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D3.6 Final technical monitoring Report:

Monitoring results of all the local projects and consolidated results

CONCERTO INITIATIVE
cRRescendo

Combined Rational and Renewable Energy Strategies in Cities, for Existing and New Dwellings and Optimal quality of life

Instrument: Integrated Project
Thematic Priority: Integrating and Strengthening the European Research Area (2002-2006), Sustainable Energy Systems

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1. Publishable Executive Summary

Conclusions on the performance

In this report, first monitoring results have been presented of all cRRescendo communities: Ajaccio, Almere, Milton Keynes and Viladecans. The nature of the work done and buildings built varies quite a lot in each of the communities. In addition, the extent to which monitoring results were available to get a good picture of the performance of the cRRescendo funded buildings and plants as a whole also varies considerably. Below summaries per community are given, followed by general remarks for the whole cRRescendo project.

In **Ajaccio** mostly refurbishment of apartment buildings, in total some 420 apartments, has taken place. The new apartment building in the historic city center (BEST table 1, 8 apartments) is finished but not monitored yet. The new public service office building (BEST table 4) is not built yet and therefore not monitored. Monitoring results of refurbished apartment building are too limited to draw any conclusions at this time. With one year monitoring more can be said about this category, about the newly built apartment building and about the 350 m^2 of solar collectors that have been installed on various buildings. For the new public service office building still no data will be available by the end of the project. All cRRescendo buildings and installations are expected to save 20% (2.5 GWh_{prim}) in primary energy compared to business as usual when all buildings have been built.

In **Almere** some 1800 single family dwellings and 300 apartments have been built within cRRescendo. Homes have been built in three efficiency categories: eco, solar and 'passive'. Monitoring results show that overall the performance of the homes is well in line with the expectations. For Eco Houses the heat consumption tends to be even lower than specified, because they were brought up to the same insulation level as the Solar Houses. In addition, the Solar Island has been built, producing enough heat for the tap water needs for some 1000 households. The Solar Island is performing somewhat less than expected, but some checks in the monitoring system still need to be done to confirm this. Monitoring of 37 kWp of photovoltaics and 9 non residential buildings is still to come.
Based on the monitoring results collected thus far, the Almere cRRescendo project has saved 30% (14 GWh_{prim}) of primary energy compared to a business as usual situation. The floor area of the homes ended up larger than originally anticipated. This happened especially in NPW and to the largest extent in the areas where private commissioners built their houses. Such effects could cause the total energy demand for homes to keep rising, despite a substantial increase in efficiency.
According to the original specifications 19% (9 GWh_{prim}) would have been saved.

In **Milton Keynes** a new apartment building with 441 apartments and a new commercial building have been built. In addition, a 3 MWe combined heat and power generation plant is now in operation. The apartments perform in line with Concerto specifications, but the commercial buildings consume substantially more electricity as well as heat. The CHP is performing at a lower efficiency level than foreseen due to larger periods of partial load operation than foreseen. Nonetheless, based on the monitoring results to date, 30% primary energy (5.8 GWh_{prim}) has been saved in the project compared to business as usual. This includes the PV-system on the bus station that is due to be built in the fall of 2011. It should be noted that savings calculations are based on savings in heat and electricity consumed in the cRRescendo buildings. For the

CHP alone without the buildings, using the same primary energy factors, savings would amount to 9.2 GWh_{prim} (16% savings with respect to business as usual).

In **Viladecans** two public service buildings have been newly built and two buildings have been refurbished. One municipal technical service building is still to be built. Preliminary results of monitoring of the four buildings show mixed performances, varying from 5% increase in primary energy consumption of day care centre la Pineda (BEST table A) to 25% reduction for refurbished Cultural Center Pablo Picasso (BEST table E). Some problems were encountered with the monitoring of the sports facilities Torre Roja (BEST table D). The PV-system (117 of the 342 kWp) performs according to expectations.
Based on the monitoring results to date, 77% primary energy (0.5 GWh_{prim}) has been saved in the project. These large savings are primarily due to the 117 kWp PV-system. According to the original specifications, including the to be built municipal building and including all 342 kWp PV, 79% (0.8GWh_{prim}) would have been saved.

These summaries clearly show the diversity in the community projects as well as the monitoring results:
For Ajaccio, projected primary energy savings compared to business as usual are significant, based on efficiency measures as well as renewable energy, both heat and electricity.
For Almere, project primary energy savings are substantial both in % as in GWh_{prim}, primary achieved by increasing efficiency in buildings but also a significant portion in renewable heat.
For Milton Keynes savings are considerable both in % as in GWh_{prim}, to a modest extent by increasing efficiency in buildings and to a large extent by efficient generation of heat and electricity by the CHP.
For Viladecans, the percentage of primary energy savings is huge in % and modest in GWh_{prim}, primarily achieved by renewable electricity and to a modest extent by efficiency measures.

It is interesting to note that electricity is becoming the largest consumer of primary energy in buildings. For the services sector this was already the case in the reference situation, but with efficient buildings this is now also the case for residential buildings, even in northern climates like the Netherlands and the UK.
The most efficient homes built are the 'passive' homes in Almere, with a total final energy consumption of about 70 kWh/m^2. The most efficient non-residential building is refurbished Cultural Center Can Amat in Viladecans, with (based on preliminary data) a total final energy consumption of more than 90 kWh/m^2.
For three out of five non residential buildings monitored consumption turned out to be significantly larger than expected. Even though discrepancies could be caused by something as basic as operational hours, it clearly shows the need to monitor, understand and manage the consumption in non-residential buildings.

Conclusions on the monitoring

Over the course of this project, a number of lessons learned can be drawn from the monitoring process and results.
Concerning the process:

- As cRRescendo had no other choice than to follow the plans in the building process and as those plans kept changing, it was impossible to make detailed monitoring plans far ahead, even though it was originally anticipated to do it like

this. Therefore, in practice, in the end it was decided to wait until the dust of the building process had settled down and final buildings plans were mostly known (and actually built) before starting the monitoring.
- At the start of the project, it was foreseen to compile results of all communities in one large monitoring database, in the detail and time resolution that it was collected for each of the buildings and plants. This would have enabled data analysis on various aggregation levels. However, due to the credit crisis, the number of buildings decreased. In addition, the development of the database foreseen for cRRescendo, that was supposed to be a generic monitoring database for a multitude of projects other than cRRescendo, was cancelled. This prompted us to switch to a simpler approach, working with spreadsheet templates per community, gathering average BEST table results on a monthly basis, and having each of the communities decide on their own approach for detailed data handling.
- Monitoring always sounds so simple that the effort it takes tends to be underestimated. In practice, several practical hurdles need to be taken. This requires a substantial efforts. In case inhabitants are involved, they need to agree on monitoring results to be gathered, in some cases actively contribute (e.g. filling in meter readings on a website or provide utility bills), or in other cases just be at home when people come by for meter readings. When this is done on a voluntary basis, it requires a substantial communication effort. This has been underestimated in some cases.

On the monitoring results and interpretation:
- Enormous variation in heat as well as electricity demand was found for apartments and houses. In Ajaccio, a range of a factor of 10 in heating demand was found. In Almere, a range of a factor of 4 was found. If such ranges were only caused by variation in set temperatures in the homes, it is estimated that a 12ºC range in set temperature is required, which is huge. In practice, variation in occupancy will probably also be part of the explanation for these variation. It would be interesting to look into this in more detail. In Almere, where results from more detailed monitoring will become available this year, it may be possible to check to what extent these two factors (set temperature and occupancy) explain such a large range.
- Monitoring Almere shows that below 6% monitored results become unreliable. As this also holds for non-residential buildings this poses a problem: how to verify the performance of individual non-residential buildings? Electricity consumption is largely dependent on type of non residential buildings, as well as occupancy and operational hours. These parameters need to be known better in order to do a proper comparison. Alternatively, it is necessary to do averaging over more buildings (just as for the homes and apartments) in order to arrive at results that can be compared with expected values. In case of refurbishment, it could have helped to perform monitoring before refurbishment. This was done in Ajaccio (but unfortunately no data in the new situation are available yet) but not in Viladecans.
- In data interpretation an issue with changed floor area compared to specifications was encountered. As not all flows scale linearly with floor area (namely hot water and electricity consumption), the original BEST table data had to be updated using as realised floor area's.

Recommendations for the Concerto Premium database

Concerning usage of data in databases:

Within the Concerto Programme a database will be built that will hold all Concerto Data. It will not only hold technical monitoring data but also costs. Assuming this database will be publicly available, the question is how this database compares to other database with energy consumption data. For example, the Odyssee Mure database reports total consumption of heat and electricity for homes in several categories in all EU countries .

The same holds for building categories in the services sector. In principle, if total floor area's are also given (which is not always the case), average consumption per m^2 for a given building type in a given country can be determined.
The Buildup.eu database on the other hand reports on best practices in building energy consumption. It contains a lot more information than energy consumption, including building specification.
Perhaps the passive homes in Almere would be an interesting best practice for large scale very low energy house building. Perhaps there are more Concerto buildings that qualify for 'best practice'. However, most cRRescendo buildings are in between average buildings and best practice buildings. What is the use for reporting energy consumption data of such buildings in an external database? The comparison of original ambition and final consumption is probably interesting for an analysis point of view, to be done by Concerto Premium. For a publicly accessible database the relationship between realised extra ambition and realised extra costs would be very interesting, although also very difficult to determine. In addition, data on improved energy efficiency upon refurbishment, again related to cost, would also be very interesting.

2. Introduction

In the Contract with the EU, clear requirements were made on the monitoring of the communities:

"More detailed monitoring may be carried out to suit local needs, but as a minimum, the following energy flow data shall be monitored for all energy demand and supply systems (including all buildings) in the Concerto area, and made available for comparison between Concerto communities:
- electricity demand per building / apartment on a monthly basis;
- space heating demand per building / apartment on a monthly basis;
- water heating demand per building / apartment on a monthly basis;
- cooling demand (where appropriate) on a monthly basis;
- electricity supply from each renewable electricity generator on a monthly basis;
- Energy supplied by each renewable heating system on a monthly basis."[1]

In addition, the Annex also required the delivery of a number of technical and non-technical indicators. More specifically, the first four technical indicators are[2]:

1. increase in % of renewable energy in electricity consumption of Concerto community
2. increase in % of renewable energy in heating / cooling consumption of Concerto community
3. reduction in energy consumption per m² of each building type (efficiency measures)
4. overall reduction in conventional energy consumption in the Concerto community (sum of efficiency gains and renewables supply)

These requirements have been leading in the monitoring plans.

Over the course of the project various constraints have limited the final plans. In the initial plans, over 5000 dwellings and buildings were going to be monitored. Because less buildings were built in the end, the amount of building monitored decreased as well. In addition, delays with the building process, but also with the monitoring, have caused that not all monitoring data is in by the end of the project. Here we report the data that has been collected for one year or until June 30th, 2011. We also give an outlook on additional data that might be collected with one year extension of the monitoring.

In §3.2 an overview of monitoring data gathered by June 30th 2011 is given. In §3.3 the data gathering methods in the four cities are discussed. In §3.4 the methodology to arrive at a cleaned up data set and the four technical indicators is discussed.

In Chapter 4 yearly results of the four communities are presented and discussed. Monthly results can be found in the appendices. The 13th indicator required by the EU

13. Details of long term Concerto community energy management and monitoring systems

is discussed at the end of Chapter 4. In Chapter 5 comparisons between the communities are made where relevant and overall conclusions are drawn on the monitoring results and the monitoring process thus far.

This report has been put together by Edith Molenbroek (Ecofys) with the help of:

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[1] Page 84 of the EU contract, 2009.
[2] Page 85 of the EU contract, 2009.

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- Ewout van der Beek (Ecofys)
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3. APPROACH

3.1. OVERVIEW MONITORING DATA

In tables 3.1 through 3.4 an overview is given of data collection for each of the communities, for the Building Energy Specification Tables ('BEST tables') as well as the Concerto Data Sheet (CDS). Three categories can be distinguished here:

1. Buildings and generators where sufficient monitoring data has been generated by the end of the project in order to evaluate its performance. In some cases, the quality of data and the analysis could be improved by extending the monitoring period. They are given a green background.
2. Buildings and generators that are ready by July 31st 2011 but cannot deliver monitoring results before the end of the project. Many buildings / generators in this category could generate enough data if one year extra would be available for monitoring and analysis. They are marked in blue.
3. Buildings and plants or generators that are not ready by July 2011 but will likely be ready by July 2012. They are still included in the overview below if a planning for finishing was available by May 2011, to show that these buildings will be built or renovated with cRRescendo influence. They are not colored.

If buildings and plants are cancelled altogether or no building deadlines are in sight, they are left out of the overview altogether.
For more specific information on specific measures taken in the buildings we refer to the BEST tables in the contract and the commissioning reports.

TABLE 3.1 MONITORING OVERVIEW AJACCIO, A) BEST AND B) CDS

Ajaccio

BEST	Building type (Annex 04-2010)	Description	Refurbishment/ new	# of dwellings /units	Monitored (reference)	Commissioned	Monitored (new)
1a	apartments	historic city center (rue de la Porta)	new	1 bld / 8 apts	Yes, 1b	July 2011	
1b	apartments	historic city center (12 rue Fesch)	reference	1 bld / 7 apts (6 monitored)	Feb. '10 - Jan. 2011	N/A	N/A
2a	housing buildings	urban renovation area St.Paul, new	refurbishment with SHW	2 bld/52 apt (15 monitored)	No	July 2011	Nov. '10
2b	housing buildings	urban renovation area Monte e Mare new	refurbishment with SHW	2 bld / 91 (15 monitored)	No	February 2011	Apr. '10 - Mar. '11
4a	public service office building	urban renovation area Les Cannes	new	1 bld	Yes, 4b	Sept. 2012	
4b	public service office building	urban renovation area St. Jean	reference	1 bld		N/A	N/A
7	housing buildings	urban renovation area (St Jean 2)	refurbishment without SHW	3 bld / 196 apts	No	Sept. 2011	
8	housing buildings	urban renovation area (Pietralba 2)	refurbishment with SHW	10 bld / 80 apts	No	Aug. 2011	

RES/POLYGEN Ajaccio	(Peak) power (Annex 04-2010)	Comments	Commissioned	Monitored
Wind	6 kW	Les Cannes new office service building (BT4)	*end 2011*	Yes
PV	163 kWp PV	St Jean 1: 146 kWp the last building Les Cannes	*end 2011*	Yes
Solar collectors	735 m^2	350 m^2 will be installed: St Paul: 93 m^2 Pietralba 2: 142 m^2 Monte e Mare: 98 m^2 rue de la Porta: 17 m^2	the last building rue de la Porta : february 2011	Monte e Mare: 76/98 m^2 monitored Monte e Mare and St. Paul started June 2011 Pietralba scheduled to start sept. 2011
Polygeneration	75 kW absorption heat pump	Les Cannes new office service building	*end 2011*	

(green)	monitoring results presented
(blue)	monitoring results can be ready by Aug. 2012
(white)	will be realised by Aug. 2012

For Ajaccio, all RES/POLYGEN is presented as part of the BEST tables in the figures and graphs to come.

TABLE 3.2 MONITORING OVERVIEW ALMERE, A) BEST AND B) CDS

Almere

BEST	Building type (Annex 04-2010)	Description	Refurbishment/ new	# of units / m^2	Monitored (reference)	Commissioned	Monitored (new)
1	apartments	columbuskwartier - eco homes	new	118 / 10064	n.a.		in progress
2	apartments	columbuskwartier - solar homes	new	83 / 7388	n.a.	ok	in progress
3	single family dwellings	columbuskwartier - eco homes	new	(412)	n.a.		in progress
4	single family dwellings	columbuskwartier - solar homes	new	331 / 46434	n.a.	ok	in progress
5	apartments	noorderplassen west - eco homes	new	86 / 8834	n.a.		in progress
6	apartments	noorderplassen west - solar homes	new		n.a.		in progress
7	single family dwellings	noorderplassen west - eco homes	new	1503 / 271944	n.a.		in progress
8	single family dwellings	noorderplassen west - solar homes	new	115 / 20004	n.a.		in progress
9	health centre	columbuskwartier	new	2	n.a.		in progress
10	office	columbuskwartier	new	3	n.a.		in progress
11	primary school	columbuskwartier	new	2	n.a.		in progress
12	shopping centre	columbuskwartier	new	1	n.a.		in progress
13	sports accomodation	columbuskwartier	new	1	n.a.		in progress
14	child day care	noorderplassen west	new	1	n.a.		in progress

BEST	Building type (Annex 04-2010)	Description	Refurbishment/ new	# of dwellings /units	Monitored (reference)	Commissioned	Monitored (new)
Almere							
15	health centre	noorderplassen west	new	1	n.a.		in progress
16	shopping centre	noorderplassen west	new	1	n.a.		in progress
17	single family dwellings	columbuskwartier - passive homes	new	104	n.a.		in progress
18	international school	cascade park	new	1	n.a.		in progress

RES/ POLYGEN	(Peak) power (Annex 04-2010)	Comments	Commissioned	Monitored
Almere				
PV	550 kWp PV	columbuskwartier	ok	part of BEST
PV	37 kWp PV	waste separation station		not yet
Solar collectors	6937 m^2	noorderplassen west		

(green)	monitoring results presented
(hatched green)	monitoring results presented (half year data available)
(blue)	monitoring results can be ready by Aug. 2012
(white)	will be realised by Aug. 2012

TABLE 3.3 MONITORING OVERVIEW MILTON KEYNES, A) BEST AND B) CDS

Milton Keynes

B1	apartments	C4.1 residential	new	441	n.a.		yes
B2	offices	B3.2 Commercial 3 offices with small retail units (the Pinnacle)	new	3	n.a.		yes

Milton Keynes

PV	165 kWp PV	tendered July 2011	autumn 2011	will be monitored
Polygeneration	6220 kW (3047 kWe, 3173 kWth)	incl. 480 m^3 thermal storage and 10 MW gas fired peak boiler	ok	yes

green	monitoring results presented
blue	monitoring results can be ready by Aug. 2012
white	will be realised by Aug. 2012

TABLE 3.4 MONITORING OVERVIEW VILADECANS, A) BEST AND B) CDS

Villadecans

BEST	Building type (Annex 04-2010)	Description	Refurbishment/ new	# of dwellings /units	Monitored (reference)	Commissioned	Monitored (new)
B	day care centre	La Pineda	new	1	n.a.		nov. 2010 -
C	cultural centre	Can Xic	refurbishment	1			nov. 2010 -
D	sports facilities	Football field	new	1	n.a.		nov. 2010 -
E	cultural centre	Pablo Picasso	refurbishment	1			nov. 2010 -
F	municipal technical service building	Ceip Ponent	new	1	n.a.	building will start Jan. 2012	

Villadecans

RES/POLYGEN	(Peak) power (Annex 04-2010)	Comments	Commissioned	Monitored
PV	342 kWp PV			

(green)	monitoring results presented
(hatched green)	monitoring results presented (half year data available)
(blue)	monitoring results can be ready by Aug. 2012
(white)	will be realised by Aug. 2012

3.2. Data acquisition methods

Several methods of data acquisition have been used in the four communities. In general, one can distinguish the following methods used within cRRescendo:

1. Automated data acquisition, including daily automated data transmission to a server
2. Automated data acquisition to a local storage device, that needs to be picked up or from which data need to be copied locally every few months.
3. For public buildings and other buildings: manual reading of meters by O&M personnel or others.
4. For dwellings: have inhabitants read their meters on a monthly basis and submit readings to a website.
5. For dwellings: have inhabitants report the yearly totals from their utility bill.
6. Obtain monthly or higher resolution data from the utility on readings of individual apartments, apartment buildings, commercial buildings. Data can be read manually or automatically, from meters used for billing purposes.
7. Obtain data from the utility on neighbourhood level meters (e.g. substations) in the grid

In some cases several methods of data acquisition have been used in parallel, in case doubts were raised on the validity of data (e.g. Milton Keynes) or in order to increase the fraction of homes monitored (Almere). In Ajaccio, different data acquisition methods were used for different flows: in some apartments, heat was measured automatically, while electricity needed to be obtained from the inhabitants' utility bill.

