manager employed in the building	Regular collection of energy consumption and cost data (bills)	Analysis of consumption (performance calculation, targets, etc.)	IT Energy management system installed (metering and on line collection of data)
No	Usually	Rarely	Rarely

Potential for energy savings/refurbishment

(Rate: high, medium, low)

Envelope insulation	Windows replacement	Heating	Cooling (VAC)	Lighting	Other (specify)
Medium	Low	High	High	High	(rate)

Comments:

Reinforcement of insulation reveals difficult in historical buildings, especially with outer insulation. Inner insulation can more easily be applied, yet not easily in small rooms.

Most often, hotels have already changed the windows. This is one of the priority renovation adopted by hotels for noise reason as well as energy saving motivation.

Potential application of the pilot technologies from EMILIE project

(Rate: very applicable, likely applicable, not applicable)

Solar heating & cooling	HVAC optimisation	Energy management	PCM
Likely applicable	Very applicable	Very applicable	Likely applicable

Comments:

Hotels face a big demand for sanitary hot water (50 to 70 L @ 60°C per customer per day). Saving energy on water heating is one of the big issues and solar water heating is a real option in many cases.

The integration of solar panels is difficult in city centers, but often easy in other locations, at least for water heating.

Largest hotels often employ a maintenance technician inhouse. In such a situation, supervision and control systems often exist. In smaller family-owned hotels, which represent about 42% of the hotels in PACA, this is not the usual situation.

Potential introduction of renewable energy sources (RES) in buildings

(Specify: solar, biomass, heat pump…)

(Rate: very applicable, likely applicable, not applicable)

Solar: Except in historical city centers, PV very applicable but not much deployed; SHW very applicable; Heating likely applicable (cost issue); cooling very applicable

Biomass: very applicable, especially in mountain and non-coastal areas, although the impact of fumes on health remains an issue in city centers

Heat pumps: very applicable, especially on the coastal strip. In remote regions the heat pump should be twined with a double flow ventilation (in case of air/air or air/water) and/or climatic well

Wind: likely applicable at small scale

Comments:
In city centers, not so many technologies can suit the needs, although one can replicate the Renewable Energy House of Brussels (cost issue to be analysed). Outside city centers, several opportunities truly exist, but hotel Managers request short pay-back times.

3.1.5 Retail (shopping) centres

Short description of the typical shopping center building *(Age of construction, size, current status, total number in region, etc.)* Construction: 1986 Orientation: South Size : 2600 m² Last renovation: 2002 1 level + mezzanine Ceiling height: 5 m Total surface in PACA: 9 682 000 m²	
Building heating area (m^2)	**2200 m²**

Energy consumption of the building					
Electricity (MWh)	**1262**				
Fuels, district heat, RES (MWh)	**172**				
TOTAL (MWh)	**1434**				
Specific energy consumption for heating (kWh/m^2)	**206**				
Specific electricity consumption (kWh/m^2)	**371**				
	Heating	Cooling (VAC)	Hot water	Lighting	Other
Share in energy consumption [%]	43%	15%	2%	20%	20%
Remarks on data quality (e.g. estimated, model, real) Estimations relying on several reports [1][3][10]					

Short description of the energy related systems

Envelope: *(Insulation of walls, roof, quality of windows, etc.)* Walls: Metal structure + concrete blocs without insulation, except in offices on the mezzanine where 8 cm inner insulation is installed Windows: Security simple glazed, aluminium frame Floors: Non-insulated concrete slab on the ground; mezzanine: metal timbers + wood plates “OSB” + comfort layer Roof: insulated concrete slab on the old part. Steel sheets on the entrance hall, insulated with 20 cm rockwool
HVAC systems: *(Types of systems installed, age, efficiency, specifics, etc.)* Ventilation: Double flow coupled to heat pumps (2002) SHW: Local electrical water heaters 50 L in offices and 300 L in the warehouse (2005) Heating/Cooling: 3 reversible heat pumps Aquaciat IDLC totalling 330 kW dated 2002 Cold: Cold room + refrigerators + freezers equipped with electrical compressors totalling ± 20% of the total consumption Electrical auxiliaries & equipment: Fans, pumps, cooking - estimated consumption: < 1% of electrical consumption
Energy management status in the buildings: None *(Rate: always, usually, rarely, no)*

Trained energy manager employed in the building	Regular collection of energy consumption and cost data (bills)	Analysis of consumption (performance calculation, targets, etc.)	IT Energy management system installed (metering and on line collection of data)
Rarely	Rarely	Rarely	Rarely

Potential for energy savings/refurbishment *(Rate: high, medium, low)*					
Envelope insulation	Windows replacement	Heating	Cooling (VAC)	Lighting	Other (specify)

High	Low (too many openings)	Medium	Medium	High	High Cold stores can be much optimized with closed fridges and freezers

Comments:

Usually, commercial building owners earn enough money to renovate regularly their building, which has also a marketing impact. Hence, equipment are often recent and energy savings are realized at a good pace.

One of the weak points of almost all food-focused commercial centers is the oversizing of heating systems which have to compensate the cooling of fridges in winter.

Insulation of buildings is rarely performed on old building parts. It is now taken into account in deep renovation or extension works thanks to the latest thermal regulations.

Potential application of the pilot technologies from EMILIE project

(Rate: very applicable, likely applicable, not applicable)

Solar heating & cooling	HVAC optimisation	Energy management	PCM
Very applicable	Likely applicable	Likely applicable	Likely applicable (office rooms)

Comments:

Solar heating and cooling is one of the most promising technologies on commercial buildings in PACA. Yet, the pay-back time is an important decision-making criterion for the owners.

With regards to energy management, it is almost impossible to act on customers' behaviour.

Potential introduction of renewable energy sources (RES) in buildings

(Specify: solar, biomass, heat pump…)

(Rate: very applicable, likely applicable, not applicable)

Comments:

Solar: PV very applicable, especially as car park shadowing; SHW unlikely applicable since consumption is limited; Heating very applicable (cost issue); cooling very applicable

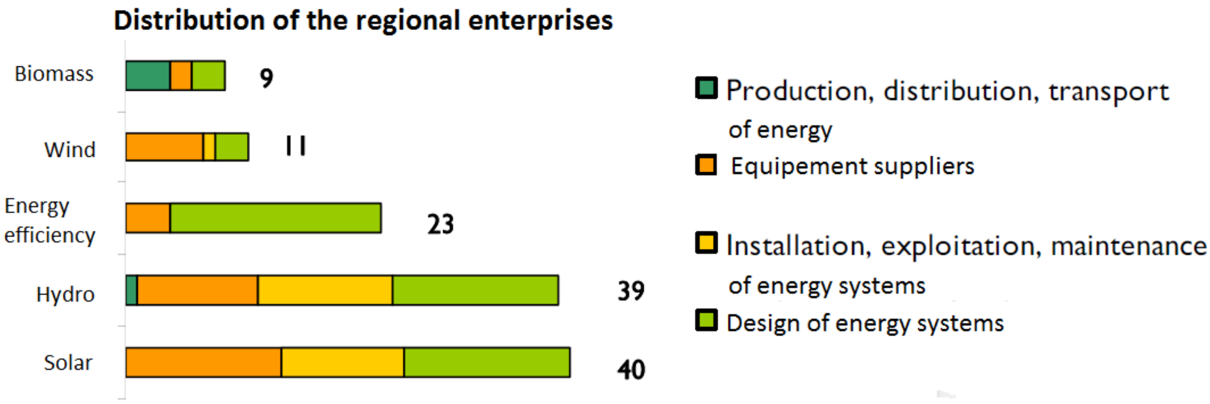
Biomass: very applicable, especially in mountain

Heat pumps: very applicable, especially on the coastal strip. In remote regions the heat pump should be twined with a double flow ventilation (in case of air/air or air/water) and/or climatic well

Wind: likely applicable

3.2 Assessment of diverse technologies effects on the supply chain

Figure 14 : Reported number of enterprises operating in the renewable energy sector in Jan. 2008



Many more companies would be reported in 2013, although regulatory turbulences led several installers of the PV sector to bankruptcy in 2011, 2012 and beginning of 2013. The advent of the new regulation "RT 2012" setting the energy performance standard of buildings applicable to any building since January 2013 generates the creation or the conversion of many companies to the energy efficiency and renewable energy businesses. Therefore, the above figures should be updated.

3.3 Assessment of the effects of diverse technologies in terms of energy savings and overall environmental impact

Prospective study for the years ahead

Two scenarios have been analysed:

- **A tendency scenario**, which takes into account all the measures taken before 01/01/2010, especially at national level through the so-called "Grenelle de l'environnement" binding programme.
- **An engaging scenario**, which assumes additional measures taken at regional level.

The segment of wastes treatment has not been included in the scenario building.

The Agriculture segment has been integrated to the scenarios, but its energy consumption is assumed to be constant, according to its low weight in the regional energy consumption.