In the table below we show per community and per BEST table or plant what type of method was used. The colors denote the same as in table 3.1-3.4 (green: data present in this report).

Table 3.5 Data acquisition methods Ajaccio

BEST	Ajaccio	
1a	apartments	3. Manual reading of meters by O&M personnel or others.
1b	apartments	3. Manual reading of meters by O&M personnel or others.
2a	housing buildings	3. Manual reading of meters by O&M personnel or others. 5. Electricity: inhabitants report yearly values from utility bill
2b	housing buildings	3. Manual reading of meters by O&M personnel or others. 5. Electricity: inhabitants report yearly values from utility bill
4a	public service office building	1. Automated data acquisition, automated data transfer
4b	public service office building	1. Automated data acquisition, automated data transfer
6	housing buildings	3. Manual reading of meters by O&M personnel or others.
7	housing buildings	3. Manual reading of meters by O&M personnel or others.
8	housing buildings	3. Manual reading of meters by O&M personnel or others.

CDS		
Wind	6 kW	1. Automated data acquisition, automated data transfer
PV	163 kW	1. Automated data acquisition, automated data transfer

SHW	735 m^2	2. Automated data acquisition, periodic local data transfer

In Ajaccio, automatic metering was done for the BEFORE measurements of the public office building (St. Jean, BEST 4). For the apartments, metering was done automatically but the logged data was not transferred automatically and had to be picked up every two months.

Table 3.6 Data acquisition methods Almere

1	apartments	3.manual reading of meters by O&M personnel or others 4. Inhabitants submit readings to website 7. Data utility neighbourhood level 1. Small fraction: Automated data acquisition and transfer
2	apartments	Id. (3, 4, 7, 1)
3	single family dwellings	Id. (3, 4, 7, 1)
4	single family dwellings	Id. (3, 4, 7, 1)
5	apartments	Id. (3, 4, 7, 1)
6	apartments	Id. (3, 4, 7, 1)
7	single family dwellings	Id. (3, 4, 7, 1)
8	single family dwellings	Id. (3, 4, 7, 1)
9	health centre	5. Yearly data from utility bills
10	office	5. Yearly data from utility bills
11	primary school	5. Yearly data from utility bills
12	shopping centre	5. Yearly data from utility bills
13	sports accomodation	5. Yearly data from utility bills
14	child day care	5. Yearly data from utility bills
15	health centre	5. Yearly data from utility bills
16	shopping centre	5. Yearly data from utility bills
17	single family dwellings	4. Inhabitants submit readings to website 7. Data utility neighbourhood level 1. Small fraction: Automated data acquisition and - transfer
18	international school	5. Yearly data from utility bills

CDS

Solar island	6700 m^2	1. Automated data acquisition, automated data transfer

In Almere, the majority of the private dwellings was monitored with help of the inhabitants who submitted meter readings through the website "Energiegewicht.nl" (energy weight). When it turned out that the response was rather low, it was decided to collect meter readings at the beginning and end of the monitoring year by having students go to the homes and asking to read the meters. In addition, data from utility substations have been used to check some of the data. Some 20 homes spread over a number of BEST tables are being monitored in more detail, but these data are not available yet.

Data of the commercial and public buildings will be obtained through utility bills requested from the building maintenance people. At the time of this report this data was not available yet.

Table 3.7 Data acquisition methods Milton Keynes

Milton Keynes

B1	apartments	6. Monthly data from utility
B2	offices	6. Monthly data from utility

CDS

PV	342 kWp	1. Automated data acquisition, automated data transfer
CHP	3047 kWe, 3173 kWth	1. Automated data acquisition, automated data transfer

In Milton Keynes, data was obtained from automated meters from Energy Service company Thamesway. In addition, Thamesway collected manual meter readings to check some of the other data.

Table 3.8 Data acquisition methods Viladecans

BEST	Villadecans	
B	day care centre	1. Automated data acquisition, automated data transfer
C	cultural centre	1. Automated data acquisition, automated data transfer
D	sports facilities	1. Automated data acquisition, automated data transfer
E	cultural centre	1. Automated data acquisition, automated data transfer
F	municipal technical service building	Ceip Ponent

CDS

PV	342 kWp	1. Automated data acquisition, automated data transfer

In Viladecans at first a start was made with manual collection of monthly data. However, this turned out not to be sufficient. Therefore a switch to automated reading was made.

3.3. Monitoring analysis

At the start of the project, it was anticipated that, in conjunction with Concerto Plus and other Concerto projects, a uniform method for data analysis in Concerto communities could be developed. The advantage of uniform data analysis is that results can be easily interpreted and compared with results from other projects. For comparison: such a uniform method has been developed in the past for analytical monitoring of photovoltaic systems, by the Joint Research Center. Some recommendations on data analysis were made by Concerto Plus[3]. However, with the large diversity in Concerto projects and the different interpretation of Concerto monitoring requirements between the projects a uniform method did not look feasible at the time. In 2008, a discussion has been held between cRRescendo technical monitoring partners on a common approach, a meeting to which Concerto Plus was invited as well. Even at this meeting it turned out that different definitions are used for parameters like degree days, useful floor area and primary energy factors, mostly based on the standardised methods for determining the energy performance of building in each country, the details of which are also regulated on a national basis.
It was decided to have a common methodology for data analysis, but to allow for such differences in definitions and the like, as long as the definitions are explained and referenced. The common methodology was laid down in detail in a report (Deliverable …). An overview of the general approach is given in the next paragraph.
The initial intention was to gather and process all raw data from all communities in one large database that had been made by Ecofys for usage other purposes and was supposed to be modified for cRRescendo use. The preparations for this were well on its way when the company that had commissioned the database had to file for bankruptcy and the database in development had to be sold. Because, also due to the credit crisis, the numbers of houses and dwellings in cRRescendo was strongly reduced, it was decided to change the approach and gather only aggregated data, i.e. monthly data.

3.4. Monitoring methodology

Introduction to monitoring methodology.

Ideally, a 'Concerto community' is an entity with clearly defined (geographical) boundaries, a community of homes, office buildings, schools with energy supply facilities in the same area. Energy is consumed and produced in the same area and there is no exchange with the outside world. In this case, the meaning of all technical indicators is quite clear.
In practice a 'Concerto community' looks different. Within a municipality, buildings and neighbourhoods and plants are selected based on their potential for fulfilling Concerto criteria but do not necessarily form a 'Community' with clearly defined geographical boundaries. An illustration of this are the Concerto area's in Viladecans and Almere, see figure 3.1.
As a practical definition, we took as cRRescendo monitoring boundaries the buildings and plants that have been subsidised by Concerto. All consumption and production of these buildings and plants adds to the overall consumption and production. Issues like how to attribute losses of power generation for plants that serve both Concerto and non-conceto area's will be discussed when they arise (see Milton Keynes results).

[3] In their document "Monitoring impact assessment agreement 06 06 26 v1.pdf".

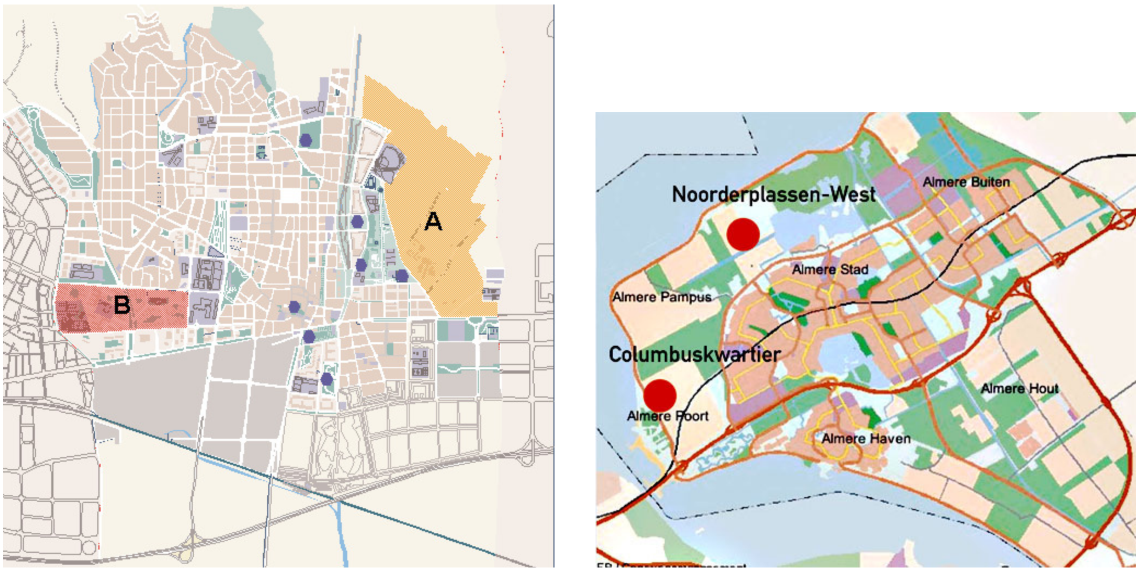


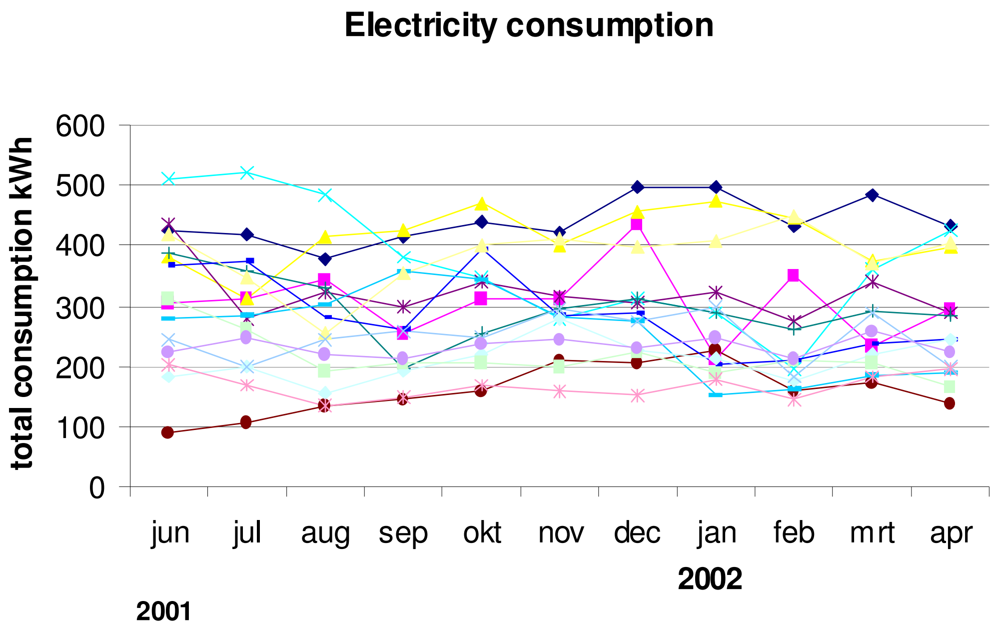
Figure 3.1. Illustration of real Concerto communities: Viladecans and Almere

Overall, the data processing distinguishes seven steps:

1. Raw data screening (not presented here)
2. Monthly data checks (graphs)
3. Correct for incomplete amounts monitored
4. Correct for missing data (MF)
5. Climatological correction
6. Monthly results
7. Yearly results

1. Raw data screening
Monitoring practice learns that careful screening of raw data is always necessary. When manual readings are taken, mistakes can be made. When automatic data acquisition is used, malfunctioning of equipment can cause for erroneous data or loss of data. Originally it was planned to automate raw data screening and make checks and filters for raw data screening of all communities, as part of a database and processing software for many other monitoring projects besides including cRRescendo. However, due to the economic crisis this large effort, of which cRRescendo monitoring was a part, had to be stopped. Therefore, in the end all communities followed their own approach.

2. Monthly data checks
When monitoring the energy consumption (or production) of a number of identical or to a large extent similar dwellings, as is done in the BEST tables in many cases, large differences can arise from one dwelling to another. An idea of this can be obtained by plotting monthly totals per dwelling, as is shown in the example graph below.



In cases where this was relevant, such graphs were made before obtaining the total and average of the group, which is necessary to arrive at the final indicators. This could result in additional data screening. For example, in some instances, apartments turned out not to be inhabited during the monitoring period. These then needed to be excluded from the dataset.

3. Correct for missing amounts monitored

Even though the intention was to monitor all buildings and plants, this was in practice not possible, due to time and money constraints or lack of participation of inhabitants. Therefore corrections needed to be made based on the m^2 (useful floor area or SHW collector area, or kWp in the case of PV) monitored compared to total.

4. Correct for missing data (MF)

In automated data acquisition, erroneous and missing data needs to be corrected for. In the case of electricity consumption this was done based on this missing time, in the case of heat consumption no the basis of degree days and in the case of solar production on the basis of horizontal irradiation.

5. Monthly results

Monthly results were plotted and examined. Monthly data can be used to gain an understanding of the behaviour of the buildings and plants.

6. Climatological correction

Electricity consumption does not get a climatological correction.
Heat consumption is corrected for heating degree days. For Ajaccio and Viladencs, actual HDDs and CDDs were determined using www.degreedays.net.
In Ajaccio, HDDs/CDDs were determined using the most straightforward HDD determination and a base temperature of 18ºC (from www.degreedays.net). In Almere,……..
In Milton Keynes, a base temperature of 15.5ºC was used. In Viladecans this was 18ºC.
Solar production is corrected using global horizontal irradiation. Because not a full year of data was available, in Viladecans the PV-data were normalised using in-plane irradiation. No actual data have become available for Viladecans. Therefore climatological monthly averages were used.

7. Yearly results and indicators

With the overall numbers of climate corrected consumption and production, the indicators can be calculated.
In some case it made sense to determine indicators based on final energy. In other cases primary energy made more sense. Below is a list of conversion factors from final to primary used in the communities for all flows, in all BEST and CDS. For electricity as well has heat (gas or district heating), primary energy factors from national building legislation have been used. For renewable energy, primary energy factors of the energy carrier it replaces have been used.

Table 3.9 Primary Energy Factors Ajaccio

yearly results (kWh)	BEST 1	BEST 2	BEST 4	BEST 6-8	CDS
Total electricity	2.58	2.58	2.58	2.58	2.58
Total heat demand	2.58	1	2.58	1	
Hot water demand	1	1	2.58	1	
Cooling demand			2.58/1		
RE electricity prod. total					2.58
RE elec. to grid					
SHW eff. coll. yield					1

For cooling demand in BEST table 4 in Ajaccio regular electricity driven cooling is taken as reference, but the new situation is an absorption heat pump driven by gas, hence two factors are mentioned.

Table 3.10 Primary Energy Factors Almere

yearly results (kWh)	BEST 1-1	BEST 12	BEST 13-18	CDS
Total electricity	2.56	2.56	2.56	2.56
Total heat demand	0.91	0.91	0.91	
Hot water demand	0.91	0.91	0.91	
Cooling demand		2.56		
RE electricity prod. total	2.56		2.56	
RE elec. to grid	2.56		2.56	
SHW eff. coll. yield				0.91

The primary energy factor for district heat in Almere is a standardised value used in the Dutch energy performance for buildings code. In case extra information on a particular project is present it can be argued to be different.

Table 3.11 Primary Energy Factors Milton Keynes

yearly results (kWh)	BEST 1	BEST 2	CDS
Total electricity	2.43	2.43	2.43
Total heat demand	0.9	0.9	0.9

Hot water demand	0.9	0.9	
Cooling demand			
RE electricity prod. total			2.43
RE elec. to grid			
SHW eff. coll. yield			

For Milton Keynes, the primary energy factor for heat from the CHP was assumed to be 0.9. Taking into account the overall generation efficiency and further downstream losses that occurred in the monitoring period April 2010 – March 2011, the primary energy factor for electricity was calculated to be 2.43 (more on this in paragraph 4.4). This was used in the primary electricity calculations for all consumption and production, including PV-production. For reference: the primary energy factor for electricity in the national energy performance for builidings regulation is 2.92 used for electricity and 1.02 for gas based heating.

Table 3.12 Primary Energy Factors Viladecans

yearly results (kWh)	BEST B-E	CDS
Total electricity	2.6	2.6
Total heat demand	1	
Hot water demand	1	
Cooling demand	2.6	
RE electricity prod. total	2.6	2.6
RE elec. to grid		
SHW eff. coll. yield	1	1

Furthermore it should be noted that for Ajaccio and Viladecans data use is made of heated floor area's, whereas in Almere and Milton Keynes gross floor area was used.

4. Results and discussion

4.1. Introduction to results

The monthly results of all measured flows are depicted graphically in the Appendices. These results shown are not corrected for climatic variations and are given in final energy.

In the paragraphs below, yearly results will be shown and discussed. All monitored data will be compared with expected data. Monitored data from the 'before' situation is compared with the average values (or 'national regulation') as well as the 'Concerto specification' aimed at after refurbishment. Monitored data from the 'before' situation has only been done in Ajaccio.

Monitored data from the 'new' situation is also compared to both the 'national regulation' values as well as expected 'Concerto specification' values.

All flows representing consumption are given as positive values. All flows representing production are given as negative values. For BEST tables, values per heated m^2 are shown.

Presented in this way, quick insights can be gained in comparing total values of consumption and production, as well as comparing individual flows.

The comparison of BEST table values is in final energy per heated m^2. Corrections to a climatologically average year has taken place in these graphs.

After showing results for each BEST table in final energy per m^2, overall results for the community as a whole in primary energy is given.
Not in all cases monitoring results are available. We present the theoretical values for all BEST tables and the community as a whole and compare it with measured values when available.

4.2. RESULTS AJACCIO

In Ajaccio reference monitoring results are available for 2 BEST tables and results after refurbishment is available for one BEST table. Below, calculated averages (or normal regulation) and calculated expected Concerto values are shown for all BEST tables, combined with monitoring results when available.

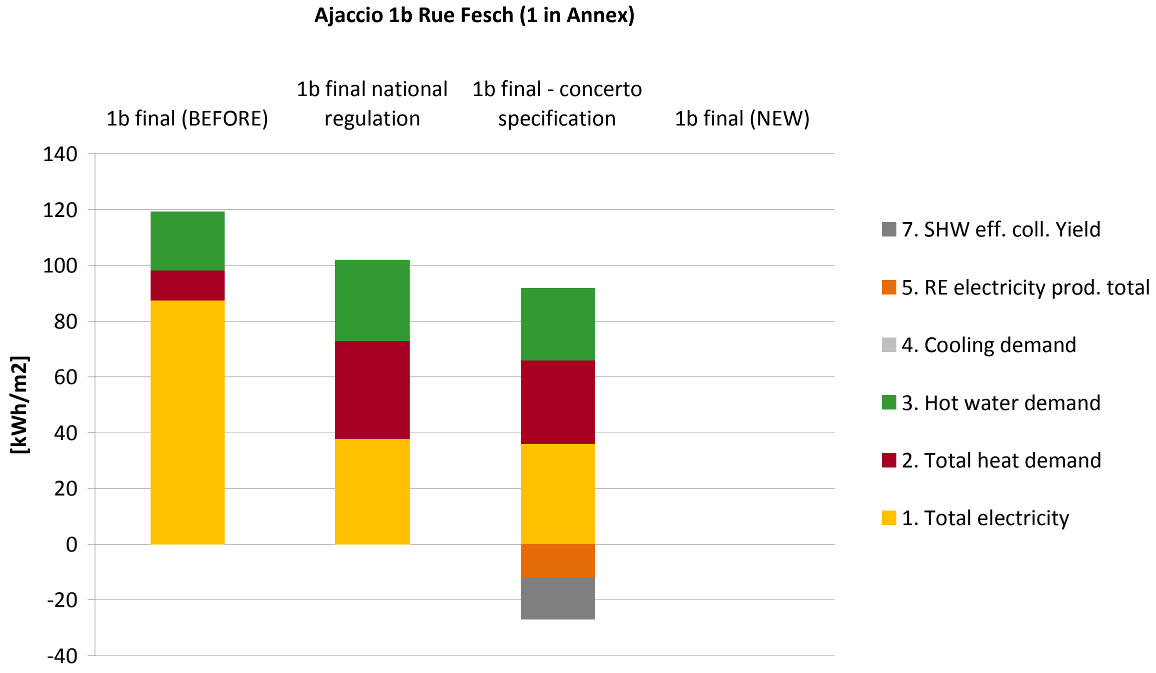


Figure 4.1. Final energy consumption and production per m^2 floor area BEST table 1, historic city center (Rue Fesch / Rue de la Porta).

In figure 4.1 reference monitoring results, average values and Concerto specification values are compared.

Reference monitoring was done in Rue Fesch, while the actual refurbished buildings are in the Rue de la Porta. Rue de la Porta has recently been commissioned (July 2011) and monitoring has started, but no results are available yet.

It is shown that overall reference consumption as monitored is on average somewhat higher than expected based on the average (called 'national regulation' here). What is more striking is that electricity consumption is very high, while heating consumption is quite low. In interpreting the data however, it should be realised that one cannot expect data based on an average of five apartments to be representative of average data. Figure 4.2 gives an impression of the spread in electricity consumption from apartment to apartment. It is shown to be huge. No further examination has been done to try and understand these differences. Therefore, it can only be said that when averaging consumption over only five apartments one should not be too surprised to get results that vary significantly from expected averages.

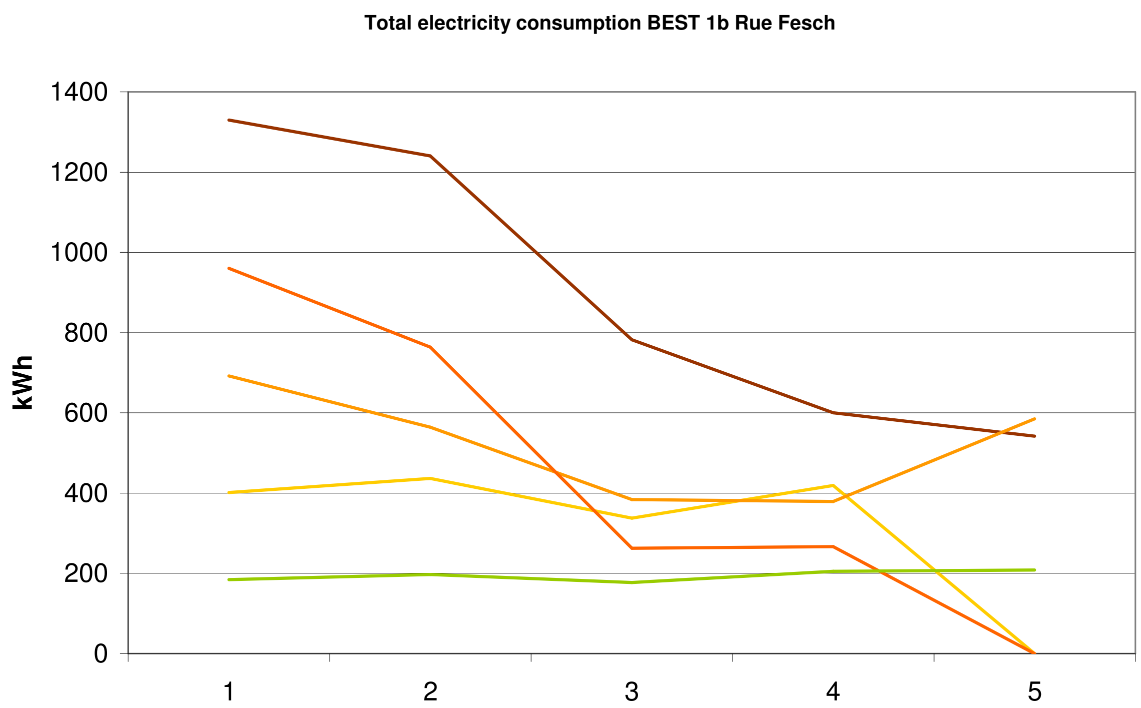


Figure 4.2. Rue Fesch (historic city center) individual electricity consumption of five apartments over a period of five months, showing very large variation.

In figure 4.3 calculated values of consumption and production for the national average and Concerto specification can be compared. In addition, the heat consumption in the situation after renovation can be compared to the calculated heat consumption. Unfortunately, data of electricity consumption were not available yet by July 2011. Whereas heat consumption was measured with local sensors and data loggers, electricity consumption had to be collected from utility bills from inhabitants. It turned out to be harder than expected to collect this from utility bills from inhabitants and was not available in time.

It should be noted that BEST table 2 consisted of housing buildings in the neighbourhood of Monte e Mare and St. Paul. St. Paul was monitored as well, but again there were problems in data collection, this time not from utility bills but in having personnel of the housing association collecting data loggers in the apartments.

Monitoring of the solar hot water heaters in Monte e Mare and St. Paul are not included here, as their overall contribution to the project is visible in the CDS (Community Data Sheet) and not in the BEST table. In addition, it was not possible to combine it because the monitoring started later and not in time for results to be there by the end of the project.

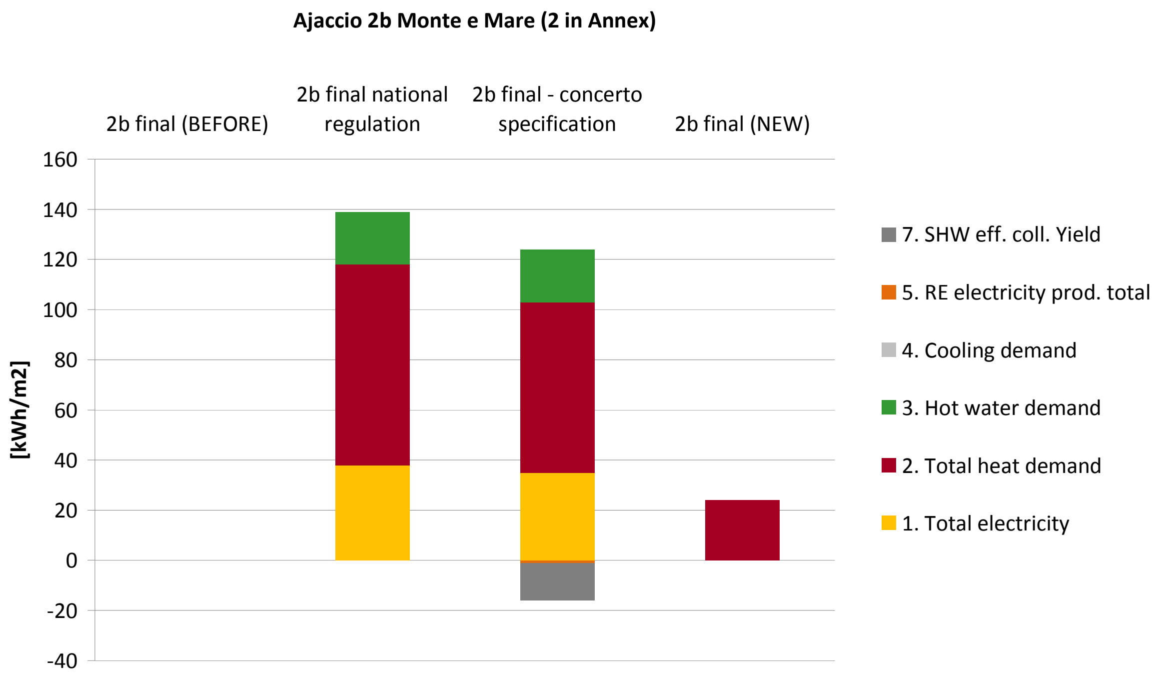


Figure 4.3 BEST table 2 (Monte e Mare part) calculated values of consumption and production according to national average and Concerto specification and measured heat consumption after refurbishment.

Again in Monte e Mare, measured heat consumption varied enormously from one apartment to another. In figure 4.4 the measured monthly heat consumption is depicted for the fifteen apartments measured in Monte e Mare.

The differences in heat consumption could be due to a variation in set temperature, but also due to varying duration of having the heating system on at a certain set temperature, such as varying occupancy during the day because of working hours or because of varying night time duration. In order to get a rough idea of the effect of different set temperatures, yearly degree day totals were calculated with base temperatures varying from 10 to 22 ºC (through www.degreedays.net). This resulted in a difference in heating degree days of almost a factor of 10. Varying the base temperature from 10 to 22 degrees results in a variation of yearly degree days of almost a factor of ten (via www.degreedays.net), which is roughly the range of heating demand found. Quite likely the spread between the apartments can be explained by quite substantial differences in set temperatures as well as occupancy.

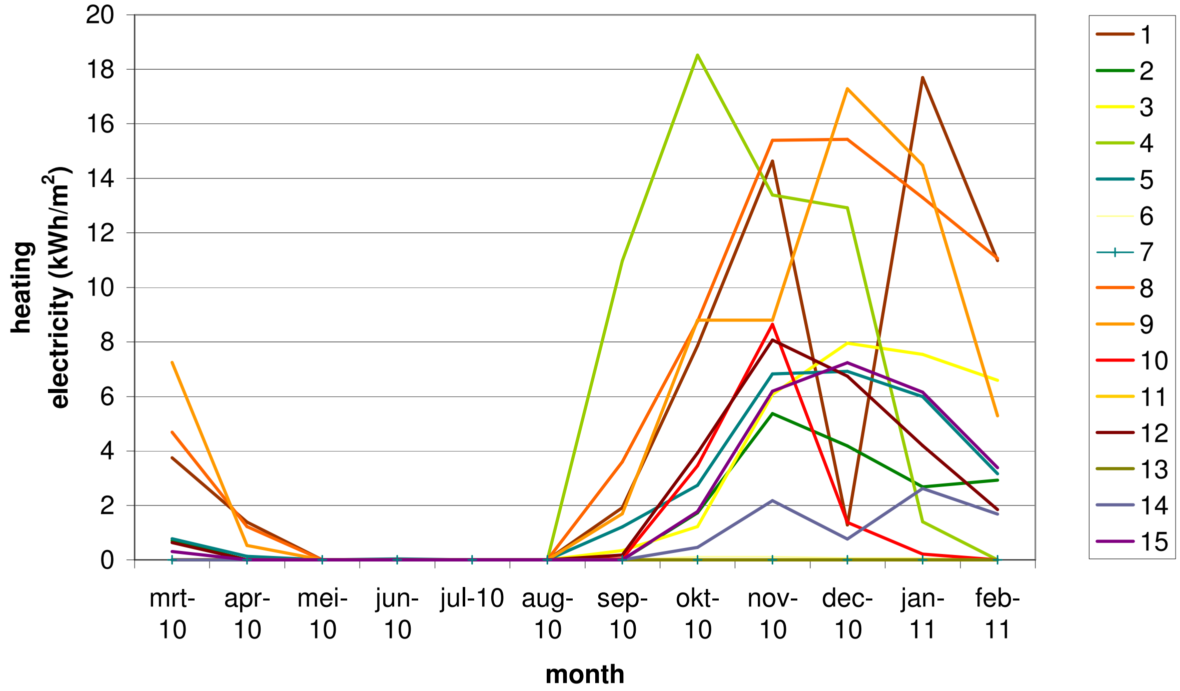


Figure 4.4 Variation on monthly heating consumption per m^2 after renovation, BEST table 2, Monte e Mare.

Next, in figure 4.5 we show the yearly graph of consumption and production for BEST table 4, the public office building in St. Jean. Here reference monitoring values are available of a similar office building in the area.

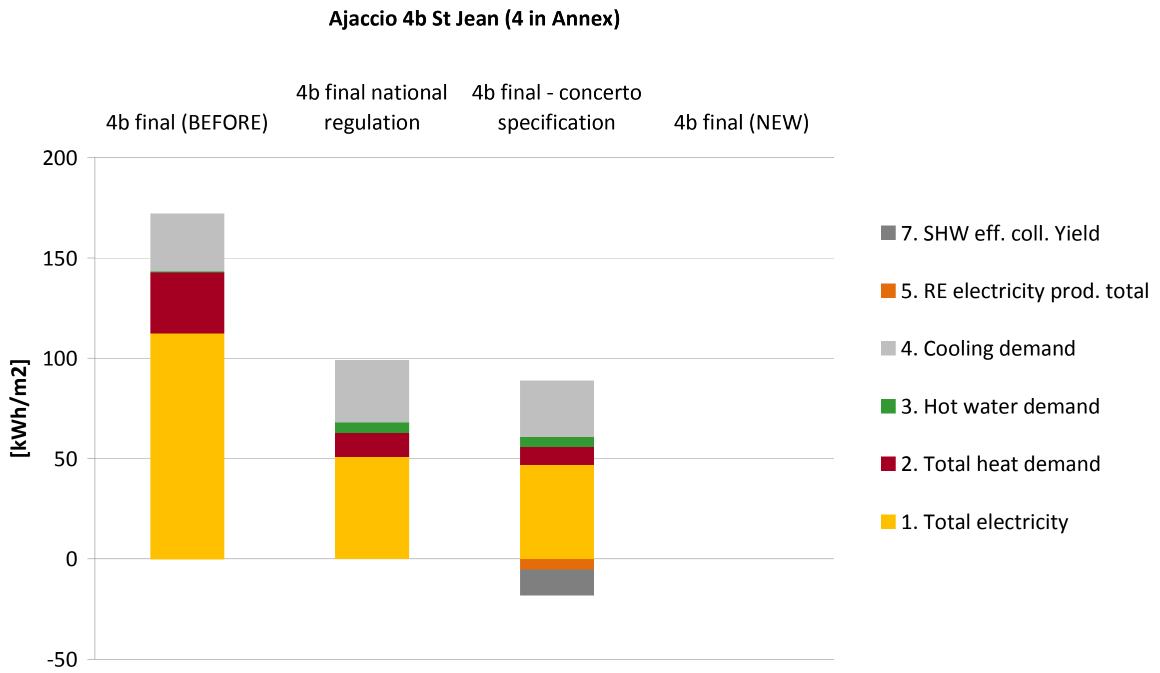


Figure 4.5. St. Jean (BEST table 4) reference monitoring compared to theoretical values of national average and Concerto specification.

It can be seen that the measured consumption in the reference situation is much higher than one would expected based on average values for such buildings. This is caused by the electricity consumption as well as the heat consumption.

Concerning electricity consumption: during inspection of the building in the monitoring period a few things were noted. First, there is too much use of lighting: not all shutters were opened during the day, the light is not switched off in the water closet. Second, computers were not switched off or put in a sleep mode during lunch break. Third, a lot of devices were found to be on standby all the time (computers, printers, DVD players), as was indicated by the high night time consumption (20% of the day time peak).
Apart from a lack of efficiency measures variations from one building to another can also be explained by for example difference in function, occupancy level and the like. This has not been looked into in detail.

Next, in figure 4.6 and 4.7 we show the yearly graph of consumption and production for BEST table 7 and 8, refurbished housing buildings in the urban renovation area. For BEST table 8 the consumption values before and after renovation are the same for these BEST tables, but in Solar Hot Water Heaters and a CASA system are added. Recently it became clear that BEST table 6 was abandoned. This is not taken into account in the total-MWh graph from figure 4.8 yet, as the dataprocessing was already finished.

BEST table 7 is commissioned at the time of report. No monitoring has started there yet, but this will still be done.
The buildings from BEST table 8 are expected to be commissioned by July 2012.

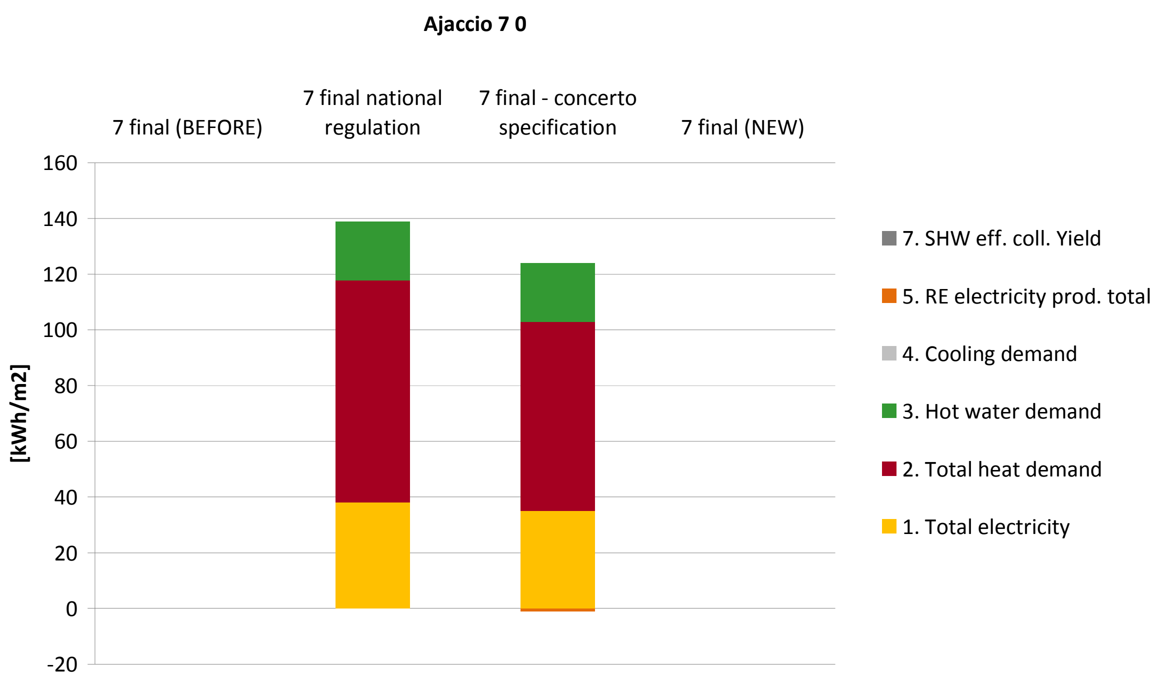


Figure 4.6 Theoretical Concerto consumption and comparison to national regulation for BEST table 7, housing buildings in the urban renovation area.