Tendency scenario

Figure 15 : Final primary energy consumption according to the tendency scenario in ktoe/yr

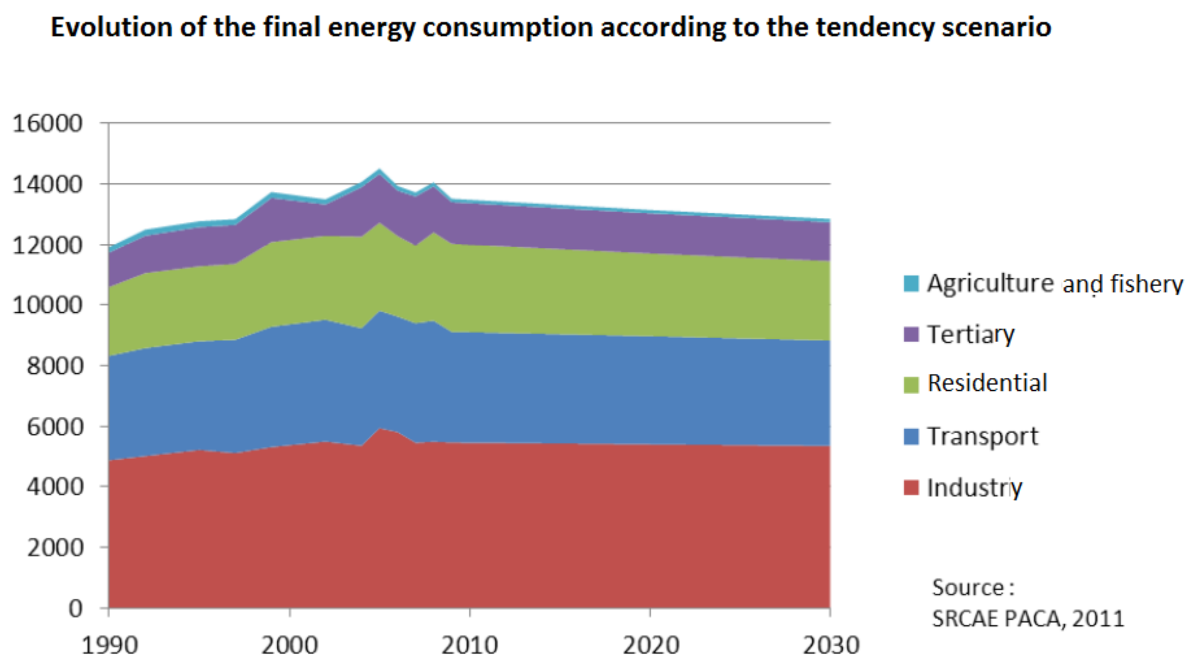


Table 3 : Synthesis of the tendency scenario of final energy consumption per segment

Synthesis of tendency scenario per segment (energy)				Gains		Evolution	
ktoe	2007	2020	2030	2020	2030	2020	2030
Industry	5 480	5 410	5 356	-71	-125	-1%	-2%
Transport	3 672	3 573	3 484	-99	-189	-3%	-5%
Residential	2 935	2 727	2 620	-207	-315	-7%	-11%
Tertiary	1 388	1 328	1 283	-60	-105	-4%	-8%
Agriculture and fishery	111	111	111	0	0	0%	0%
Total consumptions	13 586	13 149	12 853	-437	-733	-3%	-5%

Source: Schéma Régional Climat Air Energie (SRCAE)

Table 4 : Synthesis of the tendency scenario of greenhouse gases emissions per segment

Synthesis of tendency scenario per segment (GHG)				Gains		Evolution	
$MtCO_2eq$	2007	2020	2030	2020	2030	2020	2030
Industry	15,3	15,1	14,9	-0,2	-0,3	-1%	-2%
Transport	11,4	11,0	10,6	-0,4	-0,7	-3%	-6%
Residential	5,0	4,4	4,1	-0,6	-0,9	-12%	-18%
Tertiary	2,2	2,0	1,9	-0,2	-0,3	-10%	-15%
Agriculture and fishery	0,3	0,3	0,3	0,0	0,0	0%	0%
Total emissions	34,1	32,7	31,8	-1,4	-2,3	-4%	-7%

Source: Schéma Régional Climat Air Energie (SRCAE)

The tendency scenario shows regional energy consumption savings of about 3% by 2020 compared to 2007 and of about 5% by 2030, although the region faces a growing population. This makes a trend rupture compared to the past 1990-2005 period.

In terms of GreenHouse Gases emissions, savings are expected to reach 4%/yr by 2020 and 7%/yr by 2030 compared to 2007.

Engaging scenario

Figure 16 : Final primary energy consumption according to the engaging scenario in ktoe/yr

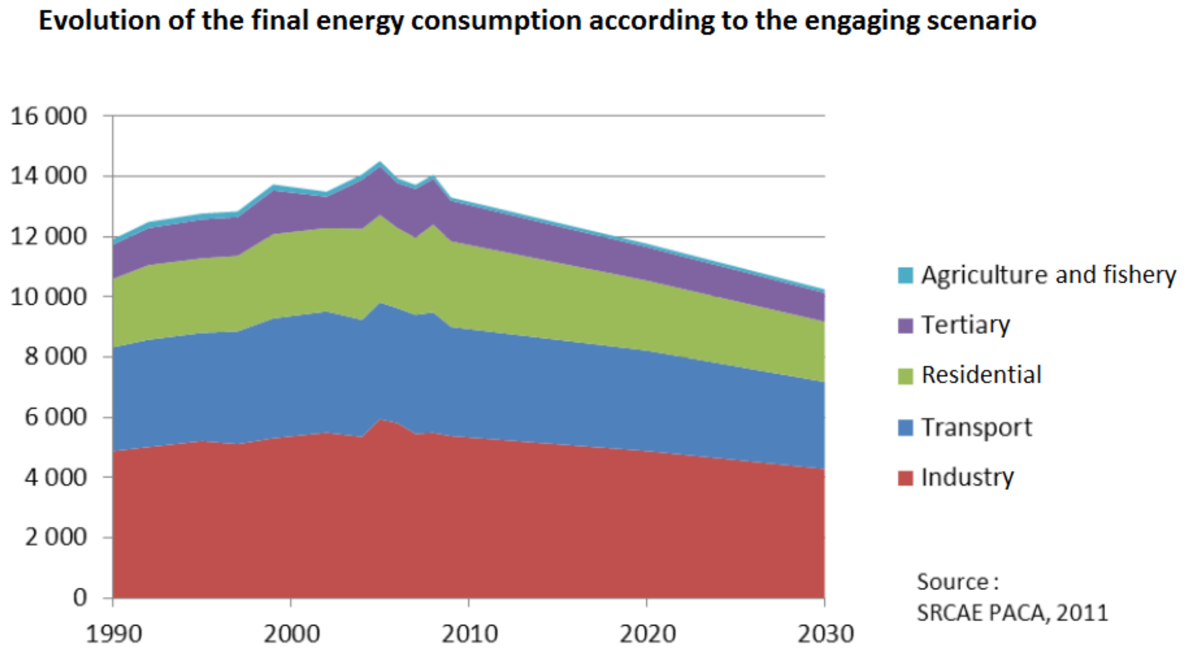


Table 5 : Synthesis of the engaging scenario of final energy consumption per segment

Synthesis of engaging scenario per segment (Energy)				Gains		Evolution	
ktoe	2007	2020	2030	2020	2030	2020	2030
Industry	5 480	4 888	4 295	-593	-1 185	-11%	-22%
Transport	3 672	3 338	2 886	-335	-787	-9%	-21%
Residential	2 935	2 322	2 002	-613	-933	-21%	-32%
Tertiary	1 388	1 113	962	-275	-426	-20%	-31%
Agriculture and fishery	111	111	111	0	0	0%	0%
Total consumptions	13 586	11 771	10 256	-1 815	-3 331	-13%	-25%

Source: Schéma Régional Climat Air Energie (SRCAE)

Table 6 : Synthesis of the engaging scenario of greenhouse gases emissions per segment

Synthesis of engaging scenario per segment (GHG)				Gains		Evolution	
$MtCO_2eq$	2007	2020	2030	2020	2030	2020	2030
Industry	15,3	13,3	11,6	-2,0	-3,7	-13%	-24%
Transport	11,4	10,2	8,8	-1,1	-2,6	-10%	-23%
Residential	5,0	3,6	2,9	-1,4	-2,1	-28%	-43%
Tertiary	2,2	1,7	1,5	-0,5	-0,7	-21%	-34%
Agriculture and fishery	0,3	0,3	0,3	0,0	0,0	0%	0%
Total emissions	34,1	29,1	25,0	-5,0	-9,1	-15%	-27%

Source: Schéma Régional Climat Air Energie (SRCAE)

The engaging scenario leads to 13% savings in energy consumptions by 2020 and 25% by 2030 compared to the 2007 regional reference.

In terms of GHG emissions, saving potentials reach 16% by 2020 and 28% by 2030 compared to the 2007 reference.