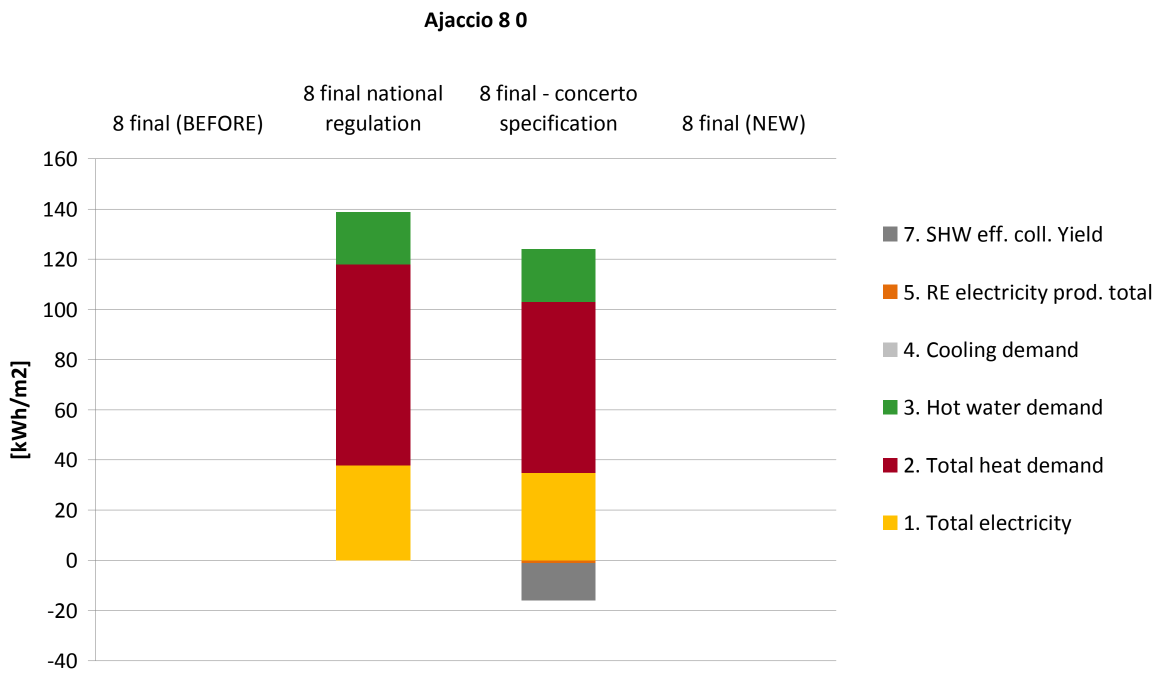


Figure 4.7 BEST table 8, housing buildings in the urban renovation area.

Adding up all the contributions from the BEST tables together and adding the contributions from the CDS tables (SHW, wind turbine) and converting to primary energy results in the figure below. Here, the expected total primary energy consumption and production of all buildings and plants that are and will be built resulting from the cRRescendo project are depicted.

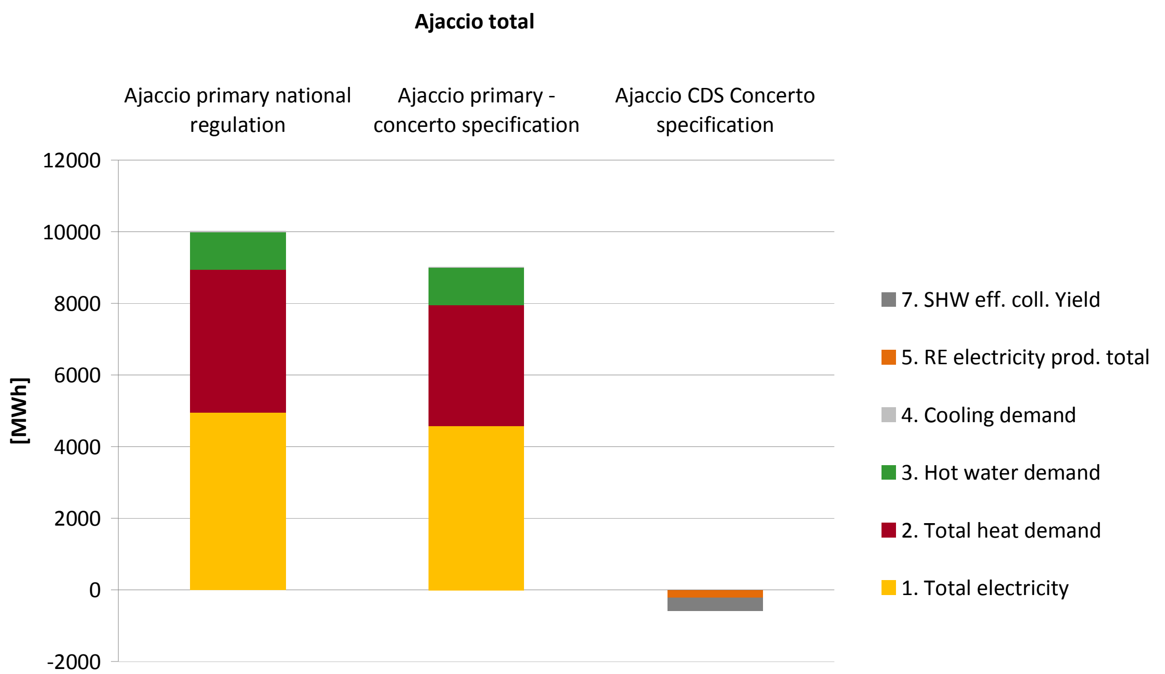


Figure 4.8 Primary Energy consumption and production in the whole Ajaccio project. 1^{st} column: primary energy consumption according to national regulation or average

practice. 2nd column: average demand expected after all cRRescendo buildings are ready. 3rd column: Expected production renewable energy supply (PV and SHW).

Because the available monitoring data of newly built buildings is very limited we decided not to extrapolate this data to an estimated total in figure 4.8 and only present the calculated figures. This makes it impossible to say something at this point about the overall performance of the project.
Since in many BEST table projects in Ajaccio (4, 6 and 8) the building process is not finished yet, it is likely that a year from now it may still not be possible to get a complete picture of monitored results of the overall project. However, more will be known on results of individual BEST tables as well as on the SHW boilers CDS table and possibly also of the wind turbine and PV panels.

In table 4.1 we show the reduction in energy consumption per m^2 of each building type, indicator 3 from the EU contract. The values are given without taking into account renewable energy measures and with renewable energy measures and are based on final energy (should be primary if

Table 4.1 Expected values for indicator 3 (reduction in energy consumption per m^2 of each building type), based on calculated energy performance values and primary energy.

BEST # / description	% reduction aimed at	% reduction aimed at with RE
1 housing buildings historic city center	10%	31%
2 housing buildings urban renovation area	10%	19%
4 public service office building	10%	23%
6 housing buildings urban renovation area	10%	41%
7 housing buildings urban renovation area	10%	11%
8 housing buildings urban renovation area	10%	19%

Calculated indicators:
Expectation indicator 1: increase in % of renewable energy in electricity consumption of Concerto community
6% (primary energy)

Expectation indicator 2: increase in % of renewable energy in heating / cooling consumption of Concerto community
4% (primary energy)

Expectation indicator 4: overall reduction in conventional energy consumption in the Concerto community (sum of efficiency gains and renewables supply)
20% (primary energy)

Recommendations and ToDo's for the next year are:

- Collect and analyse monitoring results for BEST tables 1, 2, 7 and the solar collectors.
- If possible collect and analyse preliminary monitoring data on the wind turbine and the PV-system.

4.3. Results Almere

In Almere the overwhelming majority of buildings built are homes, in the form of apartment buildings as well as single family dwellings.
Broadly speaking, the homes have been built in three efficiency categories:

- Eco Houses
- Solar Houses
- Passive Houses.

All homes are connected to district heating. The Eco Houses are intended to be 10%-20% more efficient than standard. The solar houses should integrate two measures involving passive or active solar energy and are at least 25% more efficient than standard. 'The standard' in this case are homes with an EPC (Energy Performance Coefficient according to Dutch law) at the time cRRescendo was contracted. The Passive Houses are based on the passive house standard of less than 15 kWh/m^2 heat demand and are therefore the most efficient category, even though the design does not completely fulfil the passive home standard.

Apart from the homes, several public and commercial facilities have also been built with cRRescendo specifications. These are BEST table 9 – 16 and 18, as can be seen from the overview in table 3.2. However, no monitoring data are available at this time for these buildings. They will be collected by retrieving energy bills from the building managers.

Below, we will discuss the results of the homes and the Solar Island and present the CDS totals and indicators based on the monitoring results of the BEST tables that are available to date. As already reported in paragraph 3.2, the homes in Almere were monitored in several ways. At the start it was the intention to involve inhabitants and have them report meter readings. Participation turned out very low, on the order of a few %. These response rates are not surprising if you consider that inhabitants did not have much connection or binding with cRRescendo. The original intention was to make

cRRescendo more known beforehand and create a connection, thereby improving response, but this has not happened to the extent that it had an effect on the response for monitoring.
Then the idea came up to pass by homes and collect meter readings. This was done twice: in the summer of 2010 and in the period June 2011. Therefore two ways of collecting data are reported here, and there could be some overlap between the two. Both ways of data collection are represented in the BEST table graphs shown below. The website response is called 'Energiegewicht' (Energy Weight), the collection of data going door to door is called 'Interviews Almere'.
In fact, there is a third method of data collection, as was already mentioned in Table 3.7, to obtain data from the utility on neighbourhood level meters (e.g. substations) in the grid. Only heat was recorded in this way. At the time of this report this data stream was not analysed yet.

Even with these two methods together, for some BEST tables not enough data was collected to be considered as representative for the BEST table. This was the case for BEST table 3 and 6.
The data shown here have included first checks for completeness and consistency. For example, data series of homes with less than half a year's worth of heating degree days or electricity consumption are eliminated from the set.

Another issue realised during data processing was the following: it seemed for some BEST tables that the hot water consumption per m^2 was much less than anticipated. Later on it was realised that not the hot water consumption was lower than expected, but the realised area per building had increased for these BEST tables, resulting in a lower consumption per square meter. In fact, hot water consumption was calculated from the measured total heat consumption in most cases, therefore it could not have been lower than expected. This was the case for all BEST tables except for BEST table 7, where it was measured (although minimal and hardly representative for the whole BEST Table).
The hot tap water consumption per BEST table was determined in the same way as prescribed in NEN7120: first, the average number of people in an average BEST table house is derived based on the area in a house. Then, tap water consumption is calculated based on the number of people.
The current hot tap water data as shown are not corrected yet for differences in expected and realised home area's.

More checks are still to be done and this process is not yet finalised at this time. Some changes in the final corrected data could therefore still take place and will be reported in the next round (summer 2012).

In table 4.2 the most recent overview to date of the BEST tables and its most important characteristics for the purpose of monitoring are given.

It can be observed from table 4.2 that especially in the area of Noorderplassen West the homes turned out significantly larger than originally foreseen (BEST tables 6, 7 and 8). It could be that in between the first plans on which the Concerto specifications were built and the final plans the market generally developed towards larger homes.

Table 4.2 Most recent characteristics BEST tables Almere (status sept. 2011)

BEST#	1	2	3	4	5	6	7	8	17
area	CK	CK	CK	CK	NPW	NPW	NPW	NPW	CK
type of home	apt	apt	sfd	sfd	apt	apt	sfd	sfd	sfd
energy performance type	eco	solar	eco	solar	eco	solar	eco	solar	passi ve
number of homes spec	150	64	412	340	62	0	1035	50	104
number of homes built	114	83	63	333	68	48	859	116	104
DHW calculated / measured?	calc	calc	calc	calc	calc	calc	meas	calc	calc
Gross area monitored - EW	3%			6%	1%		4%	4%	11%
Gross area monitored - IA	13%	3%		19%	6%		20%	24%	
average m^2 - Conc. Spec.	84	75	132	119	88	75	116	112	112
average m^2 - as built	86	89	184	140	91	137	177	171	107

National Regulation	kWh/m^2								
Space heating	80	77	96	79	81	77	83	78	79
DHW	19	19	19	19	19	19	19	19	19
Other	38	37	23	21	39	37	25	25	25
Contribution RE	0	0	0	0	0	0	0	0	0

Concerto Specifications	kWh/m^2								
Space heating	59	44	73	46	68	44	67	44	26
DHW	19	17	17	17	17	17	17	17	14
Other	36	36	23	21	39	36	25	24	25
Contribution RE	0	-7	0	-4	0	0	0	0	0

The results of the BEST tables in Almere are shown below.
Figure 4.9 shows the final consumption results for BEST table 1. It can be seen that final consumption is lower than national regulation, as expected. It even seems below Concerto specifications, which is due to a lower electricity consumption. In the case of the Energiegewicht data it should be noted that the % of gross area monitored is very low, giving higher uncertainty in these averaged results. However, the Interviews Almere data 13% of the gross area is monitored, giving some more certainty that the difference is significant.

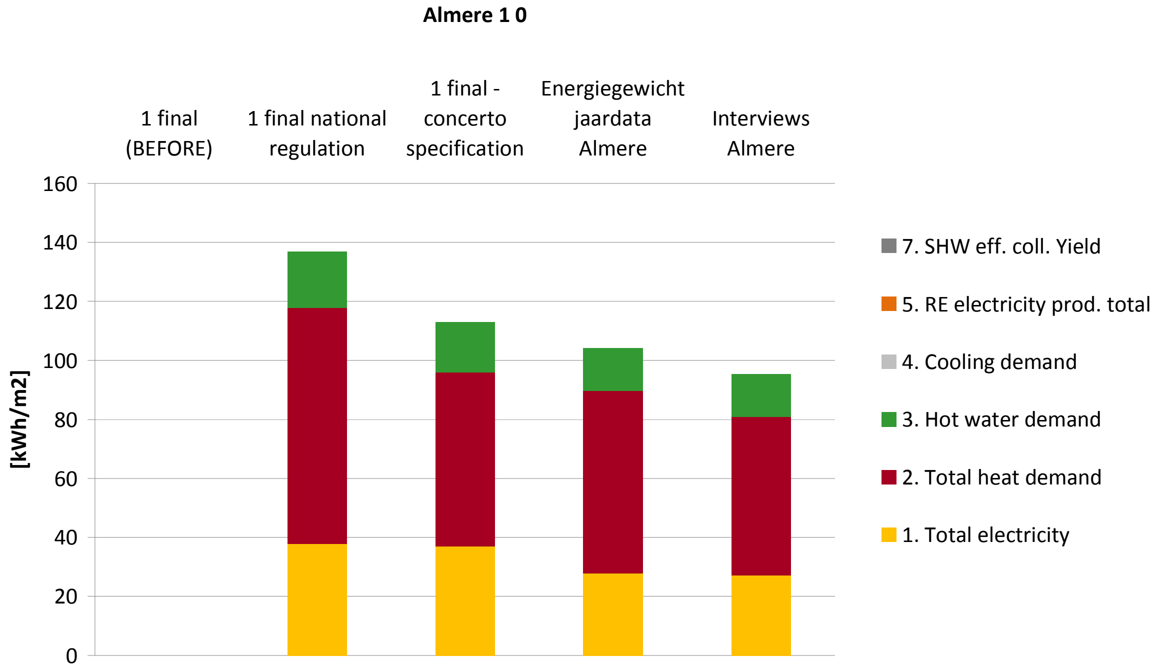


Figure 4.9 BEST Table 1 Apartment buildings Columbuskwartier, 114 Eco Houses, 3% and 13% of the gross area monitored, respectively.

Figure 4.10 shows the final consumption results for BEST table 2, Solar Houses (apartments) in Columbus quarters. From the Interviews Almere data it looks like Concerto specifications have not been achieved. However, due to the low monitoring fraction this cannot be said for sure. In any case, in the commissioning of these apartments no serious flaws that can explain such a higher heat demand than specified were found.

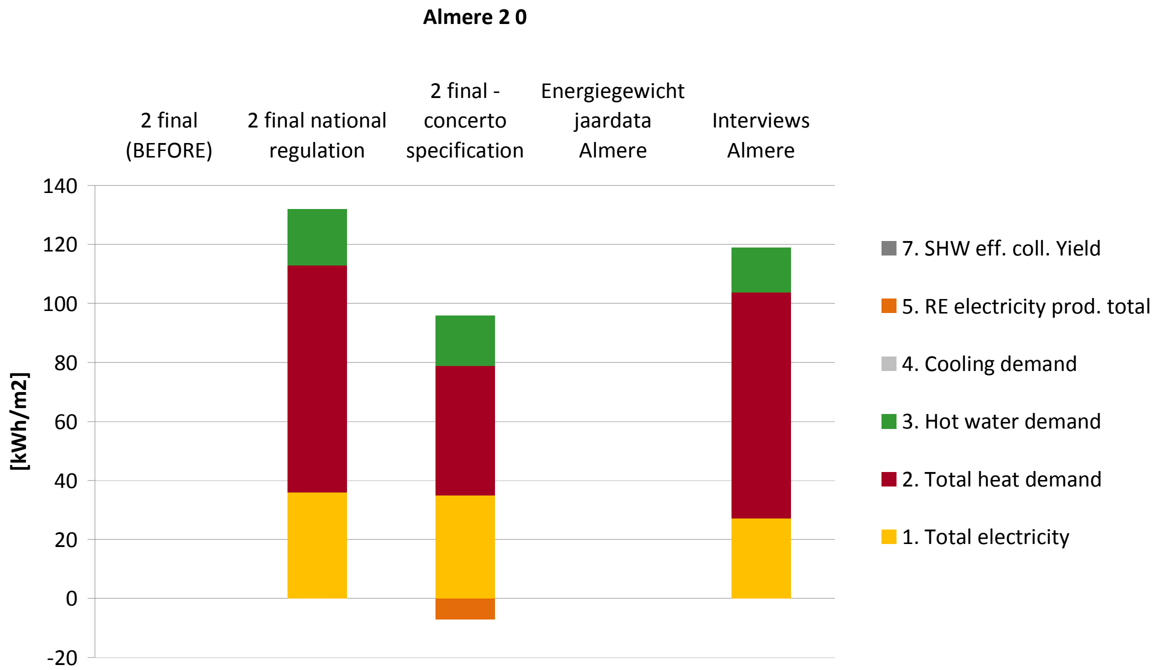


Figure 4.10 BEST Table 2 Apartment buildings Columbuskwartier, 83 Solar Houses, IA 3% monitored.

For BEST table 3, single family dwellings and Eco Houses in Columbus quarters, unfortunately not enough monitoring results were obtained during this period and therefore no graph is shown here. The expectation for this BEST table was that the heat demand would be lower than Concerto specifications. The reason for this is as follows. In Columbus quarters, Eco Houses and Solar Houses are not separated in different areas but they are dispersed: within the same street, a solar home can be adjacent to an ecohome. They were also developed by the same company and built by the same contractor and were built in the same construction flow. As a consequence of this, the builder in this area decided it was less costly to bring the Eco Houses up to the same insulation level as the Solar Houses, thereby making the building process in the area more uniform, than to stick to the original requirements. In fact, it even resulted in a number of houses –originally not specified as BEST Table 3– having a calculated energy performance equal to or less than EPC=0,75, which is in terms of energy performance enough to qualify as BEST Table 4, even though they do not have a Solar House certificate. These houses are now considered to be part of BEST table 4.

Figure 4.11 shows the final consumption results for BEST table 4, 333 single family dwellings and Solar Houses Columbus quarters. Monitoring results for both Energiegewicht and Interviews Almere data are well in line with Concerto specifications. Figure 4.12 shows the corrected heat demand versus gross area of BEST table 4. As was observed in Ajaccio as well, it can be seen here that for a given gross area, enormous spread in heat consumption is found, up to factor of four.

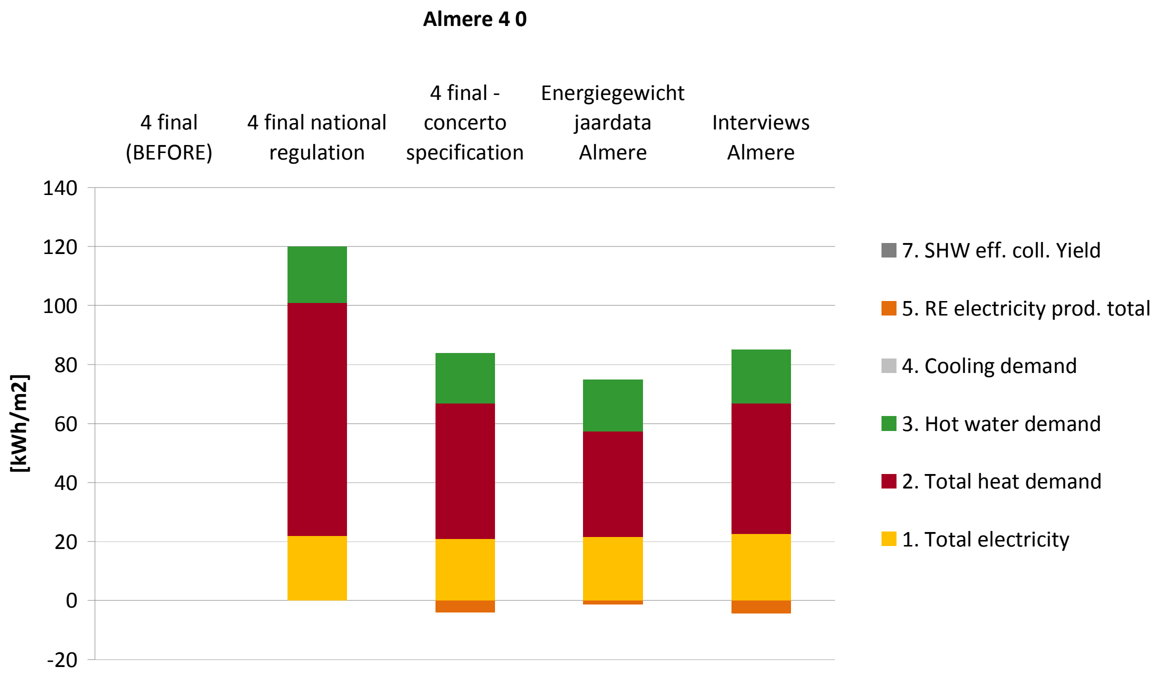


Figure 4.11 BEST Table 4 Single family dwellings Columbuskwartier, 333 Solar Houses, 6 and 19% monitored, respectively.

Just as was done in Ajaccio, in order to get a rough idea of the effect of different set temperatures, yearly degree day totals were calculated with base temperatures varying from 10 to 22 ºC (through www.degreedays.net). This resulted in a difference in heating degree days of a factor of four. Just like in Ajaccio, this is roughly the range of heating demand found. Again, quite likely it is a combination of both changing set temperatures in peoples' homes as well as occupancy.

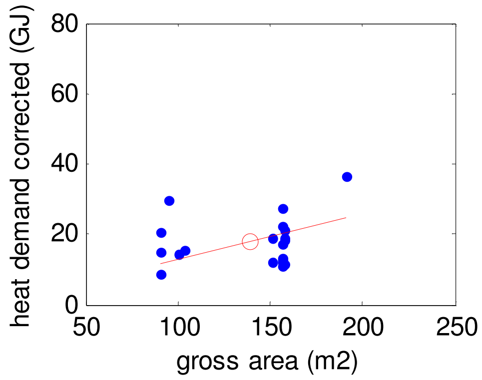


Figure 4.12 BEST Table 4 heat demand versus gross area. It shows that regardless of gross area an enormous spread is found from one home to another.

Figure 4.13 shows the final consumption results for BEST table 5, 68 eco apartments in Noorderplassen West. Hot water demand has not been collected here. Due to the rather low fraction of gross area monitored (equal to one apartment) the Energiegewicht data cannot be relied upon. The Interviews Almere data seem more reliable and more or les in line with or better than expectations.

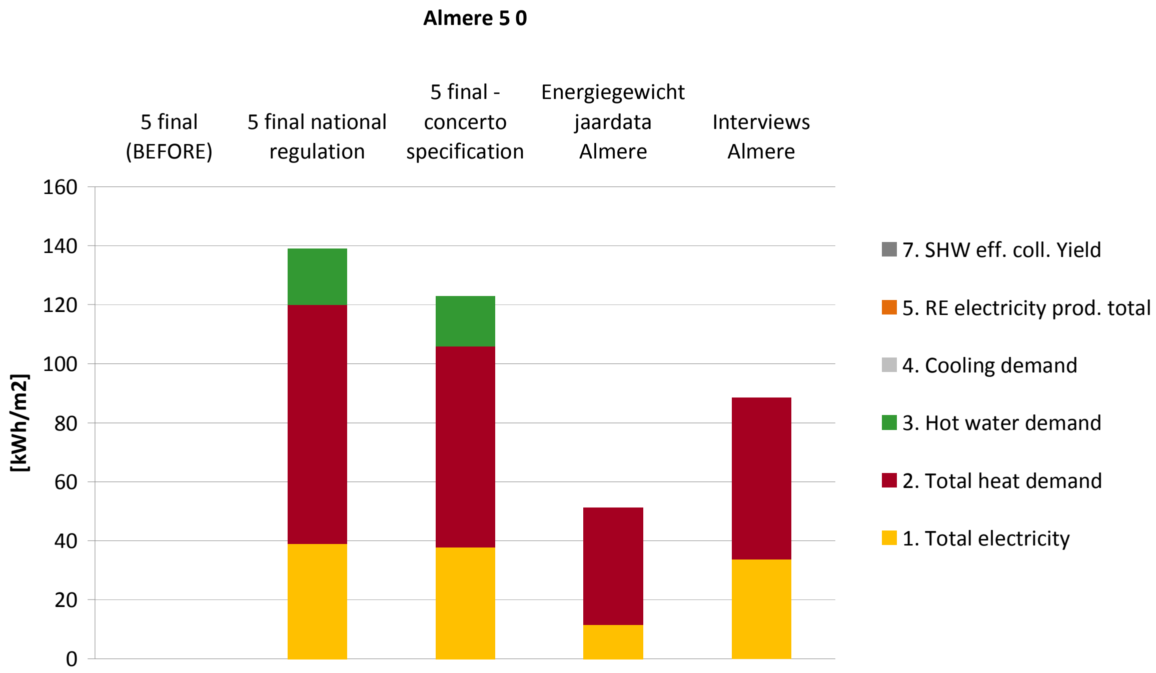


Figure 4.13 BEST Table 5 Apartment buildings Noorderplassen West, 68 eco apartments, 1 and 6% monitored, respectively.

Of BEST table 6, 48 Solar Houses (apartments) in Noorderplassen West, no data has been collected yet and therefore no results are shown here.
In figure 4.14 the final consumption results for BEST table 7, 859 Eco Houses in Noorderplassen West are shown. The heat consumption per m^2 is lower than Concerto specifications. The reason for this could be that the homes are considerable larger in

combination with the fact that heat consumption does not scale exactly linearly with area, but this should still be looked into further.
Furthermore the differences in hot tap water consumption from Energiegewicht and Interviews Almere are quite large. This is due to the fact that in the case of Energiegewicht hot tap water is measured (these homes have separate district heating for heating and hot tap water and therefore can be easily measured separately), but in the case of Interviews Almere calculated (see also comments on hot tap water at the beginning of this paragraph).

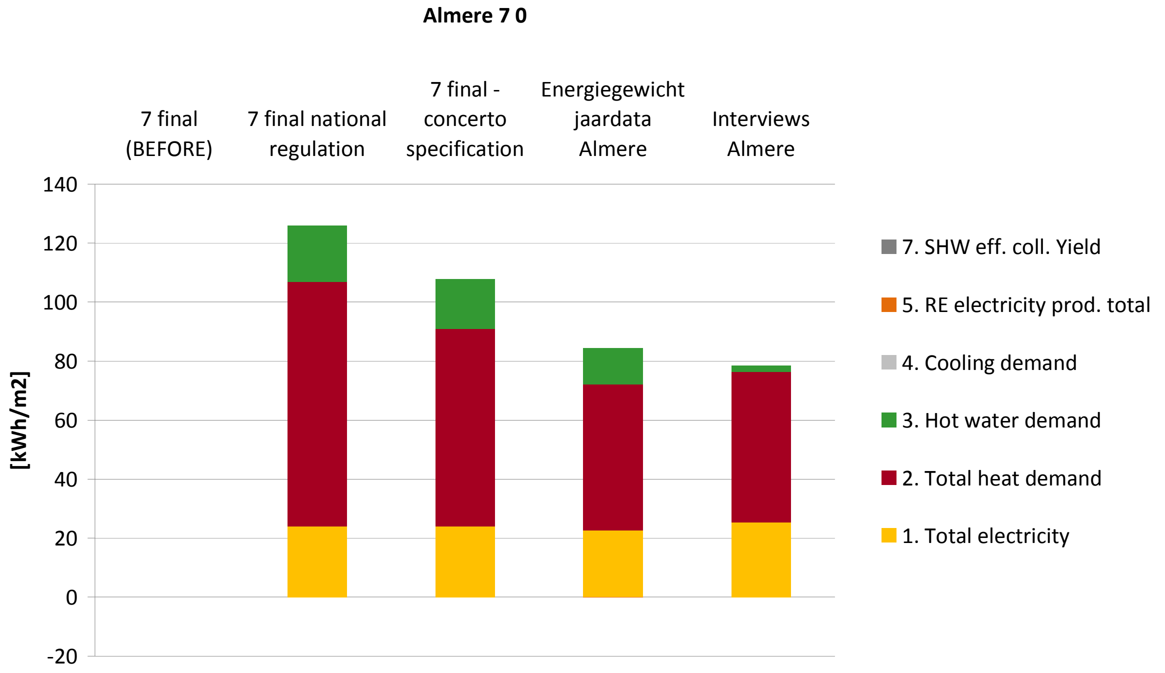


Figure 4.14 BEST Table 7 Single family dwellings Noorderplassen West, 855 Eco Houses, 4 and 20% monitored, respectively.

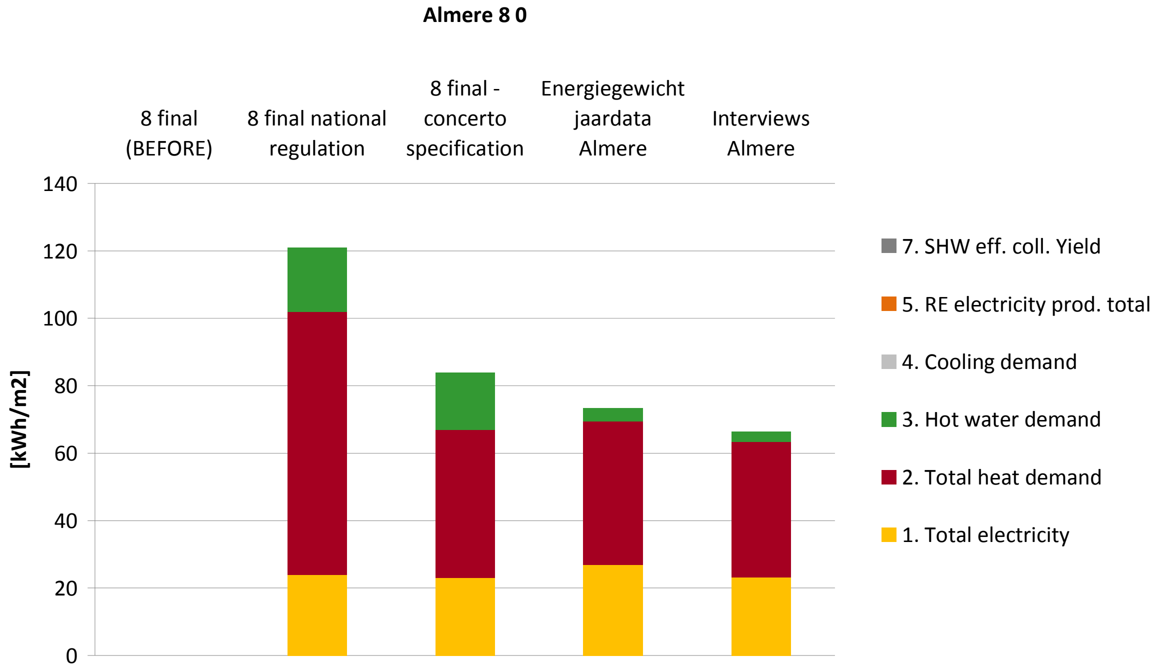


Figure 4.15 BEST Table 8 Single family dwellings Noorderplassen West, 116 Solar Houses, 4 and 24% monitored, respectively.

In figure 4.15 the final consumption results for BEST table 8, 116 Solar Houses in Noorderplassen West are shown. Monitoring results for heat and electricity are well in line with specifications. Again calculated hot tap water values are too low because the numbers are again divided by a larger floor area than anticipated. Equally to some houses in BEST Table 4, these Solar House only comply with the energy requirements of the Solar House certificate.

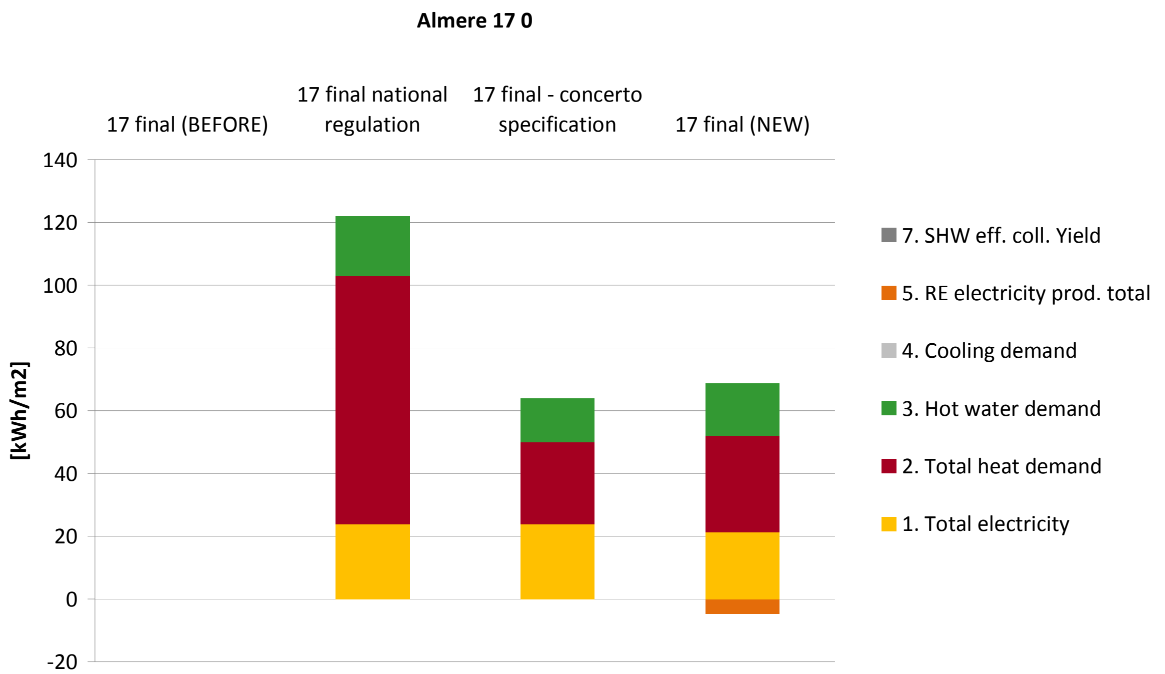


Figure 4.16 BEST Table 17 Single family dwellings Columbuskwartier, 104 Passive Houses, 11% monitored.

In figure 4.16 the final consumption results for BEST table 17, 104 Passive Houses in Columbus quarters are shown. Electricity and heat demand are well in line with Concerto specification.

For the construction of the current Almere total graphs it was decided per BEST table which source was the most reliable.
The following data was taken (apart from BEST 7 coinciding with the data having the highest % of gross area monitored):

- BEST 1 Interviews
- BEST 2 Interviews
- BEST 4 Interviews
- BEST 5 Interviews
- BEST 7 'Energiegewicht' (Energy weight)
- BEST 8 Interviews
- BEST 17 'Energiegewicht' (Energy weight)

In figure 4.16 the total primary energy consumption and generation for Almere are given. The totals are based on as built area's of the buildings.

On the production side: the PV in the CDS (37 kWp on the waste separation station) no data have been gathered yet, so this is not shown in the CDS totals.
The heat production of the Solar Island is depicted in this graph. The production from July 2010 to July 2011 was 8772 GJ. Normalised to an average year (using irradiation data from Amsterdam) resulted in a yield of 8221 GJ, or 2284 MWh (2078 MWh_{prim}).

2284 MWh (330 kWh or 1.2 GJ per m^2 solar collector installed) is somewhat lower than originally specified (380 kWh or 1.4 GJ per m^2). However, utility Nuon who provided the data, has an as yet unsolved problem in their monitoring data. They found differences in two data streams measured with the same sensors and they do not know yet where the problem is, they will check the datalogging process. The data used here are the data giving the lower values of the two. Nuon reported that the system has functioned normally in this whole monitoring period. For the Solar Island, an interesting question from a performance point of view is whether such a ground based installation tends to give a higher or a lower yield than a large number of individual solar collectors on houses. In the Solar Island, all heat is added to the district heating system of Almere and utilized regardless of the individual heat demand in a specific home, which would increase the yield. On the other hand, before the heat can be utilized at all it needs to have reached a temperature of at least 80ºC (in order to be able to contribute to the district heating) rather than 60 ºC for a home, which would decrease the yield. The Solar Island also suffers more from distribution losses. With the data as it is it looks like the Solar Island performs slightly less. However, the data needs to be checked first in order to draw a conclusion on this. On the other hand, from the point of view of development, organization and management of solar energy, it is probably easier to have a single Solar Island then 900-1100 individual solar collectors. Another benefit of the Solar Island is the function of landmark and icon for the city of Almere.

Monthly data of the Solar Island are giving in Appendix B.

On the consumption side, it looks like the Concerto targets are more than achieved for the heat consumption. One factor that explains this is that originally planned Eco Houses in Columbus quarters / NPW have been better insulated than originally planned, because the Solar Houses were built mixed with the Eco Houses and it was easier in the building process to insulate all homes in the same way.

It is interesting to note that whereas in the standard situation heat consumption is still the largest consumer of energy, in the Concerto situation electricity consumption has become the largest consumer.
It should also be noted though that totals in MWh of consumption are based on as realised total gross area's. The total gross area is larger than originally anticipated. This is partially due to that more single family dwellings and apartments were eligible for cRRescendo. This is very positive and results in larger overall savings than originally foreseen. However, the second reason is that the average gross area per home and per apartment has increased significantly, especially for the single family dwellings. This trend is most pronounced in the area's with private commissioning, as more detached dwellings are built in this category. It is obvious that a larger home results in a larger energy consumption. Therefore, whether overall savings have been achieved depends on how you look at it and how you set the boundaries. All in all though it can be said that the gross area per home is not something that can be influenced by cRRescendo. Taking this into account, the picture shown in figure 4.17 seems a fair picture from a cRRescendo point of view. The data have been used for determination of the indicators.

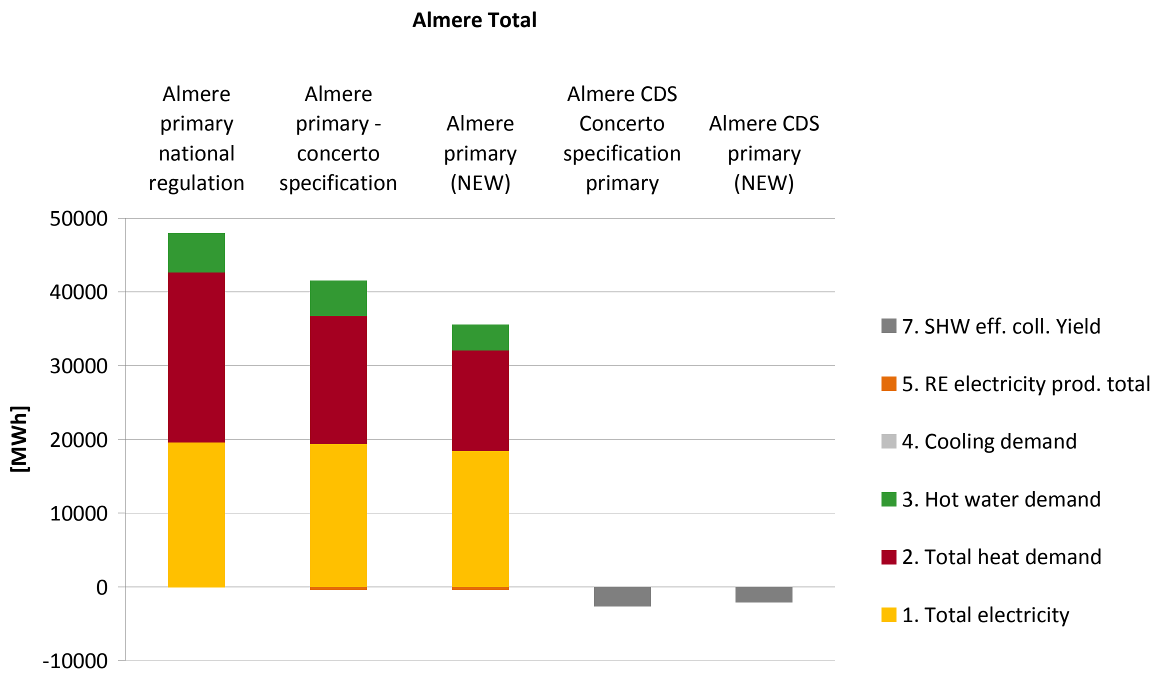


Figure 4.17 Almere total, as realised m^2 used both for specifications and monitored values

We will now discuss the indicators based on the monitoring results to date.