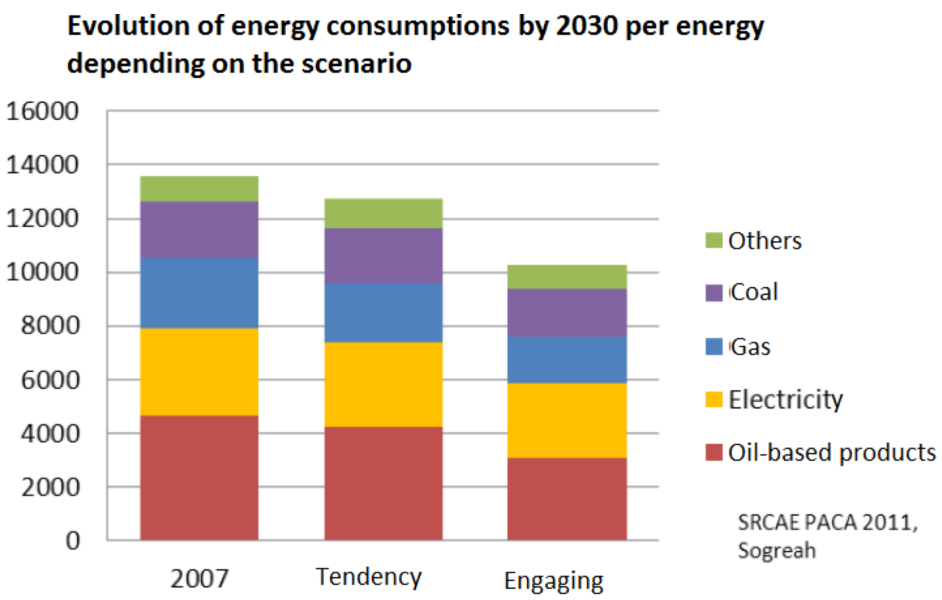
Summary per energy source

Table 7 : Evolution of consumptions per energy depending on the scenario

ktoe		2020		2030	
Energies	***2007***	***Tendency***	***Engaging***	***Tendency***	***Engaging***
oil-based products	4683	4433	3737	4215	3095
Electricity ***In TWh***	3242 (37,7 TWh)	3258 (37,9 TWh)	2926 (34 TWh)	3155 (36,7 TWh)	2753 (32 TWh)
Gas	2618	2271	2214	2220	1768
Coal	2111	2091	1940	2068	1766
Others	934	1095	950	1078	867
Total	***13589***	***13149***	***11766***	***12736***	***10249***

Source: Schéma Régional Climat Air Energie (SRCAE)

Figure 17 : Final primary energy consumption by 2030 per energy depending on the scenario in ktoe/yr



Summary per market segment

Table 8 : Evolution of consumptions per segment depending on the scenario

ktoe		2020		2030	
Segment	*2007*	*Tendency*	*Engaging*	*Tendency*	*Engaging*
Industry	5480	5410	4888	5356	4295
Transport	3672	3573	3338	3484	2886
Residential	2935	2727	2322	2620	2000
Tertiary	1388	1328	1113	1283	962
Agriculture	111	111	111	111	111
Total	***13586***	***13149***	***11771***	***12853***	***10254***

Source: Schéma Régional Climat Air Energie (SRCAE)

Figure 18 : Final primary energy consumption by 2030 per segment depending on the scenario in ktoe/yr

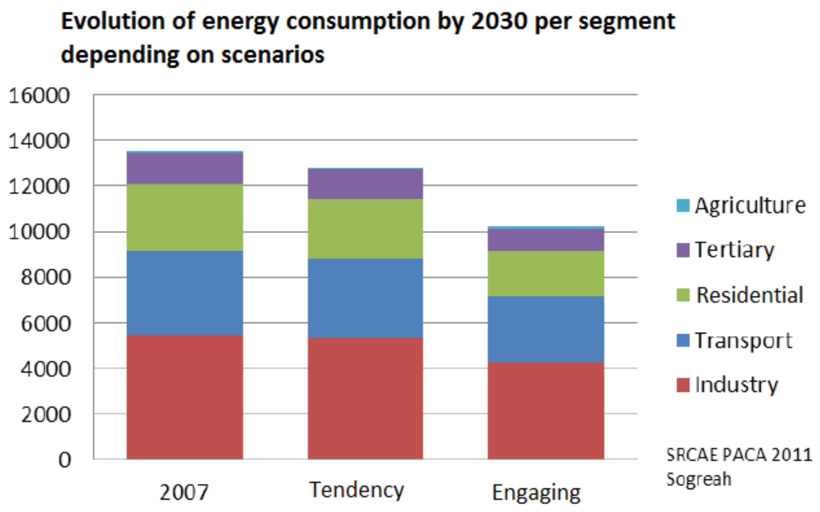
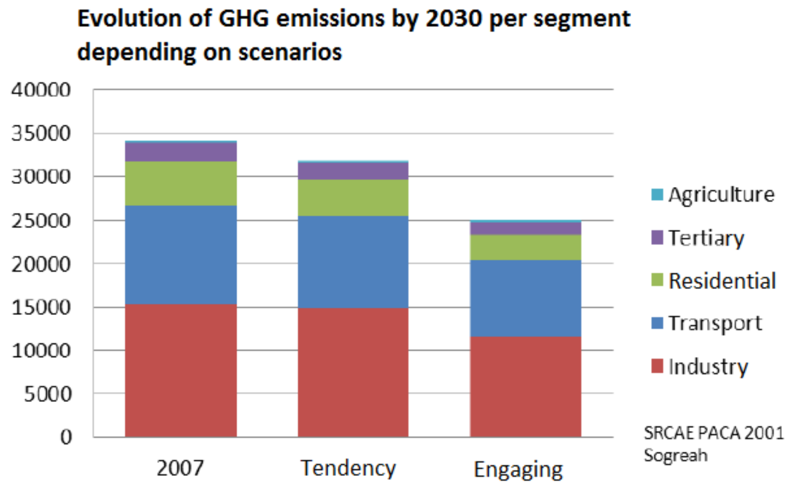


Table 9 : Evolution of GHG emissions per segment depending on the scenario

$ktCO_2eq$		2020		2030	
Segment	*2007*	*Tendency*	*Engaging*	*Tendency*	*Engaging*
Industry	15293	15096	13274	14945	11641
Transport	11356	11003	10227	10645	8776
Residential	5014	4395	3601	4123	2871
Tertiary	2202	1991	1736	1861	1453
Agriculture	262	262	262	262	262
Total	***34127***	***32747***	***29099***	***31836***	***25002***

Source: Schéma Régional Climat Air Energie (SRCAE)

Figure 19 : GHG emissions by 2030 per segment depending on the scenario in $ktCO_2eq/yr$



Focus on the potential savings in the building segments

Figure 20 : Impact of the different levers on goal outreach regarding final energy consumption, in ktoe/yr

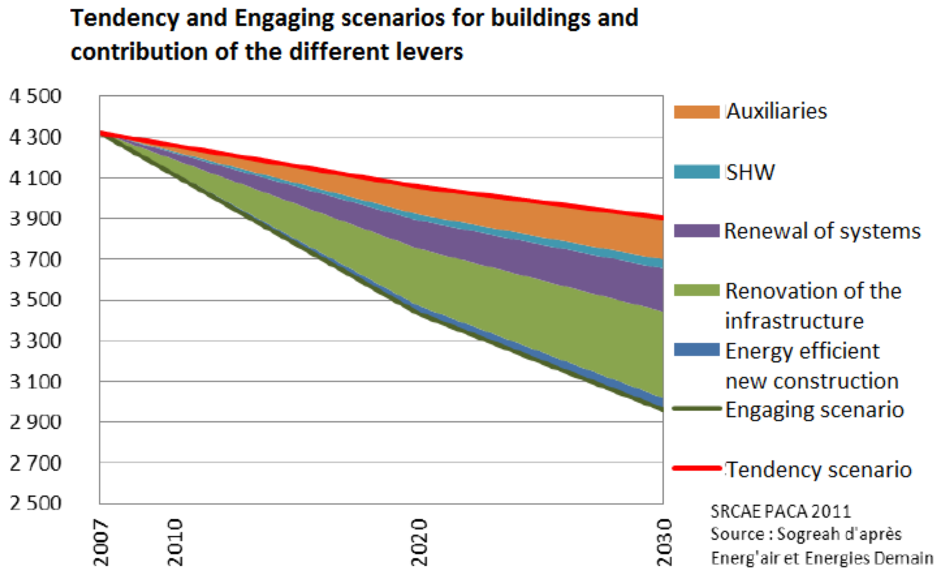
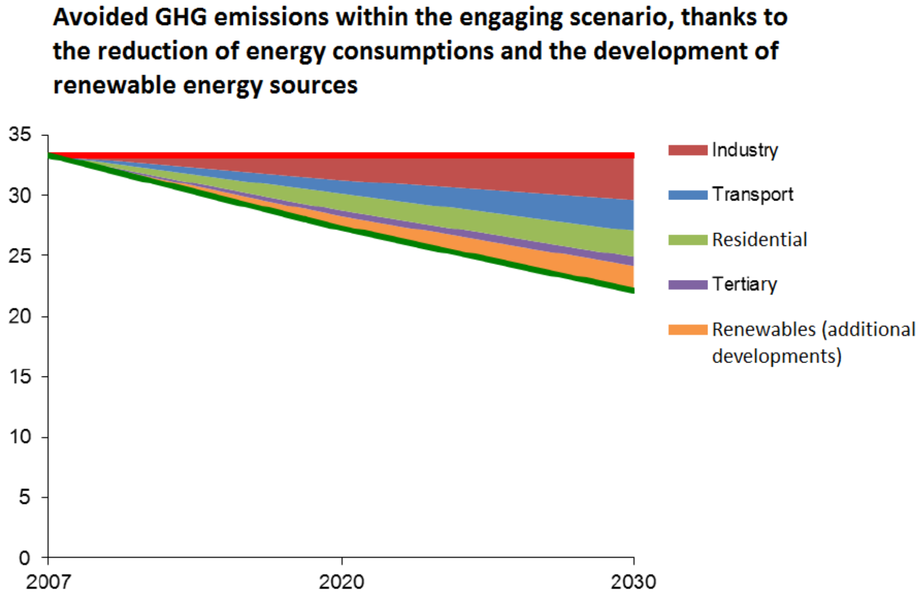


Figure 21 : Avoided GHG emissions within the engaging scenario, in $ktCO_2eq/yr$



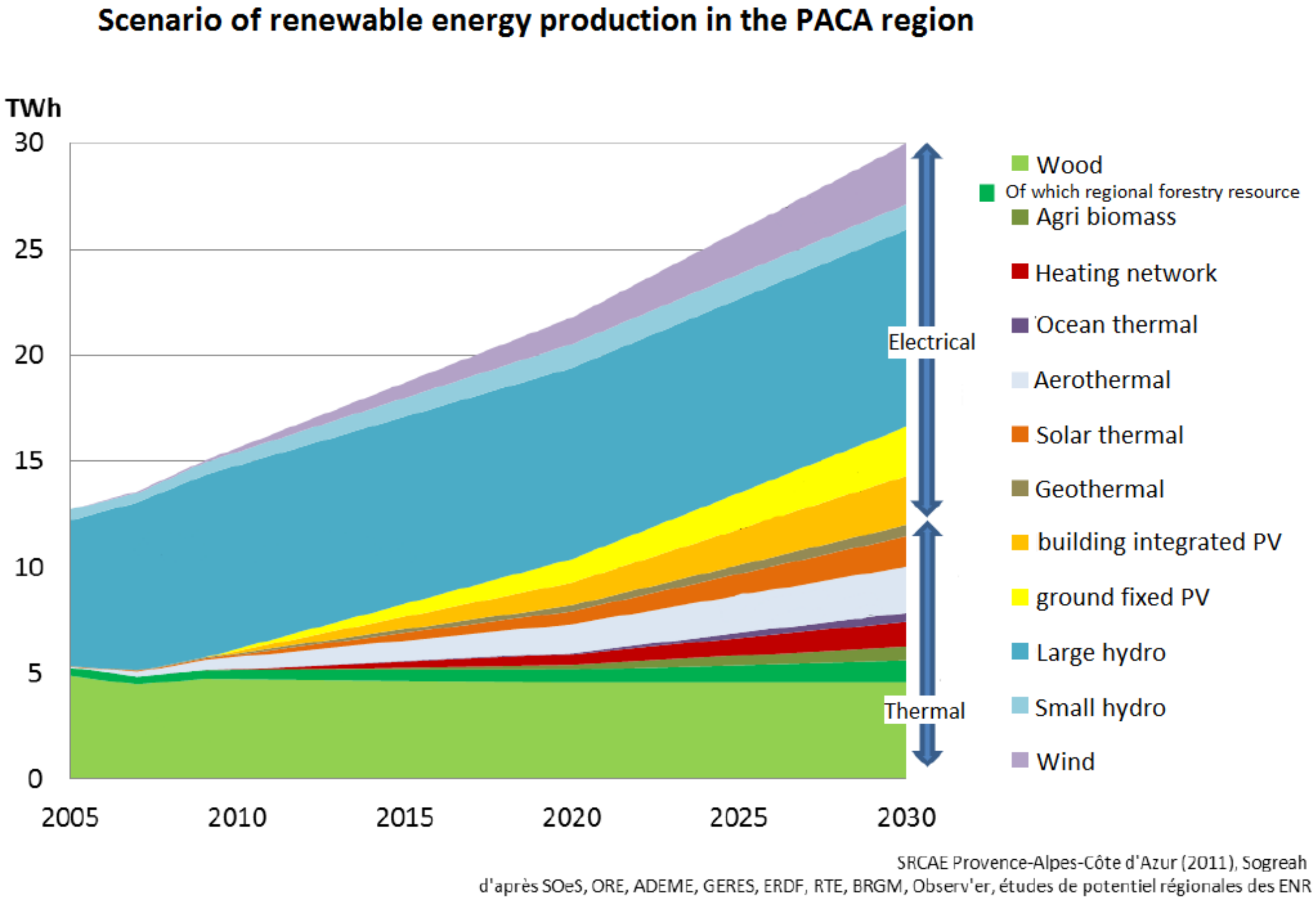
Development potential of renewable energy sources

The scenario built for the evolution of the renewable energy production in the PACA region gives an **objective of total renewable energy production of 22 TWh by 2020 and 30 TWh by 2030**.

With an annual production of about 17 TWh in 2010, this scenario gives an increase of 3% a year over the period.

The specific objectives of the PACA region regarding installed power by 2020 and 2030 per renewable energy segment are depicted hereafter.

Figure 22 : PACA regional scenario for the development of renewable energy sources, in TWh/yr



The energy sources for which the expected growth is the most important in absolute value are, in decreasing order, photovoltaic, wind, then aerothermal, solar thermal and heat recovery from waste water networks.

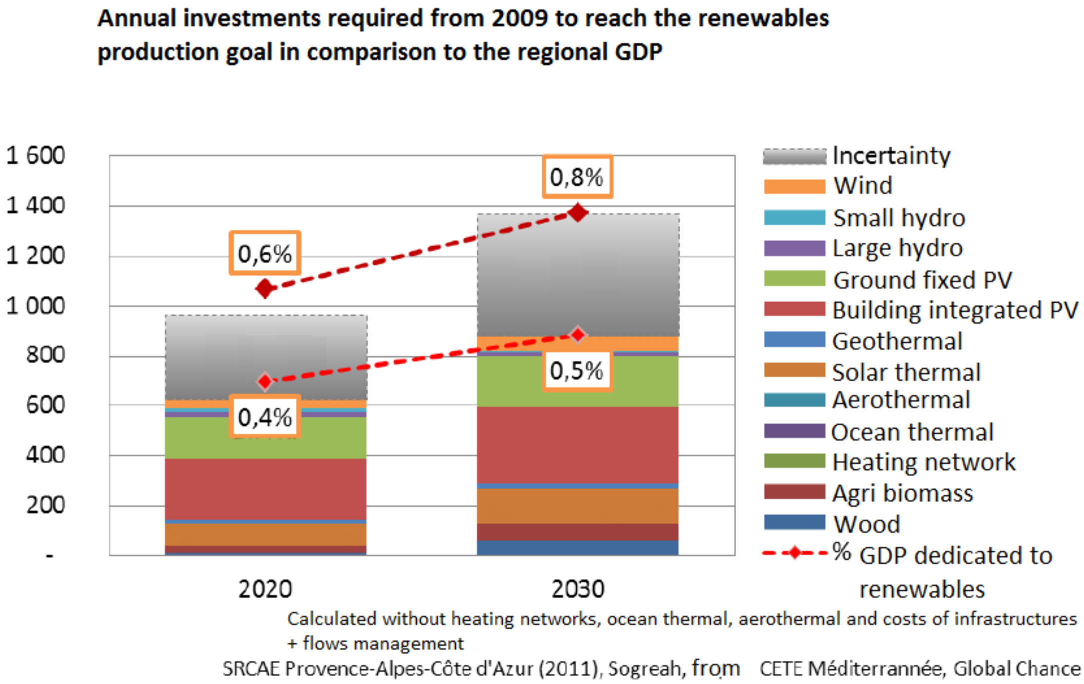
Expressed in growth rate compared to the rates of 2010, the emphasis is put on, in decreasing order, photovoltaic, heat recovery, ocean thermal, wind and solar thermal energies.

Table 10 : PACA regional scenario for the development of renewable energy sources, in installed MW power

Power	[MW]	2020	2030
Thermal energy	Wood	2 600	2 800
	Agri biomass	110	330
	Heating network	110	270
	Ocean thermal	17	115
	Aerothermal	1 400	2 200
	Solar thermal	1 200	2 800
	Geothermal	200	400
Electrical energy	Building integrated PV	900	1 900
	Ground fixed PV	920	1 900
	Large hydro	3 000	3 100
	Small hydro	250	270
	Wind	545	1 245

To accomplish the above scenario, it could be necessary to allocate each year till 2020 about 0,5% of the regional GDP to the development of renewable energies, i.e. up to 1 Bn€/yr, then about 0,8% of the regional GDP in the period extending from 2020 to 2030, i.e. 1,4 Bn€/yr.

Figure 23 : Annual investment required from 2009 to reach the renewables production goal in comparison to the regional GDP, in M€



The coverage rate of energy needs by renewable energy sources is defined as the ratio between the energy demand and the useful energy produced from renewable sources. This coverage rate is calculated per energy transport vector: electricity, heat and fuels. An analysis of the energy demand scenarios per type and nature of usage – base, semi-base, peak; electricity, heat, fuel – allows highlighting the coverage rates per demand type.

Regarding the electricity usages, the coverage rate by renewables reaches around 30% by 2030, of which more than a half dedicated to base demand, the fastest growing demand type.

In order to ensure the distribution electricity network stability, such a share of fatal and intermittent energy production pushes towards the development of advanced management systems – selective power cuts, smart grids – and of storage capacities sized at the right scale (e.g. hydrogen coupled to fuel cells).

Regarding the thermal usages, the coverage rate by renewables reaches more than 20% of the demand by 2030, of which the main share is of semi-base type.

Without strong measures to lower the thermal energy consumption, many production facilities calculated to supply peak loads may be oversized and would lead to exaggerated costs. Hence, some could be tempted to implement auxiliary power fueled by conventional fossil sources to supply peak loads.