Indicator 1:
As no monitoring results are in for the PV-system on the waste disposal facility this indicator cannot be calculated yet.

Indicator 2:
Based on 2078 MWh_{prim}/year for the Solar Island, a total of 3517 MWh_{prim} of hot tap water and 13596_{prim} MWh of total heat demand in cRRescendo, the percentage of renewable heating in cRRescendo is **12%**.

Indicators 3 (reduction in energy consumption per m2 of each building type) Almere, based on monitored as well as calculated energy performance values, in primary energy.

Table 4.3 Indicator 3 from monitored values (primary energy)

BEST # / description	% reduction	% reduction aimed at
1: Apartment buildings Columbus quarters, Eco	30%	13%
2: Apartment buildings Columbus quarters, Solar	15%	19%
4: Single family dwellings Columbus quarters, Solar	21%	24%
5: Apartment buildings Noorderplassen West, Eco	29%	8%
7: Single family dwellings Noorderplassen West, Eco	26%	11%
8: Single family dwellings Noorderplassen West, Solar	34%	24%
17: 'Passive Houses' Columbus quarters	26%	35%

Indicator 4 the 'overall reduction in conventional energy consumption in the Concerto community (sum of efficiency gains and renewables supply) Almere:
Based on the data depicted in figure 4.17, which is equivalent to the numbers in the table below, overall **31%** of primary energy have been saved. In this number, PV-CDS data is not included as it is not available yet. This is better than the Concerto specification, primarily due to the lower heat consumption realised in the project.

Table 4.4 Overview primary energy flows Almere

	national regulation	Concerto specification	Monitored values
Primary energy factor electricity			
Primary energy factor heat			
Hot water consumption	5356	4773	3517
Heat consumption	23059	17408	13596
Electricity consumption	19571	19396	18511
Solar thermal-production		-2638	-2078
total (MWh)	47986	38528	33093
% reduction		**20%**	**31%**

For Almere, based in the data analysed thus far and our experience in the project, our conclusions are as follows:

- Overall it looks like the results are more than met.
- The floor area of the homes ended up larger than originally anticipated. Such effects cause the total energy demand for homes to keep rising, despite a substantial increase in efficiency.
- Upfront agreements on energy saving with project developers works better then trying to add energy saving during the design process. It is in the interest of the project developer to start developing. Once started, it is not in the interest of the project developer to build low energy dwellings. Energy saving is in the interest of the consumer.
- Mixing of various ambitions on energy-saving in the development of dwellings causes the lower ambitions to profit from the knowledge and lessons of the higher

ambitions provided exchange of knowledge is organised. This happens automatically in case the developer, architect and contractor are the same for all ambitions. Lower ambitions on energy saving can also profit from higher ambitions when the same construction method is used and the houses of both ambitions are dispersed.

Recommendations and ToDo's for the next year are:

- Gather monitoring results for the remaining BEST tables (3, 6 and the non residential buildings: 9 through 16 and 18).
- Find out the discrepancy in expected and realised values for the Solar Island. Analyse the performance of the Solar Island.
- When monitoring results of the 20 homes monitored in detail are available and analysed, check those results with the conclusions of the overall monitoring.
- Sending a questionnaire related to occupant behaviour on heating and ventilation. Analyze the results in relation to the energy-use and characteristics of the buildings.
- Analysis of a district heating system in an area with well insulated dwellings and a collective solar collector.
- Writing recommendations for the implementation and enforcement of future agreements on sustainable building.
- Investigate the validity of the national standard on energy performance of newly built low energy houses.
- Collect and analyse monitoring data for the non-residential buildings

- **RESULTS MILTON KEYNES**

In Milton Keynes, we report on BEST table A (441 apartments called C4.1 Residential), BEST table B (an office building, B3.2, 'the Pinnacle') and the Combined Heat and Power plant in the Energy Center. This is also shown from table 3.3. The data and interpretation of the data are based on the final technical monitoring report from Arup and over the period April 2010 – March 2011. For a detailed performance analysis of each of the buildings and especially the CHP plant we refer to this report. Whereas this report focuses on the buildings and plants that have been built with cRRescendo subsidy as is laid down in the contract with the EU, Arup's report includes more buildings.
Arup's report includes all buildings and installations that are connected to the Energy Center of which the CHP is a part. This has enabled Arup to get a full picture of the energy flows, including the losses that occur in between the production and the consumption of electricity and heat and including import and export of electricity. The following flows, measured in the period April 2010 – March 2011, are considered to be 'losses' in our analysis:

- 3% loss of the total CHP electricity production is 'lost' due to internal consumption at the Energy Center
- 9% of the total amount of electricity supplied to the site supplied by the Energy Center is lost or unaccounted for
- Of the total heat produced by the CHP and the peak boiler together, 9% is lost in the distribution (or unaccounted for)
- Of the total heat produced by the CHP and the peak boiler together, 11% is dumped

Taking these flows into account as losses in addition to the first generation losses and including electricity import and export, a Sankey Diagram is constructed of the Energy Center flows, shown in figure 4.21. It shows that 38% of the primary energy in the gas is converted to electricity that can be used for consumption (including export) and 25% of the heat is converted to useful heat for consumption.

Based on these numbers, the primary energy factors for heat and electricity are determined. If 0.9 is the primary energy factor attributed to the heat generation, the primary energy factor for electricity is 2.43. These are the values reported in the table in paragraph 3.4.

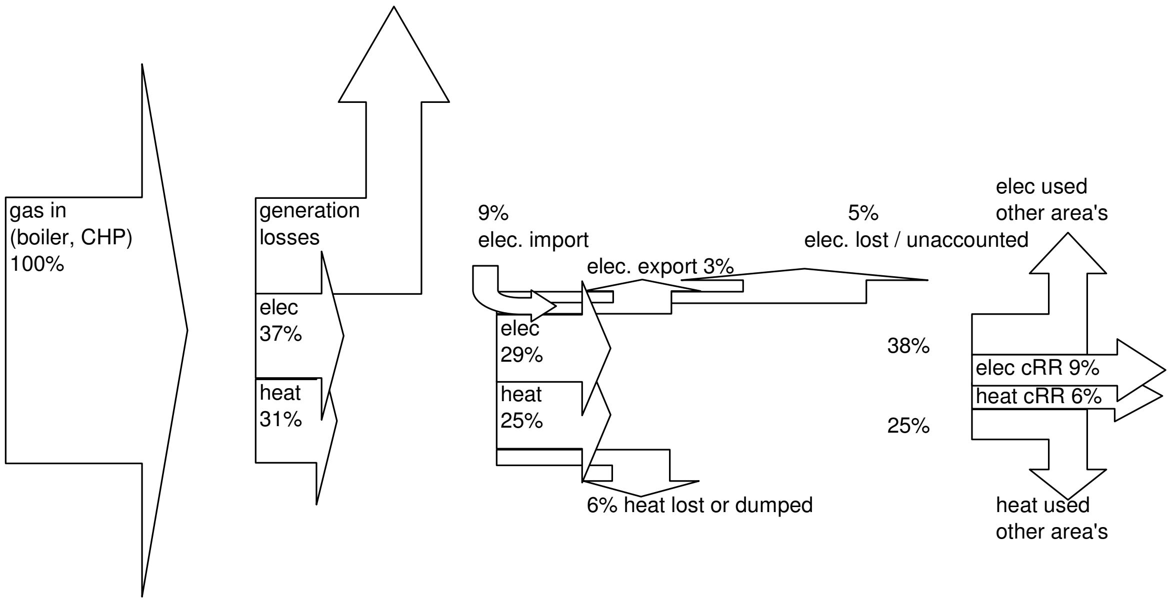


Figure 4.21 Sankey Diagram energy flows CHP in Milton Keynes

We now continue to show the results of the BEST tables, starting with BEST table A, C4.1 Residential, in figure 4.22.

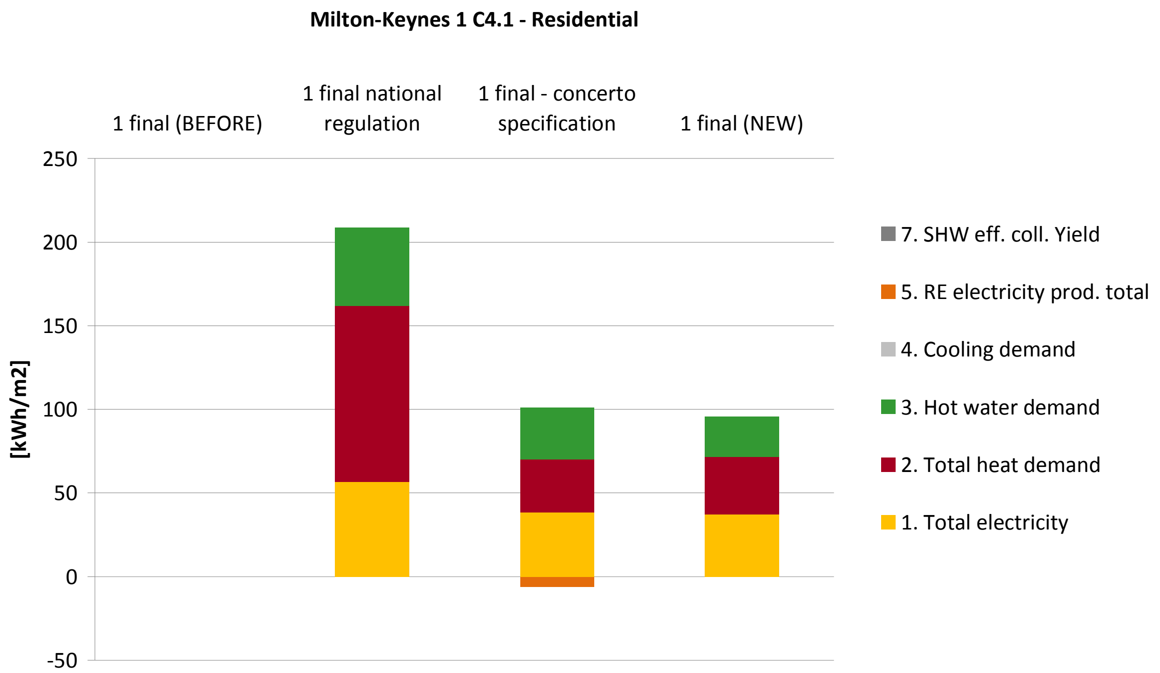


Figure 4.22 Final energy consumption of BEST table A, C4.1 Residential.

Because photovoltaic panels were supposed to be placed on top of the roof of the apartment building(s), this can be seen in the Concerto specifications. It turned out that this was not possible. The same happened with BEST table B, the B3.2 Commercial area. Instead of on those buildings, photovoltaic panels have now been placed on the bus station in Milton Keynes. As commissioning will be done in the autumn of 2011 no monitoring data are available yet.
Apart from that it is shown that the overall final consumption is more or less in line with Concerto targets. Hot water consumption not was measured separately, but determined by taking the heat consumption in the months June through September 2010, assume this to be representative for the average monthly hot water consumption and extrapolating this to a year.
In figure 4.23 the monthly electricity consumption of 42 individual apartments is shown.

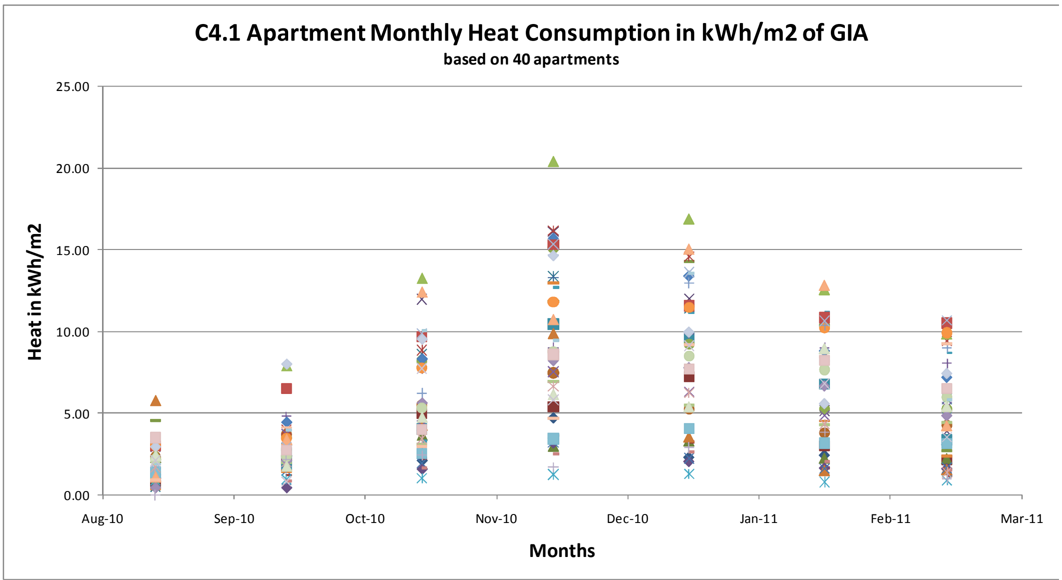


Figure 4.23 Monthly electricity consumption of 42 individual apartments from BEST table A (C4.1 Residential).

In figure 4.24 the results of BEST table B, B3.2 Commercial (Pinnacle Building), are shown.

Just as in Ajaccio, variation in consumption from apartment to apartment is very large. However, this time the number of apartments is large enough that the average consumption can be well compared with Concerto specifications. No corrections were done for vacancy of apartments. However, in this period we expect most apartments to be occupied.

Both heat and electricity demand are found to be higher, both compared to Concerto targets as compared to national average for office buildings.
In the summer of 2011 only 50% of the office and retail area's in B3.2 were occupied. This suggests consumption may even be higher if the buildings were fully occupied. On the other hand, it is likely that like most area's are heated and cooled and ventilated as if they were occupied, so for heat and cooling it may not make much of difference. For electricity demand it would make a difference. Analysis of the profile of electricity showed that the night time demand rarely falls below 50% of the day time peak. This indicates that a lot of equipment and lighting are not turned off during off-hours.
It is striking from the monthly totals (Appendix, figure C2) that cooling as well has heating takes place year round. Even though the cooling demand is more or less in line

with Concerto specifications, significant cooling consumption takes place in the winter months, where the ambient temperature is low enough that free cooling is possible.

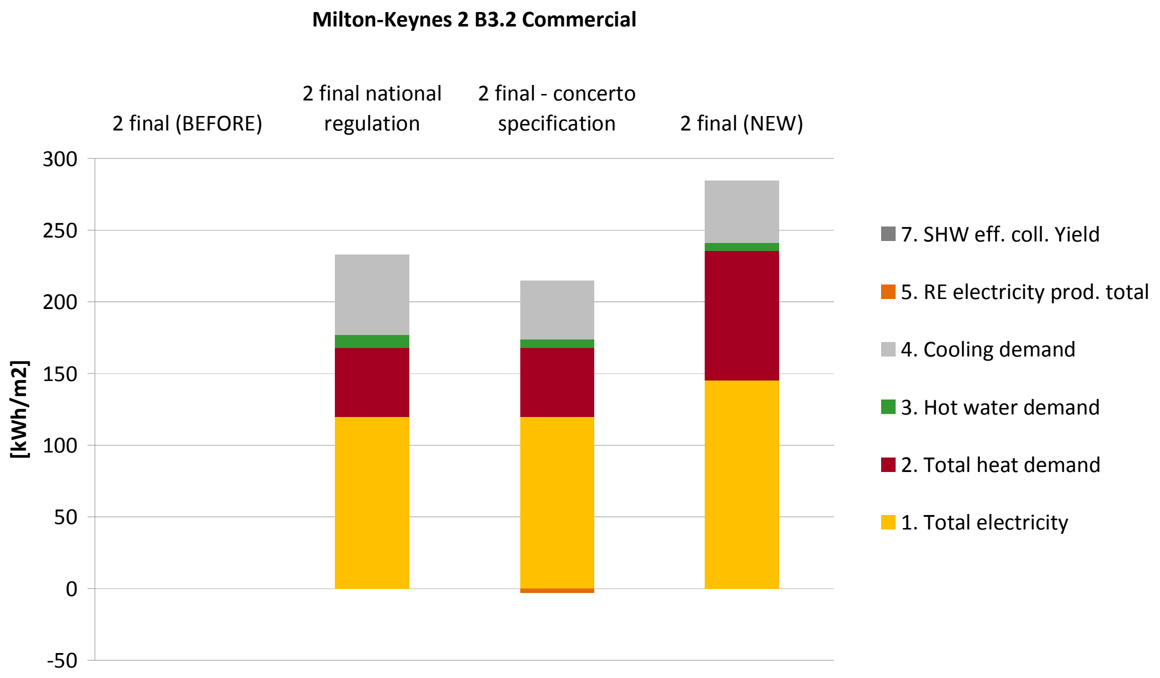


Figure 4.24 Final energy consumption of BEST table B, B3.2 Commercial (Pinnacle Building).

In the Arup report, the following recommendations for improvements in the performance of the development are done:

- The commercial buildings require attention as they are under performing and they have a major impact on the energy and carbon emissions from the development
- The energy management of the commercial developments should be reviewed as there is a high electrical demand evident during the unoccupied periods – over-night and weekends where electrical demand rarely falls below 50% of the daytime peak.
- The BMS and controls in the commercial buildings should be checked against occupancy as the energy demand is indicating operational periods in excess of 16 hours a day and weekend running.
- The control algorithms should be checked in the B3.2 commercial buildings as they are showing chiller operation during some of the most severe cold periods. The potential to use free cooling at these times should be explored.
- The thermal losses in the district heating system are indicated at 9% of delivered heat, for the year March 2010 to April 2011 which is expected performance. However previously to this period losses were seen to be much higher, so monitoring should be continued to ensure losses remain low.
- Comparing the electricity consumed at an individual building level with that supplied to the private wire system suggests a loss of 9%. This appears to be excessive and assuming losses in the transformers to be about 6% the remaining 3% needs to be accounted for.
- The CHP efficiencies for the period reported in the above Tables the electrical generation efficiency was 37% and thermal efficiency was found to be 30%. This corresponds to manufacturer’s nominal electrical efficiency of 42% and thermal

efficiency of 43%. There is a degree of over-sizing of the central plant to accommodate future expansion so one of the machine is often all that is required to meet the demand and that will be operating on part load for significant periods.

It is the intention of HCA in Milton Keynes to follow up on this and to check any improvements by continuing the monitoring one more year.

In figure 4.25, the overall monitoring results are depicted for Milton Keynes in comparison with national regulation and concerto specification. The 1st column gives the primary energy consumption according to national regulation or average practice. The 2nd column gives the expected primary energy consumption according to Concerto specification. The 3rd column gives the primary energy consumption according to monitored data. The 4th column gives the Concerto specifications for production of polygeneration and renewable energy supply (CHP and PV). The 5th column gives the monitored primary energy production from polygeneration (CHP).