Figure 24 : Coverage rate of electricity needs by renewables per demand type

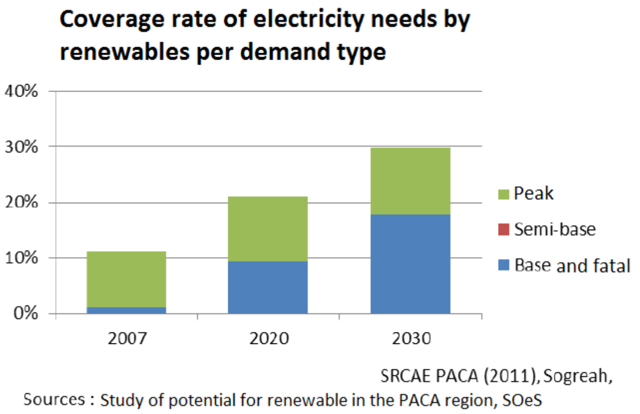
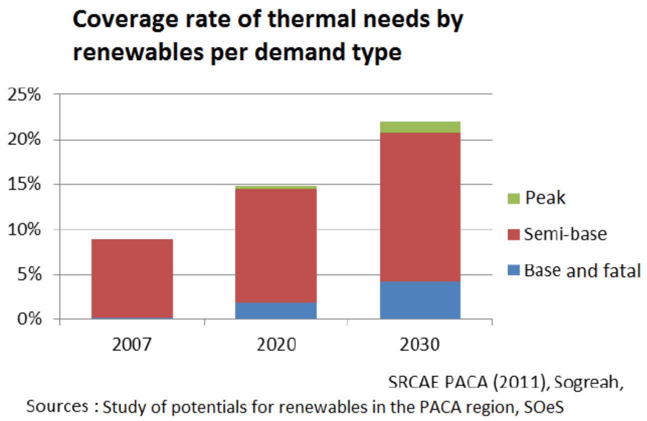


Figure 25 : Coverage rate of thermal needs by renewables per demand type



Although the penetration of renewable energies in the regional mix shows a great potential, the core objectives of the regional roadmap concentrate on energy efficiency, with the following targets :

- **25% of energy savings by 2030** compared to 2007, and **13% by 2020**;
- **36% decrease of non-renewable energy consumption by 2030** compared to 2007, and **23% decrease by 2020**.

Many hurdles still prevent a dynamic renovation of the building stock:

- **Financing problems**: given the high cost of a renovation, additional financial levers should be set, in order to reach the long term goals.
- **Structural hurdles**: for some building categories – especially collective housings and private rentals – the arguments to sensitize the owners are hard to find.

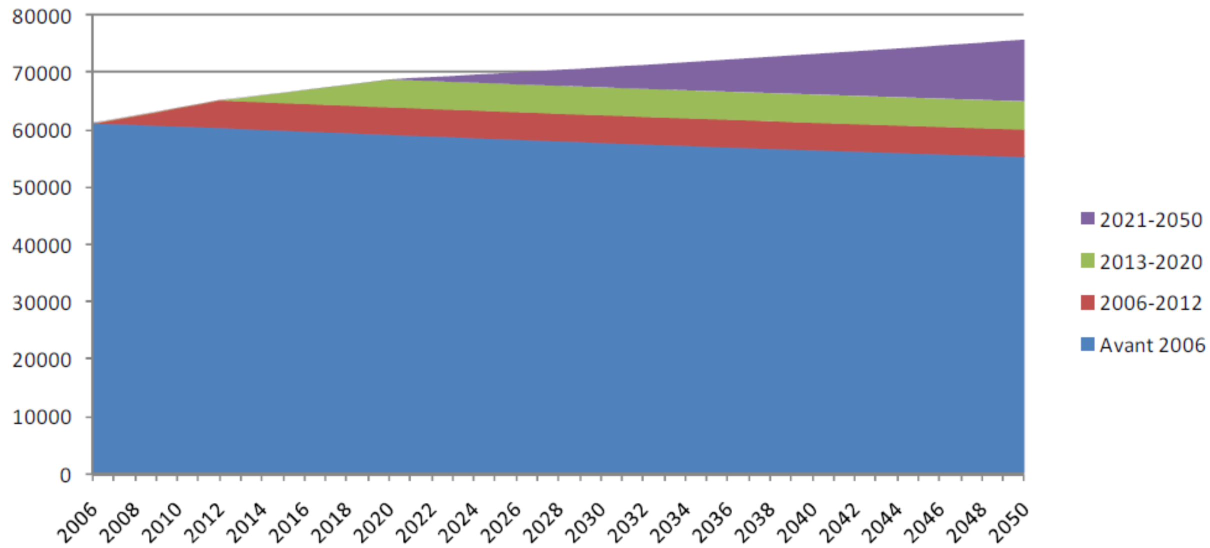
- **Quality concerns**: building and energy value chains must cope together with the development of the required competences to ensure the qualitative implementation of the renovation programmes.
- **Cultural barriers**: The PACA region, like any other Mediterranean area, benefit from mild climate conditions, which prevents people from prioritizing the building renovation. Moreover, wealthy inhabitants, who are numerous on the Côte d'Azur and who hold an investment capacity, do not really care about the energy bill.

The future evolution of the tertiary building stock is based on the foreseen increase of the population and on the rate of destroys and new constructions per activity branch

The tertiary building stock would reach 69 million m² in 2020 (+12%) and 75,8 million m² in 2050 (+24%). Existing buildings in 2007 will still represent **86% of the surface in 2020 and 73% in 2050.**

The roadmap of the French thermal regulation applicable to buildings foresees that any new building shall be balanced positive in energy: it will produce more energy than it will consume.

Figure 26 : Foreseen evolution of the tertiary building stock, in thousands m²



The potential energy savings from the existing tertiary building stock have been estimated according to different renovation levels :

Renovation deepness of the tertiary building stock
Light on structure: Regulatory level “RT item by item”, without technical system change
Light on systems: Substitution of all the technical systems by efficient technologies, without structure renovation
Intermediary: Regulatory level “RT global” (reduction of consumptions by 30%) for the whole building stock
Deep: Regulatory level “BBC” (low consumption building) including the substitution of all the systems by more efficient ones

Table 11 : Proposed levels of renovation deepness for the existing tertiary building stock

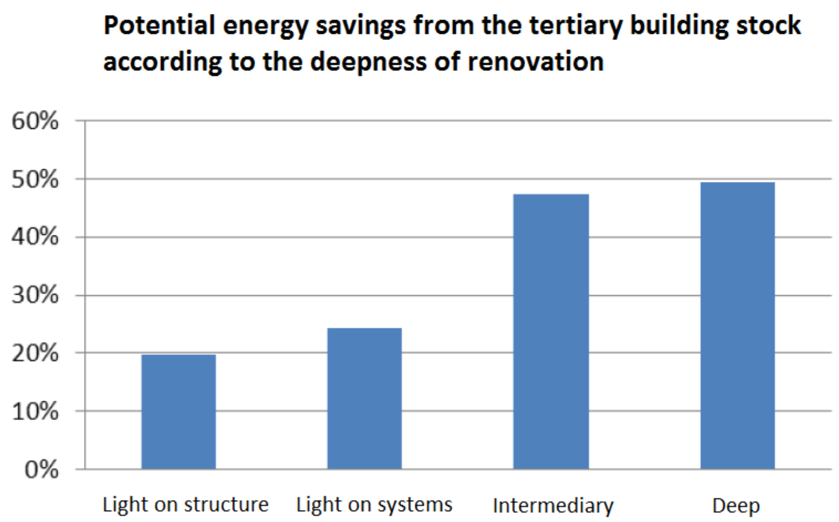


Figure 27 : Foreseen evolution of the tertiary building stock, in thousands m²
Source: Sogreah according to Energies Demain

The implementation of deep renovation works to the whole tertiary building stock allows reaching a ceiling of energy savings of 49%.

Bunches of renovation works are applied according to different building profiles. The levers are modeled separately and cannot always be added (especially when dealing both with structure and technical systems).

An estimation of the energy saving potential by the year 2020 and 2050 is given hereafter, which takes into account the complementarities between energy source substitutions and actions on auxiliaries consumption and on behavior changes that can realistically be expected by then.

Energy saving potential per usage from the 2007 tertiary building stock	2020	2050
Space heating	50%	75%
Space cooling	26%	31%
Sanitary hot water	32%	60%
Auxiliaries electricity	35%	41%
Cooking	0%	5%
Public lighting	20%	50%

Table 12 : Estimated energy saving potentials from a deep renovation of the 2007 tertiary building stock

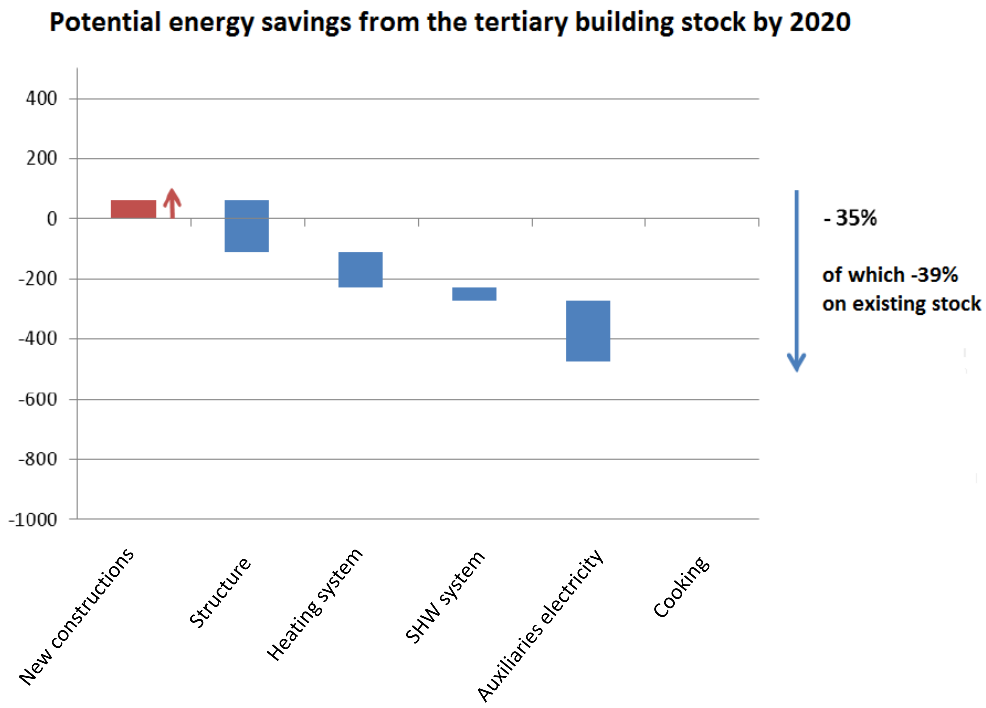


Figure 28 : Potential energy savings from the tertiary building stock by 2020, in ktoe
Source: Sogreah according to Energies Demain

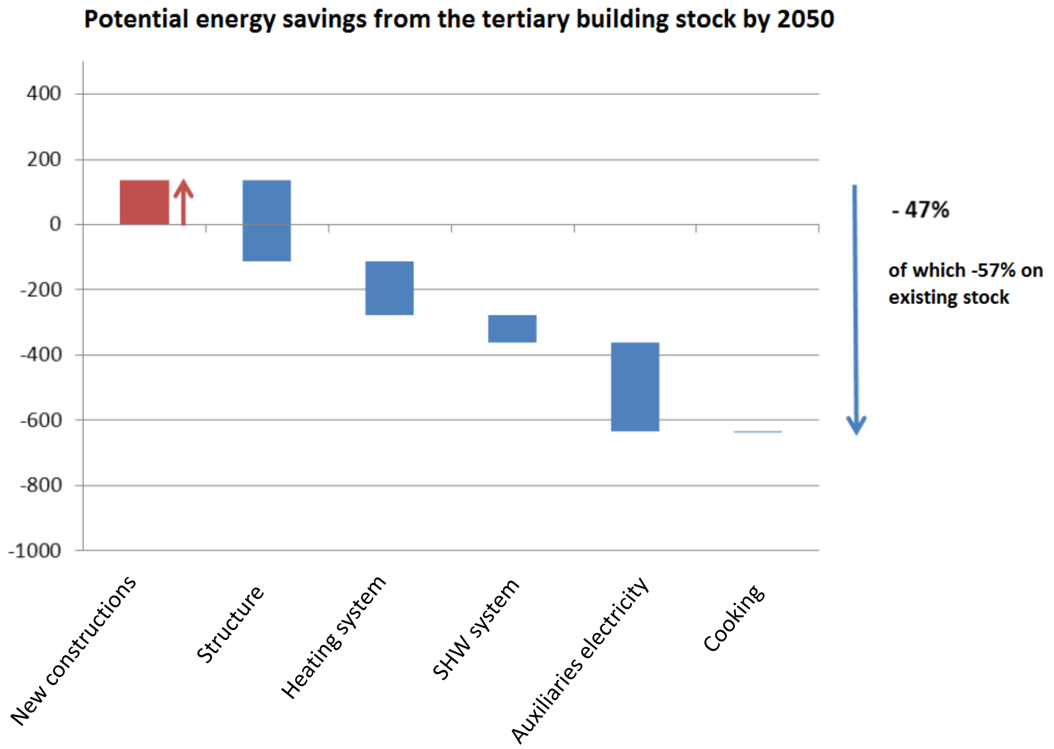


Figure 29 : Potential energy savings from the tertiary building stock by 2050, in ktoe
Source: Sogreah according to Energies Demain

It looks important to pinpoint that these saving potentials take into account an evolution of the consumption behaviors and an improved maintenance of the systems. Thus, **the improvement of behaviors and maintenance usages can lead to savings from 10 to 15%**.

Renovating deeply the whole tertiary building stock by 2050 requires a **renovation pace of 1,5 million m² per year and a cumulated investment of 17 to 27 billion €** (280 to 440 €/m² at current costs).

Costs and payback depending on renovation deepness	Total cost (M€)		Cost of avoided kWh over 30 years	
	Min	Max	Min	Max
Light on structure	4201	5412	5,2	6,7
Light on systems	8606	11079	8,7	11,0
Intermediary	16933	21481	8,7	11,0
Deep	21046	26572	10,3	13,2

Table 13 : Estimated costs and payback depending on the renovation deepness of the 2007 tertiary building stock

Energy saving potentials would lead to GHG emission cuts of a maximum factor of 2,53.

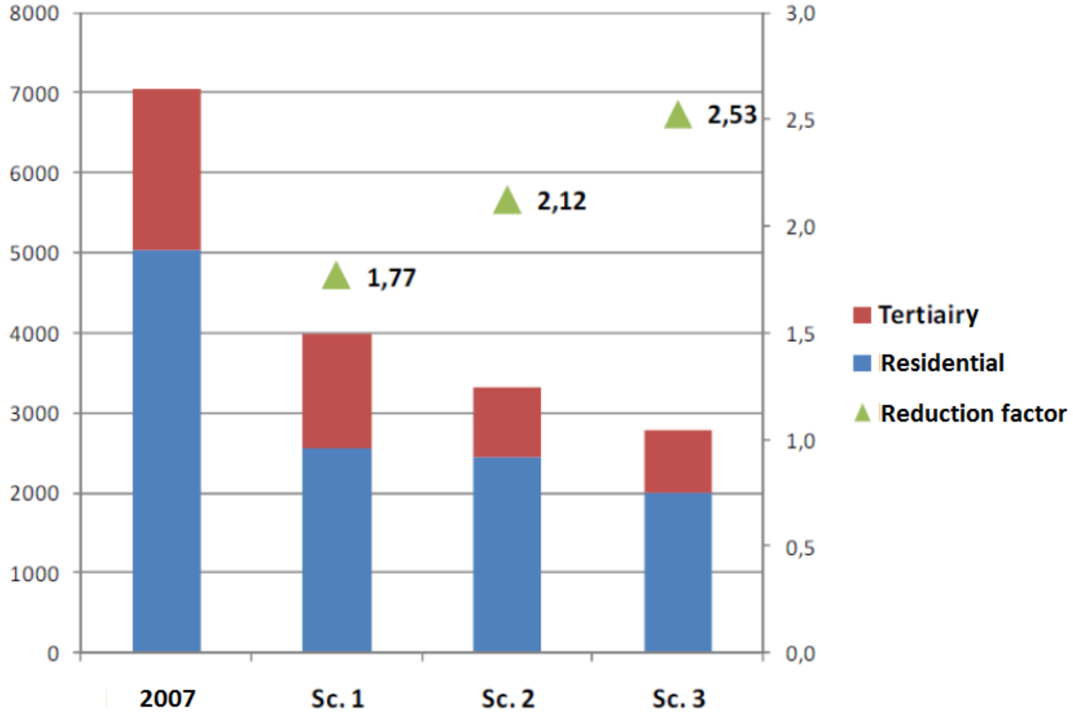


Figure 30 : GHG emission cuts depending on renovation deepness of the whole building stock, in ktCO$_2$eq

In order to maximize the probability of achieving the most ambitious target, the following three endeavors have been identified:

- Improvement of heat production and distribution systems together with the substitution of GHG emitting technologies by renewable energy sources
- Behavior change, in view of mitigating the risk of continuous increase of the energy demand, especially with regards to the auxiliaries electricity consumption and air conditioning (e.g. 28°C instead of 24°C set point). The introduction of smart meters together with the deployment of smart grids may leverage the customer motivation.
- Regulatory softening in order to enable massive renovation with external insulation layers.