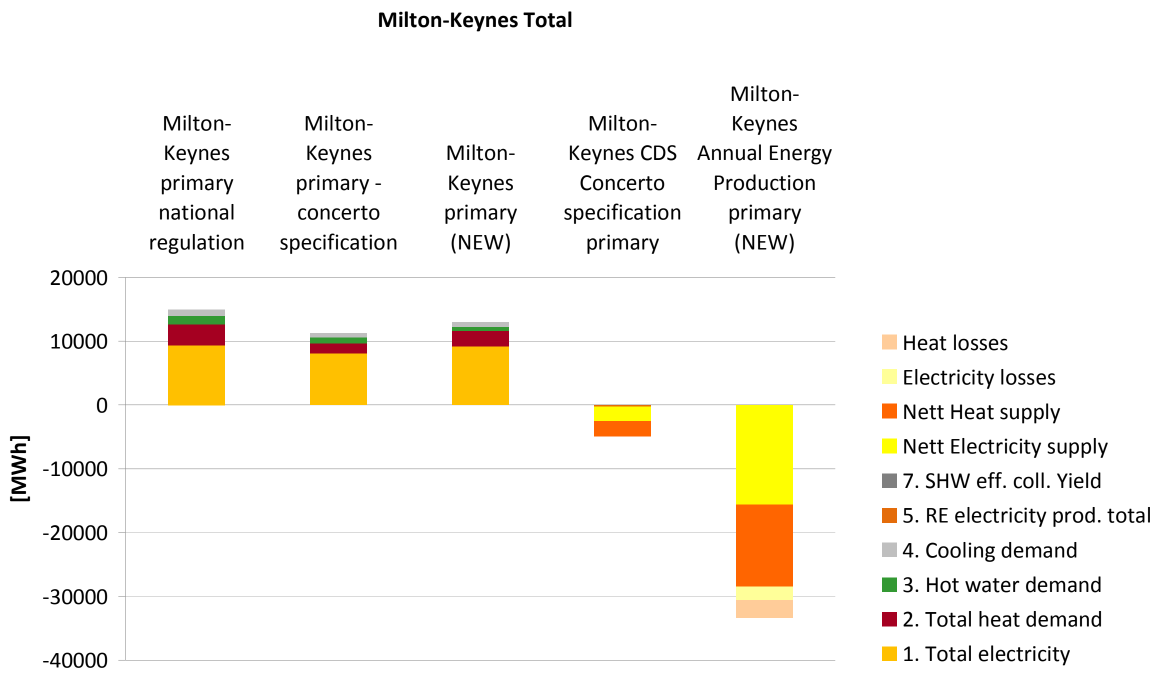


Figure 4.25. Primary energy consumption and production of the cRRescendo part of the Milton Keynes Development (BEST A, BEST B, PV on bus station).

It should be noted that the realised CHP production and targeted CHP production cannot be compared in a straightforward way, as it can with renewable energy. Discrepancies between expected and realised production are not only cause by performance issues of the CHP, but the number of full load hours can be different from that used in the calculations.

We end with reporting the technical indicators. In the technical indicator 1 and 4 we assumed the PV panel to perform according to specifications, for the sake of being complete. Next year we will be able to update this with complete information.

Indicator 1:
If the 165 kW PV-system on the busstation to be installed this fall behave as expected and produces 92 MWh per year, and if the electricity consumption in the cRRescendo

community in Milton Keynes stays what it was in the period April 2010 – March 2011, the percentage of renewable electricity would be 2.4%. This is a little lower than it could be because of the higher electricity consumption in the BEST table B, B3.2 Commercial. If the electricity consumption would be on cRRescendo target, 2.8% of the electricity consumption would be renewable.

Indicator 2:
There is no renewable heat in Milton Keynes, so this indicator is 0%.

Table 4.5 Indicator 3 (reduction in energy consumption per m^2 of each building type), based on monitored as well as calculated energy performance values, in primary energy.

BEST # / description	% reduction	% reduction aimed at
A 441 apartments – C4.1 Residential	48%	45%
B stores and offices – B3.2 Commercial (Pinnacle Building)	-14%	8%

In case of BEST table B, B3.2 Commercial, there is no reduction in primary energy consumption achieved yet, due to factors already described above[4]. There is the hope though, that with optimisation of the energy management a reduction will be achieved.

Indicator 4:
In calculating indicator 4, the 'overall reduction in conventional energy consumption in the Concerto community (sum of efficiency gains and renewables supply)', several ways exist of dealing with the CHP, the associated losses and the cRRescendo boundaries.
Our method was as follows:
We assume the CHP (and the total energy produced by it) and BEST table A and B (and the total energy consumed by it) as cRRescendo boundaries.
There are two efficiency components that lead to an overall reduction in conventional energy consumption: (1) on the consumption side the increased efficiency of the buildings and (2) on the production side the increased generation efficiency of electricity and heat, compared to electricity from the grid and gas heating as reference. In addition, there is a renewable energy contribution from the PV panels.
Regarding the energy produced by the CHP: whereas electricity and heat have primary energy factors of 2.92 and 1.02, respectively, in energy performance for building calculations, based on monitored values and efficiencies of the CHP-plant, values of 2.43. and 0.9 have been determined.
As the production for heat as well as electricity of the CHP is higher than the consumption, it is valid to say that these lower primary energy factors apply to all cRRescendo consumption.
In combining the savings from the consumption and the production side, we use national regulation primary energy factors for the consumption according to national regulation, and the primary energy factors based on monitoring data from the CHP for the consumption in the new situation. When this is done, the following results:

Tabel 4.6 Monitored primary energy flows Milton Keynes

	national regulation	Concerto specification	Monitored values

[4] For the cooling consumption a Primary Energy Factor of electricity (2.43) for converting to primary energy was used. This may not be correct because the commercial building B3.2 used cold from (not well functioning) absorption chillers. However, this does not influence final results and conclusions very much.

Primary energy factor electricity	2.92	2.43	2.43
Primary energy factor heat	1.02	0.9	0.9
Cooling consumption	3145	1917	2036
Hot water consumption	1458	854	667
Heat consumption	3821	1606	2405
Electricity consumption	11216	8111	9234
PV-production		-520	-520
total (MWh)	19639	11968	13822
% reduction		**39%**	**30%**

The reduction in primary energy is partly due to the increased efficiency of the buildings (BEST A, namely) and partly due to the CHP. Taking the same primary energy factors for the before and the monitored-after situation, would result in a reduction in primary energy consumption of 14% instead of 30%.
The lower reduction compared to the Concerto specifications is mainly caused by two effects:

- The way too large consumption of BEST table B, B3.2 Commercial (cooling, heating as wel as electricity)
- The fact that the CHP is operating at partial load more than planned has a lowering effect on the efficiency

It can be concluded that, even though significant savings have been achieved, there is still potential for improvement.

Overall recommendations and ToDo's for the Milton Keynes project:

- Follow up on Arup's recommendations and keep monitoring the CHP and commercial buildings for another year.
- Get into contact with the tenants of the commercial building on energy management

4.4. Results Viladecans

In Viladecans monitoring results are available from November 2010 through June 2011, or eight months. For correction to a climatalogically average year it is better to have a full year available. However, this was not the case. Therefore, the monitored yearly results shown for BEST table B, C, D and E and the 342 kWp PV systems are derived from these eight months. The results should be considered as preliminary.

Monthly data of each of the BEST tables can be found in Appendix B.

First we show totals of final energy demand and production of BEST table B, day care centre La Pineda that was newly built, for the national regulation / average, Concerto specification and monitored results. Heat consumption from monitored results turns out be much larger than Concerto specified, even much larger than 'national regulation'. In figure B1 in Annex B it can be seen that heat is consumed through the month of May 2011 and the maximum per month (18 kWh/m^2/month) is also very high, in fact it already equals a full year of heat consumption according to the specifications.
In the months of April and May both heating demand and cooling demand is found, but compared to the yearly average this is a small contribution and could easily be attributed to some cold mornings and hot afternoons.
It still remains to be examined why the discrepancy between specification and measurement of heat demand is so large, more than can be explained by issues like occupancy. It is ofcourse clear that in a daycare centre, where children under one year old are taken care of, will require substantial heating. One would expect that to be taken into account in the specifications.
It was also found during this monitoring period that the sum of heat and hot water consumption is 80% of the gas consumption. As the heating system is a condensing boiler one would expect this to be on the order of 100%. It could be that some heat or hot water consumption is missing in the measurements.
In the next year, monitoring will be continued, enabling more than a full year of data to be gathered. Also the calculations of the specifications will be double checked. Hopefully this will reduce the discrepancy between expected and measured data.

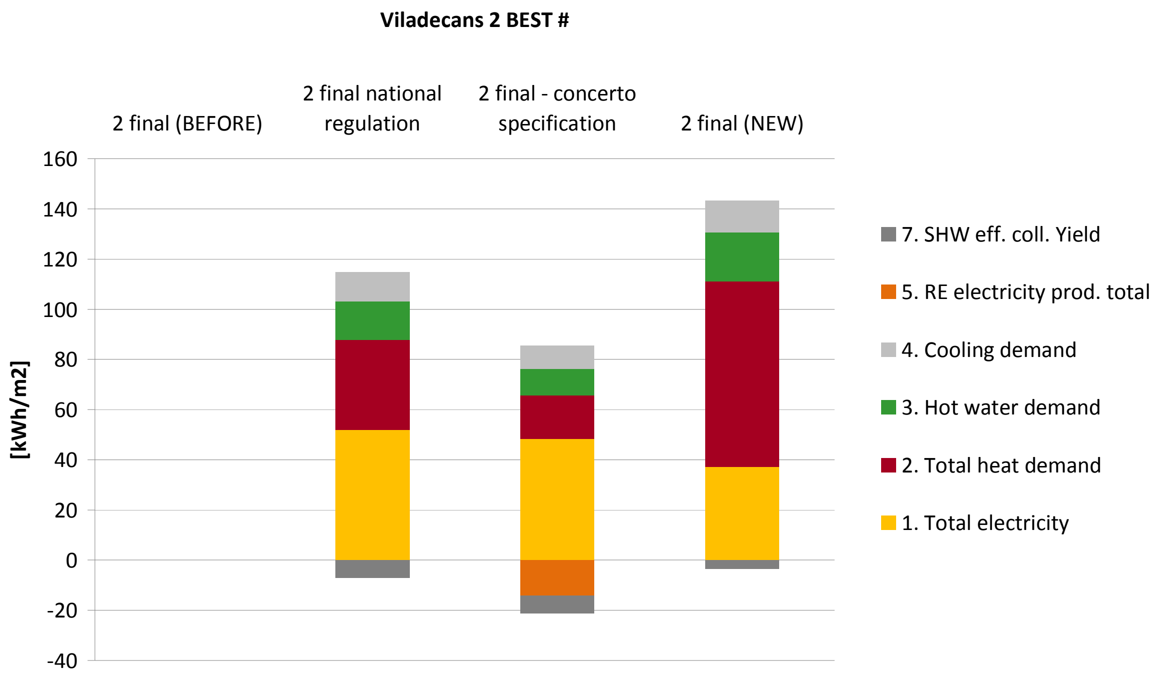


Figure 4.26 BEST B Day care centre La Pineda, newly built. Comparison of final energy per m^2 according to national regulation / average, Concerto specification and monitored data.

Solar hot water production is only 50% of the Concerto specifications. In fact, some problems with the collector have been reported. Due to some incidences with collector liquid losses in the primary circuit it has been out of order for a while.

Even though PV was foreseen in the Contract, no PV was placed on the day care Centre. Instead, the 342 kWp from the CDS table was placed on other buildings.

In figure 4.27 we show totals of final energy demand and production of BEST table C, refurbished Cultural Centre Can Xic, for the national regulation / average, Concerto specification and monitored results. Electricity consumption higher than expected. Cooling demand and heat demand are significantly lower than the Concerto targets. However, care should be taken especially for the cooling demand, as extrapolation to a yearly total has taken place of only three months of cooling data, in which one third of the yearly cooling degree days occur.
Also, for all flows it should be realised that occupancy greatly affects demand and might be higher or lower than the assumed standard.
10.2 kW of PV was placed on the building but it is not part of cRRescendo and therefore no monitoring data is reported here.

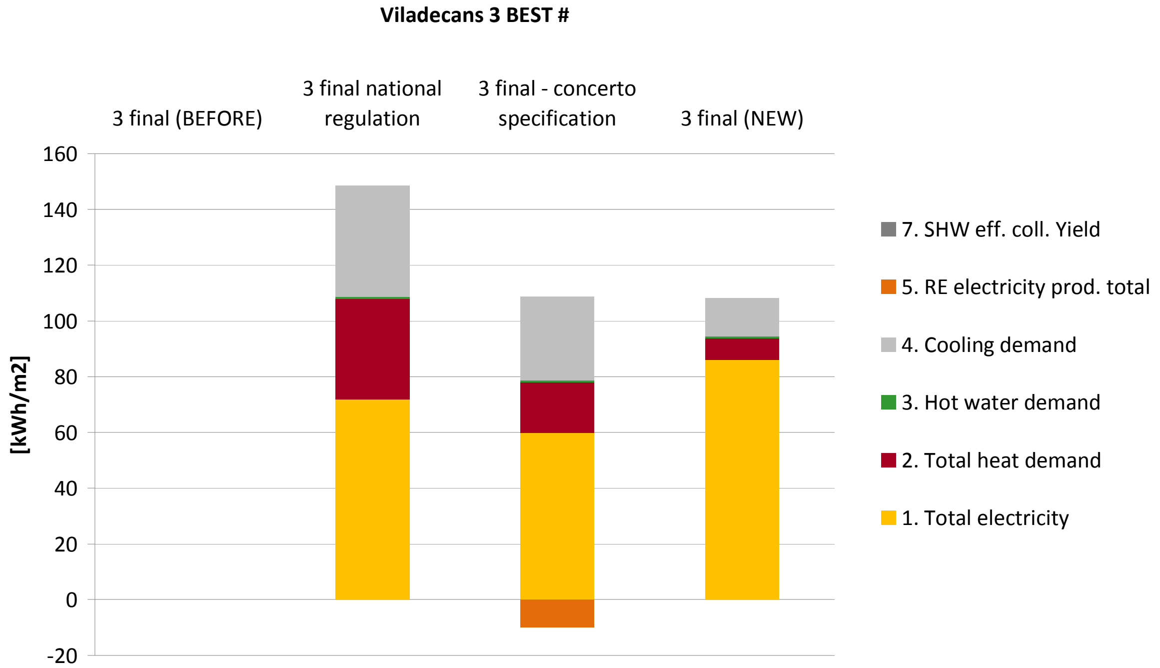


Figure 4.27 BEST table C Cultural Centre Can Xic, refurbishment. Comparison of final energy per m^2 according to national regulation / average, Concerto specification and monitored data.

Next we show totals of final energy demand and production of BEST table D, football fields and sports facilities Torre Roja, newly built, for the national regulation / average, Concerto specification and monitored results.

It turns out that the electricity consumption measured also includes the electricity consumption from lighting at the soccer fields, whereas this is not taken into account in the Concerto specifications. In the Concerto specifications, only electricity consumption from the buildings is taken into account. For the last year of monitoring extra meters will be placed to separate the contribution of the soccer fields from the electricity consumption of the building.
Hot water and heating demand are also higher. However, it was found that these measurements are not reliable due to interference of some regulation elements with the meters. This has been fixed now, enabling better measurement in the last monitoring year.

In the Concerto specifications PV was foreseen, but this was not realised, at least not on this building.

The solar hot water production is calculated to be much higher than Concerto specifications, but this is deceptive. In fact, the solar hot water system malfunctioned most of the monitoring period, resulting practically zero production in the months of November through April 2011. Therefore the data shown is based on only two months of monitored data.

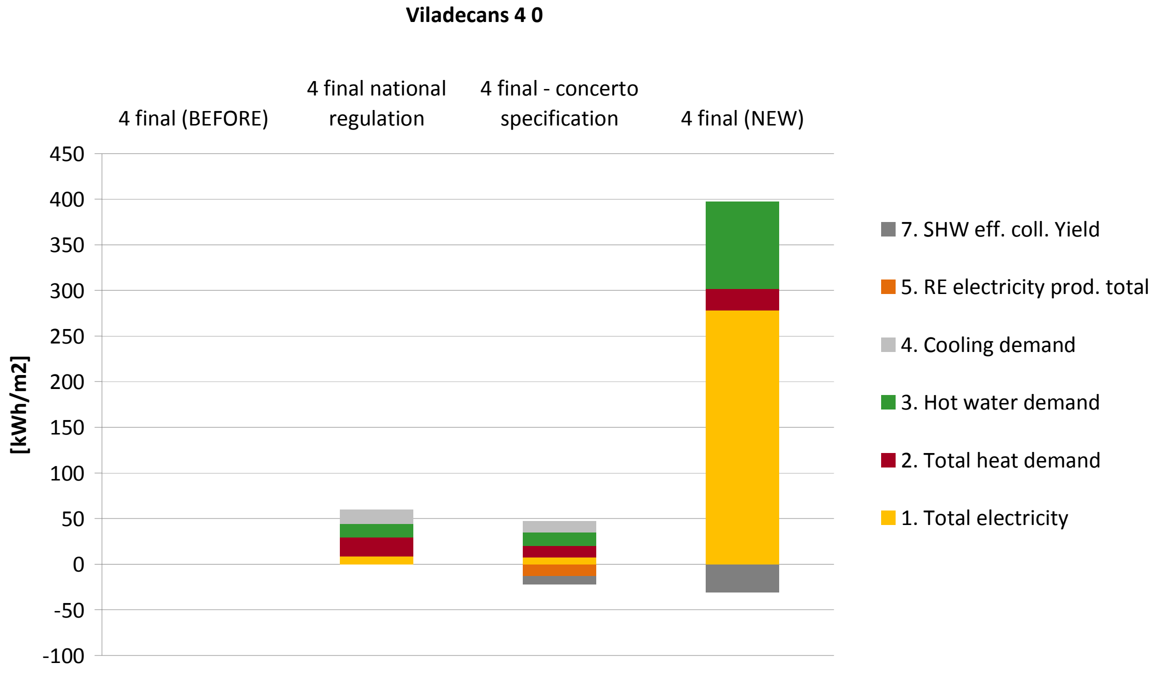


Figure 4.28 BEST table D Football fields and sports facilities Torre Roja, new. Comparison of final energy per m^2 according to national regulation / average, Concerto specification and monitored data.

Next we show totals of final energy demand and production of BEST table E, refurbished Cultural center Can Amat / Pablo Picasso, newly built, for the national regulation / average and Concerto specification.