Synthesis of renovation scenarios for the tertiary building stock in PACA

Lever	Tendency scenario	Engaging scenario
New construction	Thermal standard "RT 2012" till 2020, then progressively binding regulation till 2050 Space cooling tolerated according to the thermal standard	No more cooling need High efficiency water heating and lighting Positive energy standard "BEPOS" from 2020
Technical Systems	Space heating: oil disappears, substitution by gas (48%), electricity (40%) and biomass (10%) SHW: substitution by heat pump, solar or heater source Cooling only upon high occupants density Lighting: LED and OLED lamps Auxiliaries electricity: high efficiency cold stores and electronic equipment Renewal of systems every 20 years	
Existing structures	Renovation of 0,5% of the surface per year (± 300.000 m²/yr), with more binding quality targets from 2020	Renovation of 3% of the surface per year in the private sector and 5 to 7% in the public sector (± 1,5 Mm²/yr), with more binding quality targets from 2020

Table 14 : Renovation scenarios for the tertiary buildings in the PACA region

Tertiary	2020		2030		2050	
Gains per usage	Existing	Total	Existing	Total	Existing	Total
Engaging scenario	**-24%**	**-20%**	**-37%**	**-31%**	**-53%**	**-43%**
Others	-24%	-18%	-35%	-25%	-41%	-26%
Heating	-29%	-27%	-47%	-43%	-73%	-69%
Cooling	-19%	-19%	-27%	-27%	-31%	-31%
Cooking	0%	14%	-1%	18%	-3%	27%
SHW	-22%	-16%	-35%	-27%	-57%	-44%
Public lighting	-15%	-15%	-24%	-24%	-40%	-40%

Table 15 : Potential energy savings according to the engaging scenario of the prospective study

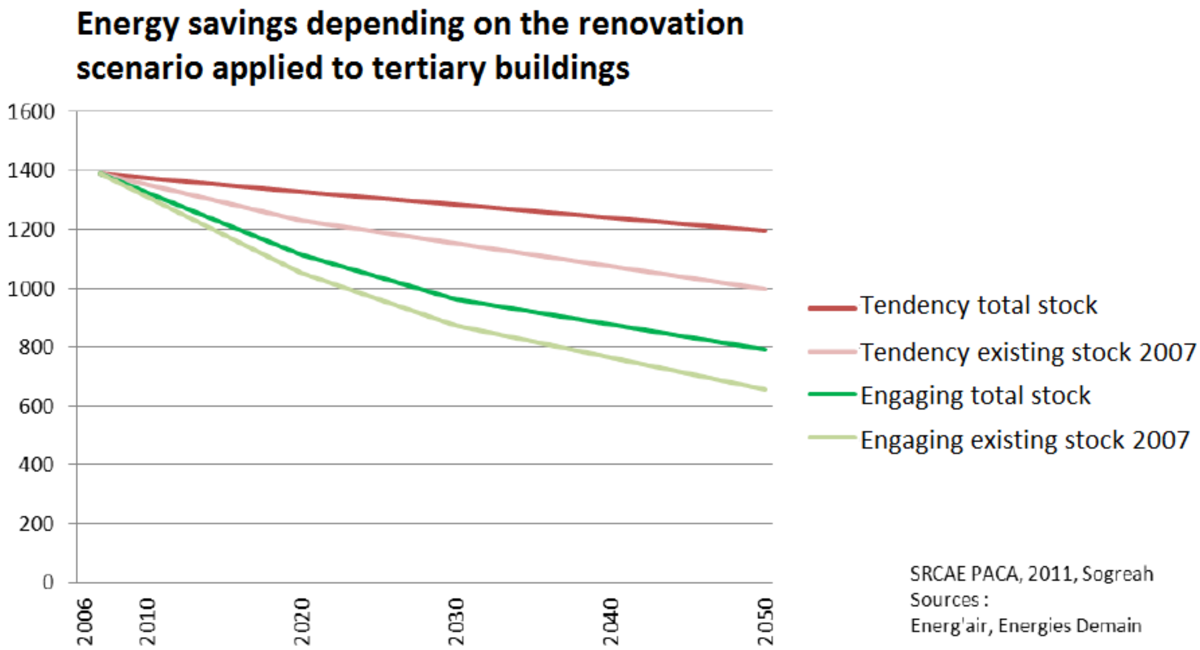


Figure 31 : Potential energy savings according to the engaging scenario of the prospective study, in ktoe

It is pinpointed that a significant consumption reduction is applied to public lighting (usually accounted in the tertiary segment), which can account for 18% of the energy bill of a city.

Unlike the residential segment, the use of space cooling in the tertiary sector is minimized in the engaging scenario, which supposes a tremendous effort to decrease the demand in existing buildings and the bioclimatic design for summer comfort of new buildings.

Finally, gains per usage incorporate significant behavior changes towards energy efficiency (heating/cooling set points, equipment choice, maintenance regularity, …), without which the long term objectives cannot be reached.

4 Pilot plants preparation

4.1 Key building data

Company name	Lycée Paul Héraud
Address (location)	25 Rue de Bonne, 05000 GAP
Type of service	Education building
Altitude	885 m above sea
Number of employees / daily users	350 pupils + 90 adults

Shortly describe the current status of building and occupancy level	The site is made of 6 main buildings: Building A (1965) : - Ground floor : Administration, class rooms, boarding school, kitchens - G+1 : class rooms, science rooms, boarding school - G+2 : Salles de classes, infirmerie, logement infirmière, chambre internat - G+3 : class rooms, science rooms, boarding school Building Ab (1965) : - Ground floor : Canteen - G-1 : Documentation center - G-2 : Technical room, Locker room, gymnasium Building B (1965) : - Ground floor: Professors' room, class rooms - G+1 : class rooms - G+2 : class rooms Building C (1992): - Ground floor: Technology workshops - G+1 : Technology class rooms Building D (not audited) : - Ground floor: Reception, 1 house Building G : - Ground floor: Workshop
Average heating/cooling degree day of a location	2630 Basic winter temperature : -13°C

<table>
<tr><td>Technical state of building</td><td>Buildings A, Ab and B
<table>
<tr><th>Component</th><th>Description</th><th>Surface [m²]</th><th>U [W/(m².K)]</th></tr>
<tr><td>Floor</td><td>Concrete slab on the ground</td><td>2419</td><td>3.77</td></tr>
<tr><td>Floor</td><td>Floor on non-insulated buffer volume</td><td>2148</td><td>2.30</td></tr>
<tr><td>Roof</td><td>Insulating pavement on restaurant roof</td><td>132</td><td>0.67</td></tr>
<tr><td>Roof</td><td>Insulating pavement on kitchen roof non-insulated</td><td>262</td><td>1.43</td></tr>
<tr><td>Roof</td><td>Terrasse roof A & B with polystyren insulation</td><td>1754</td><td>0.37</td></tr>
<tr><td>Roof</td><td>Terrasse roof Doc center with polystyren insulat°</td><td>277</td><td>0.67</td></tr>
<tr><td>Wall</td><td>non-insulated concrete wall</td><td>1615</td><td>1.59</td></tr>
<tr><td>Wall</td><td>Outer insulated concrete wall</td><td>158</td><td>0.35</td></tr>
<tr><td>Windows</td><td>DGlazed aluminum 4/12/4 without sun protection</td><td>1411</td><td>2.30</td></tr>
<tr><td>Windows</td><td>DGlazed Wood 4/12/4 without sun protection</td><td>16</td><td>2.90</td></tr>
</table>
Building C
<table>
<tr><th>Component</th><th>Description</th><th>Surface [m²]</th><th>U [W/(m².K)]</th></tr>
<tr><td>Wall</td><td>Workshop: sandwich panels</td><td>779</td><td>0.70</td></tr>
<tr><td>Floor</td><td>Concrete slab on the ground</td><td>2129</td><td>3.77</td></tr>
<tr><td>Roof</td><td>Workshop steel sheets</td><td>1503</td><td>0.67</td></tr>
<tr><td>Roof</td><td>Workshop steel sheets</td><td>60</td><td>0.72</td></tr>
<tr><td>Roof</td><td>Insulated sloped roofing in class rooms</td><td>294</td><td>0.37</td></tr>
<tr><td>Wall</td><td>Non-insulated concrete wall</td><td>40</td><td>1.59</td></tr>
<tr><td>Opening</td><td>Workshop door</td><td>125</td><td>2.50</td></tr>
<tr><td>Opening</td><td>DGlazed alu 4/12/4 without sun protect°</td><td>129</td><td>2.30</td></tr>
<tr><td>Opening</td><td>skydome polycarbonate</td><td>155</td><td>2.80</td></tr>
</table></td></tr>
<tr><td>Total floor area [m²]</td><td>A+Ab+B: 4567 m²</td></tr>
<tr><td>Heated floor area [m²]</td><td>A+Ab+B: 4567 m²</td></tr>
<tr><td>Cooled floor area [m²]</td><td>A+Ab+B: 0 m²</td></tr>
</table>

4.2 Energy consumption and costs for the years 2009 – 2011

<table>
<tr><td rowspan="3">Average energy consumption within the last three years [MWh/year]</td><td>2010: 1964 MWh</td></tr>
<tr><td>2009: 1785 MWh</td></tr>
<tr><td>2008: 2063 MWh</td></tr>
<tr><td>Types of consumed energy sources</td><td>Liquid fuel, Natural Gas, Electricity</td></tr>
<tr><td>Break down of energy consumption by energy source [MWh/year, €/year]</td><td>Liquid fuel: 1574 MWh/yr – 79.000 €/yr (2010)
Natural Gas: 49 MWh/yr – 2.200 €/yr (2010)
Electricity: 340 MWh/yr – 23.000 €/yr (2010)</td></tr>
<tr><td>CO_2 emission production break down by type of fuel consumed [tons of CO_2/year]</td><td>Liquid fuel:
Natural Gas:
Electricity:</td></tr>
<tr><td rowspan="2">Break down (assumption) of energy consumption by consumption area [%]</td><td>Heating : 70%</td></tr>
<tr><td>Cooling (VAC): 0%</td></tr>
</table>

(if available according to measurements)	Hot water: 10%	
	Lighting: 9%	
	Other (specify): 6% kitchen + 2,5% auxiliaries + 2,5% others (computers, copier, etc.)	
Does systematic evidence of energy consumption exist (is there an energy management system implemented)?	Energy consumption is monitored and subject to a monthly bill check. A supervision system dedicated to the heating system exist and allows monitoring and controlling the distribution per area to some extent. Yet, sub-counters would be necessary to get a more precise idea of the real sources of important consumption levels.	
Is there any company energy policy/strategy?	Yes.	
How does the company plan the energy efficiency measures?	The region implements the P3E programme aiming at auditing the 180 regional secondary schools in view of setting up renovation programmes. The Lycée Paul Héraud has been selected as the EMILIE pilot site because an exemplary renovation programme is anticipated for the year 2015 (after the EMILIE experiment)	

4.3 Analysis of technical equipment

Shortly describe the status of technical equipment in building	(type of heating and hot water system, VAC and internal lighting, type of regulation and measurement of building technologies etc.) The central heating system which provides space heating for all the buildings, except G, and sanitary hot water is made of 3 boilers fuelled with liquid fuel. Only the kitchen and building D, which is not audited, consume natural gas. This heating system is supervised and controlled from a computer in a dedicated room (Trend supervision). The distribution network includes several independent loops to distribute zones of various usages. Building G is heated through an electrical heating floor fed by a 1 kw electrical heater located in the heated office (surface 150 m²). Ventilation units vary from a building to the other: Mainly natural ventilation is observed in buildings A to B, except in the boarding school and toilets where clean single flow mechanical extraction are found. Building C: - Aerotherms in workshops, fed with 80% recycled air - Single flow mechanical ventilation in class rooms

<table>
<tr><td>Heating</td><td>
(type of heating - e.g. district/local heating/other, size (heating boiler output in MW) and type of boilers (hot water boiler, steam boiler, condensing boiler…), in-service date of boilers, type of fuel e.g. natural gas, electricity, coal, wood etc., type of heat distribution system and heating bodies)
2 boilers brand SECCACIER, Power 780 kW from year 1990 and 1163 kW from year 1989
1 boiler brand GUILLOT, power 1628 kW, age not accessible but old
2 burners brand WEISHAUPT, from year 1991
1 burner brand CUENOD, from year 2004
Emitters are iron radiators in Buildings A, Ab, B and air blowers in workshops. Gymnasium is not heated.
Controller tuning :
<table>
<tr><th>Zone</th><th>Comfort temp.</th><th>Comfort time frame</th><th>Reduced temp.</th></tr>
<tr><td>Boarding school</td><td>20°C</td><td>17:00 to 22:00 and 2:00 to 7:00</td><td>17°C</td></tr>
<tr><td>Building A</td><td>20°C</td><td>5:30 to 17:00</td><td>15°C</td></tr>
<tr><td>Housings</td><td>21°C</td><td>4:00 to 22:30</td><td>16°C</td></tr>
<tr><td>Administration</td><td>21°C</td><td>8:00 to 18:00</td><td>16°C</td></tr>
<tr><td>Canteen</td><td>20°C</td><td>4:00 to 13:00 and 18:00 to 20:00</td><td>15°C</td></tr>
<tr><td>Workshop zone A</td><td>20°C</td><td>6:00 to 16:00</td><td>15°C</td></tr>
<tr><td>Workshop zone B</td><td>17°C</td><td>6:00 to 16:00</td><td>14°C</td></tr>
</table>
</td></tr>
<tr><td>VAC</td><td>
(type of ventilation system – central/local, does a heat-recuperation exist, type of air-conditioning system – central/individual units, in-service date of the system, installed power)
Buildings A, Ab and B: Natural ventilation, except in wet rooms where self-tuning mechanical ventilation units are observed. Openings for fresh air entrance are located on the windows.
In Building C, ventilation is ensured by a similar system as above in the class rooms, whereas the aerotherm ensures the workshop ventilation by introducing 20% of fresh air (80% being recycled air).
Air conditioning is found only in the server room and the rubbish room close to the kitchen.
</td></tr>
</table>

Hot water	(type of hot water system preparation – local/central, type of fuel – electricity/natural gas/others, installed power, in-service date of the system) Sanitary Hot Water is distributed through 2 plate heat exchangers. A 1000 L accumulation tank, insulated with 5 cm rockwool covers the kitchen needs. A second 1000 L accumulation tanks having similar insulation covers the needs of the boarding school and of the other buildings. SHW needs are estimated as follows: - Administration: 50 l/day - Boarding school: 30 l/day x 140 pupils - Teaching zone: 200 l/day - Canteen: 10 l/day x 60.000 meals/yr - Workshops: 150 l/day per workshop - Housings: 130 l/day per dwelling 36 weeks of activity are considered, having 5 working days, and full time occupation for dwellings. SHW delivery yield is estimated to 47,56%
Indoor lighting	(age, technical state, type of lamps and lighting sources, installed power, type of ballast – electronical/classic, lighting regulation – e.g. local switching, sectional switching, photo cells, dimming, in-service date of the system etc.) Most of the light in all buildings are powered with T8-type fluorescent tubes. A few lights in the main Hall are equipped with low-consumption lamps. Some corridors are equipped with IR detection switches. 500 lux were measured in class rooms and 100 to 200 lux measured in corridors, which is fine.

Other electrical equipment	(Shortly describe other el. equipment used in the operation – e .g. computers, printers, scanners etc.).
	Other electrical loads include:
	Buildings A, Ab and B:
	- about 250 computers rated 150 W in average
	- kitchen (refurbished in 2003):
	  o 4 cold rooms positive temp.
	  o 1 cold room at 10°C
	  o 1 freezing room at negative temp
	  o About 20 small appliances
	Building C:
	- About 50 computers rated 150 W in average
	- Workshop equipment totalling about 30 kW

4.4 Potential improvements

Need of refurbishment	(Describe main points where EE improvement would be needed, e.g. need of windows replacement, thermal insulation of buildings, installation of recuperation, not appropriate maintenance and service etc.) First of all, many surfaces need to be insulated according to the latest standards to remove bad comfort sensations. The overall heating system should be changed, starting with the change of old fuel heaters for higher efficiency boilers or renewable energy and finishing with the introduction of thermostatic valves on radiators. The hot water storage and distribution is not optimized (too many losses). Building C heating and ventialting system needs to be deeply rethought.

<table>
<tr>
<td>Potential measures which could be applied</td>
<td>
(Describe what type EE and RES measures can be applied in future – e.g. using solar collectors, using of wood pellets for heating, EE measures like regulation of heating, replacement of boilers by new modern boilers, heat recuperation, using of excess heat, renovation of VAC system, replacement of lamps, regulation of lighting and other measures connected to building and technical equipment of building.)
(Make a link to a proposed pilot project.)
<table>
<tr><th>Action</th><th>Potential savings (kWh/yr)</th><th>Potential GHG savings (kgCO2/yr)</th></tr>
<tr><td>NG boilers</td><td>214 578</td><td>156 108</td></tr>
<tr><td>SHW improvement</td><td>- 53 584</td><td>15 486</td></tr>
<tr><td>Thermostatic valves</td><td>401 129</td><td>127 371</td></tr>
<tr><td>Floors insulation</td><td>229 246</td><td>70 682</td></tr>
<tr><td>Roof insulation</td><td>67 299</td><td>19 555</td></tr>
<tr><td>Terrasses insulation</td><td>29 452</td><td>8 063</td></tr>
<tr><td>Double flow ventilation</td><td>87 474</td><td>34 289</td></tr>
<tr><td>Lighting optimization</td><td>282 373</td><td>6 723</td></tr>
<tr><td>Workshops insulation</td><td>61 636</td><td>17 725</td></tr>
<tr><td>Outer insulation of concrete walls</td><td>191 994</td><td>59 570</td></tr>
<tr><td>Biomass boilers</td><td>- 711 689</td><td>393 764</td></tr>
<tr><td>Solar water heaters</td><td>61 962</td><td>45 169</td></tr>
<tr><td>Solar heating&cooling</td><td colspan="2">Difficult to estimate</td></tr>
<tr><td>Behaviour inflexion</td><td>144 410</td><td>105 272</td></tr>
</table>
</td>
</tr>
</table>

Potential investments in EE/RES

State low cost investments (organizational and educational measures), medium cost investments (e.g. heat exchange, installation of regulation and measurement systems, renovation of lighting system, and etc.), high cost investments (e.g. thermal insulation of buildings, replacement of windows, installation of solar-thermal collectors, installation of the PV system, replacement of the heating/cooling/ventilation system etc.)

Action	Modification cost (€)	Charges (€/yr)	payback (years)	Actual cost over 35 years* (€)
NG boilers	289 000	- 34 067	12	- 813 734
SHW improvement	15 000	209	> 35	14 849
Thermostatic valves	15 000	- 24 665	1	- 664 713
Floors insulation	150 500	- 14 934	15	- 213 926
Roof insulation	211 400	- 4 384	>35	151 215
Terrasses insulation	202 100	- 2 052	>35	202 831
Double flow ventilation	282 340	16 047	>35	621 299
Lighting optimization	308 270	18 481	>35	698 570
Workshops insulation	858 270	- 4 014	>35	989 330
Outer insulation of concrete walls	823 275	- 12 506	>35	713 364
Biomass boilers	602 000	- 14 280	34	- 78 598
Solar water heaters	36 900	2 100	14	- 24 450
Solar heating&cooling	Difficult to estimate			
Behaviour inflexion	65 000	500	7	- 161 489

* Calculated over a 35 years period using the following rates : actualization rate : 4%, inflation of energy prices : Electricity : 2,2%, Gas : 1,5%, Fuel : 2,4%, Wood : 0,5%