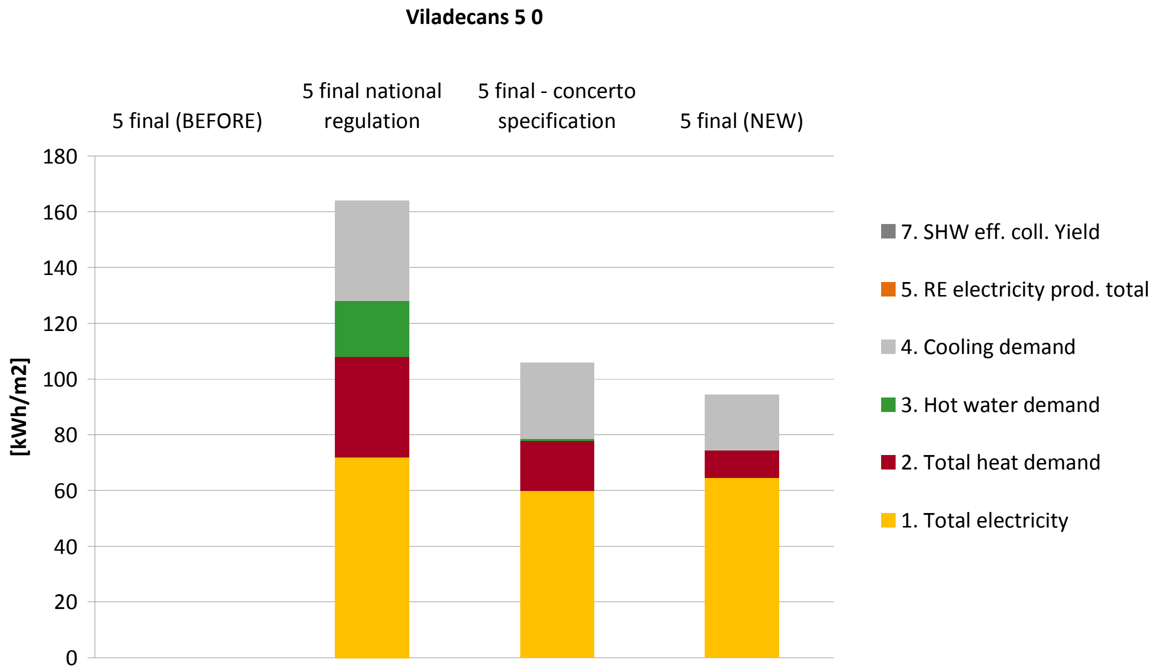


Figure 4.29 BEST table E Cultural center Can Amat / Pablo Picasso, refurbishment. Comparison of final energy per m^2 according to national regulation / average, Concerto specification and monitored data.

At the time of processing, only four months of data were available, which is quite low for extrapolation to a complete year. This is especially for heating as the heating season was practically over when the monitoring started. Therefore, the data should be taken as indicative. Nonetheless, the totals for cooling and electricity flows seem to be reasonably in line with Concerto specifications.

In figure 4.30 below we show totals of final energy demand and production of BEST table F, municipal technical service building Ceip Ponent, to be newly built starting Jan. 2012.

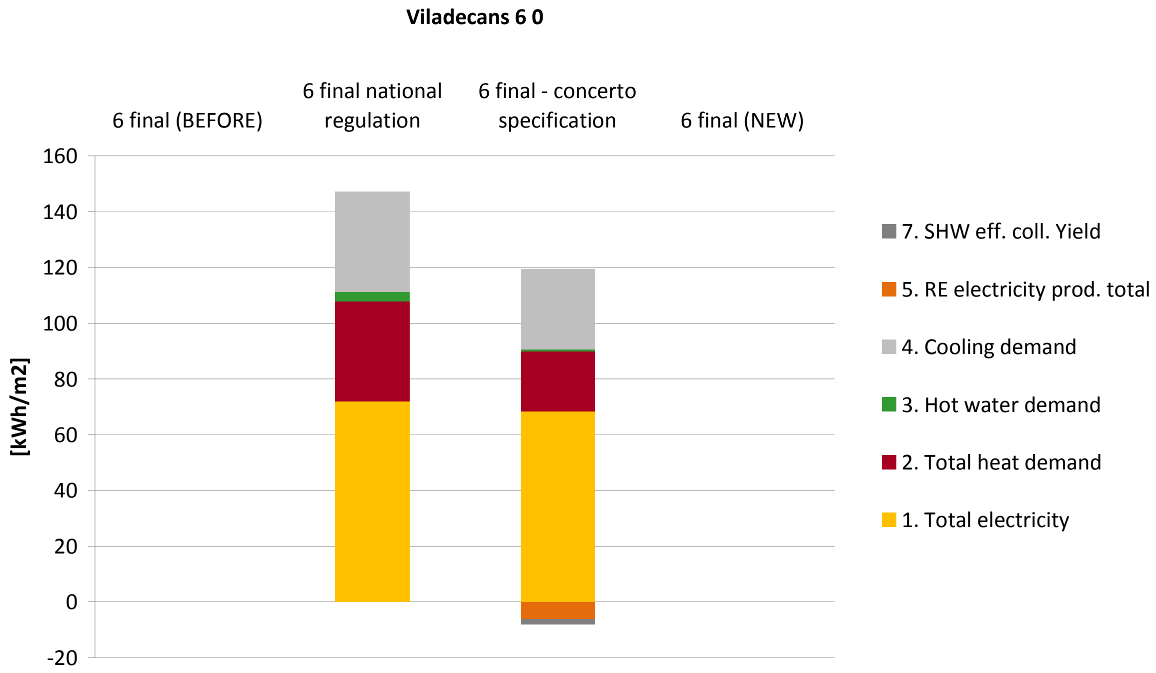


Figure 4.30 BEST table F Municipal technical service building Ceip Ponent, to be newly built starting Jan. 2012. Comparison of final energy per m^2 according to national regulation / average and Concerto specification.

Even though data at Viladecans are not complete yet, an overview of all results achieved to data is given in figure 4.31. In this graph, total demand from BEST table B (Day care centre La Pineda), C (Cultural Centre Can Xic) and E (Cultural Centre Can Amat) is added together. In addition, the production of 117 kWp of PV is shown. In the end, 342 kWp will have been installed as part of cRRescendo, but only of 117 kWp monitoring data were available by this time. The PV-systems perform as expected. Also, the totals of these BEST tables also more or less perform as expected. It should be noted that the sports facilities, BEST D, are left out because no good monitoring data are available yet.

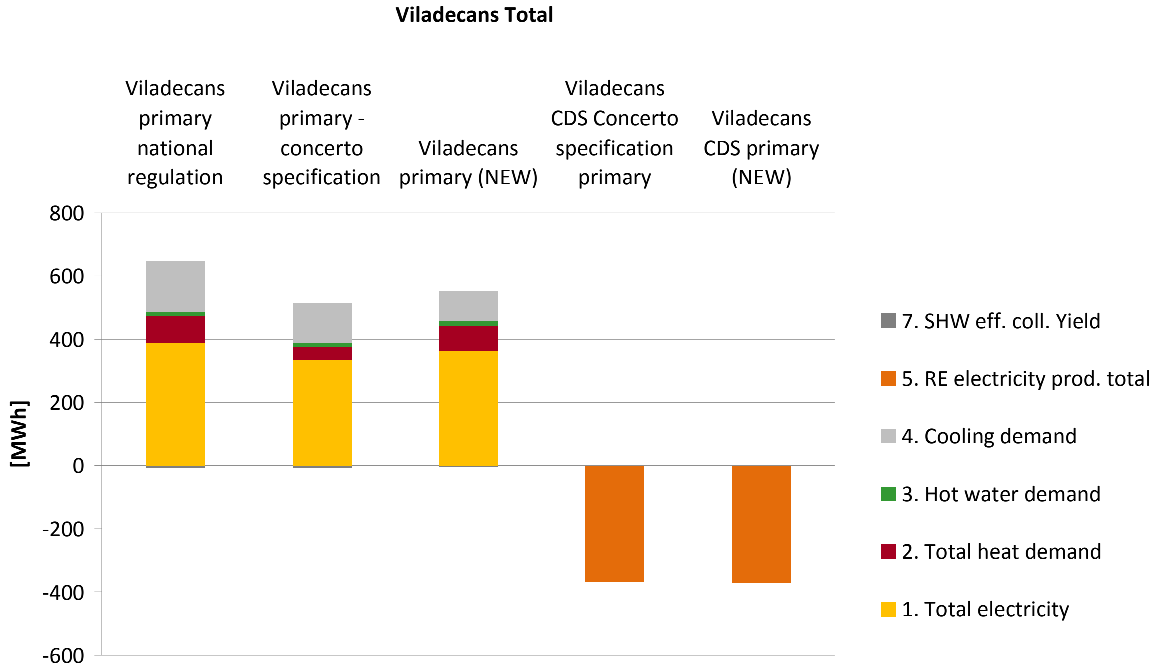


Figure 4.31 Primary energy consumption and production in the whole Viladecans project realised and monitored up until summer 2011 (BEST B, C, E and 117 kW PV).

In order to get an idea of how this overview of total monitored systems and buildings compares to the total amount of energy consumed and produced within the Viladecans cRRescendo project figure 4.32 is shown. These are the calculated values in the normal situation and Concerto specifications.

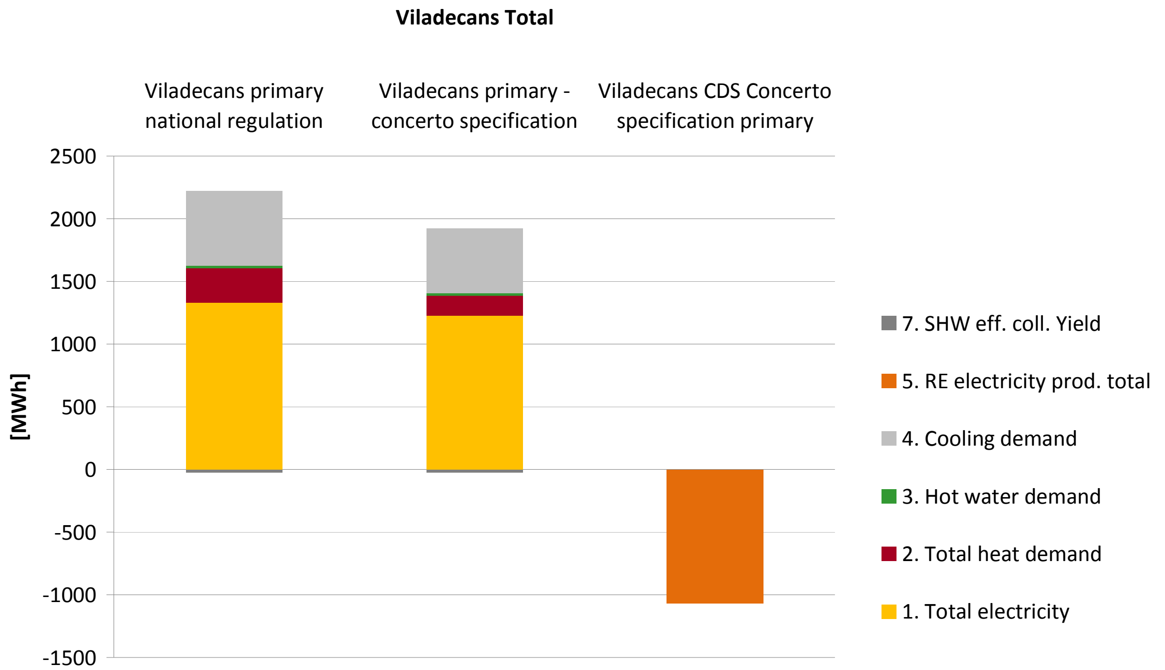


Figure 4.32 Primary energy consumption and production in the whole Viladecans project expecting to be realised and monitored by Aug. 2012 (BEST B, C, D, E, F, 342 kWPV).

With the data available it is not so useful to calculate indicator 1,2 or 4 just yet. Even for indicator 3 more data are required for reliable numbers. However, preliminary numbers for BEST B, C and E are given in table 4.7 below.

Table 4.7 Indicator 3 (reduction in energy consumption per m^2 of each building type), based on calculated energy performance values and primary energy.

BEST # / description	% reduction	% reduction foreseen
B Day Care Centre	-5%	36%
C Cultural Centre Can Xic	18%	31%
E Cultural Centre	25%	20%

It should also be realised that differences in consumption between specifications and measured values can be due to differences in occupancy and differences in non building related electricity consumption, as the baseline values are based on averages.

Indicator 1:
101% renewable electricity

Indicator 2: 0% renewable heat

Indicator 4: 77% reduction in primary energy.

Tabel 4.6 Monitored primary energy flows Viladecans, of monitored buildings (BEST B, C, E) and 117 kW of PV

	national regulation	Concerto specification	Monitored values
Cooling consumption	160	128	94
Hot water consumption	14	10	18
Heat consumption	84	41	79
Electricity consumption	390	337	363
PV-production		-365	-370
total (MWh)	648	151	184
% reduction		**77%**	**72%**

Preliminary conclusions for Viladecans are therefore:

- BEST B, the day care centre, has a much higher heat demand that specified and it should be found out where the discrepancy is.
- BEST C, Cultural Centre Can Xic, has a lower heat and cooling demand than specified but a higher electricity demand. An extra year of monitoring would be worthwhile to verify is behaviour is observed over a longer period of time.
- BEST D, the sports facilities, have experienced some measurement problems. The measurements will be done again the last monitoring year.
- BEST E, Culture Center Can Amat, behaves as expected or better.
- The monitored PV-system performs as expected.
- Overall it looks like savings are somewhat lower than expected. However, it should be noted that with the buildings in Viladecans, more than with houses

depend on degree of occupancy and could easily skew results toward higher or lower numbers.

Recommendations are to continue monitoring the buildings until more and firmer results are achieved, to monitor the remaining PV-system and to look into the heat demand of the day care centre.

4.5. Details of long term Concerto community energy management

The 13th indicator required by the EU is 'Details of long term Concerto community energy management and monitoring systems, which continue to operate after the end of the project'. There are several compelling reasons to continue to monitor the buildings and plants. Two main reasons are:

- Energy savings: many studies have shown that monitoring and feedback of this information to the consumer produces energy savings on the order of 5 – 10%[5]
- Renewable energy: especially with small renewable energy systems there is a risk that malfunctioning is not noticed which can result in serious down-time.

Below, we explain how Milton Keynes and Ajaccio have taken measures to ensure that savings will continue to be met or will be met in the longer term future. Almere and Viladecans will report on this by the end of the project.
For each of the communities we distinguish between utility maintained, buildings in the services sector and residential buildings, as given in the overview below.

	Utility maintained systems	Dwellings Rental / private	Buildings services sector
Ajaccio		SHW	
Almere	Solar Island	PV	
Milton Keynes	CHP, PV		
Viladecans			PV

production **consumption**

Utility maintained systems

In **Almere** the Solar Island, maintained by utility Nuon, is being monitored from a distance. There are two people responsible for maintenance of the Solar Island. Therefore down time will be noticed quite quickly.

The CHP system at **Milton Keynes** is operated and maintained by a specialist company called Thameswey. They are effectively a privately owned utility company who generate, distribute, meter and sell the heat and power from the energy centre in central Milton Keynes. Because Thameswey pay for all of the fuel and maintenance for the energy plant, they endeavour to opporate the plant as efficiently as possible, to maximise their profit margin.

Thameswey do not, however have a commercial incentive to help their customers to minimise the energy consumption. For that to be achieved, there would need to be an arrangement whereby Thameswey were rewarded for energy not used. Such commercial

[5] For private consumers: see e.g. S. Darby: The effectiveness of feedback on energy consumption, Environmental Change Unit, University of Oxford, 2006, or L.T. Firet: Directe feedback energiegebruik helpt bij energiebesparing, TU Eindhoven, 2009.

arrangements are almost unknown in the UK and are at odds with the expectations of energy consumers.

The commercial arrangements for the new PV array in **Milton Keynes** are not yet finalised, but it is anticipated that the scheme will benefit from a Feed-in Tariff that will incentivise the future operator to maintain the system at a high level of efficiency.
The system will be equipped with automatic meter reading equipment, which will be internet enabled. This is so that the system performance data can be accessed remotely, enabling problems to be spotted and achievements publicised.

BUILDINGS IN THE SERVICES SECTOR

Some general recommendations for energy management in the services sector can be made[6]:

1. Ensure that good and comprehensible energy monitoring systems are implemented
2. Securing energy management in the organization is a necessary precondition for achieving electricity savings. The presence of a good energy management policy must be a condition for subsidies and other government facilities.
3. Provide the right internal incentives. After all, it's the people on the work floor who have to make the energy savings. A targeted reward system can ensure that sufficient attention is devoted to energy saving.
4. Provide the right external incentives. Companies and government organizations can include criteria for energy performance of their suppliers in tenders. This is an effective way of completing chain responsibility.

Below we discuss each of the communities approach on this.

In **Ajaccio**, after reference monitoring of the public service building St. Jean was done by Ademe, efforts have been made to convey the results and the recommendations to the staff of the building, including the director, who is in principle responsible for energy management. In addition, at the entrance of the public service office building a display was placed with information on energy consumption, see the picture in figure 4.33.
The information on the screen informs the public not only about the energy consumption but also the CO_2 emissions.
The information about the CO_2 emissions is especially in Corsica very important because 1 kWh produced in Corsica produced 738 g of CO_2, it is five times more than in France. (46 % of electricity in Corsica is produced by thermal power station with fuel oil).

Despite these efforts, serious and systematic efforts for energy management in the service sector in Corsica is only just beginning. Efforts are now targeted to getting energy performance certificates with a label at the entrance of buildings with a public function, as is prescribed by the Energy Performance for Buildings Directive. A lot still needs to be done in this area.

In **Almere** the monitoring of the non-residential buildings is not finished yet. It is planned to combine this with information on energy management and will be reported next year.

In **Milton Keynes** the commercial buildings are operated by the tenants. It is not known if energy management procedures are in place.

[6] From K. Blok et al "Urgent action needed! Recommendations for electricity savings in the Netherlands", Sept. 2010

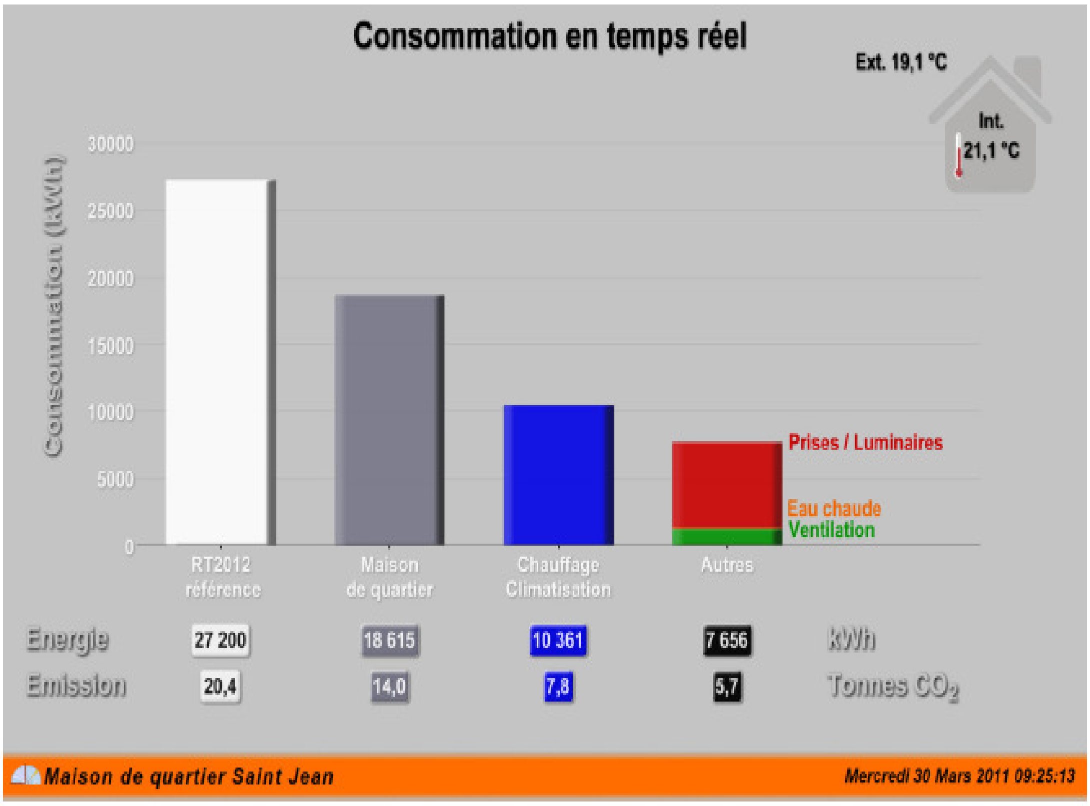


Figure 4.33. Display public service building St. Jean, Ajaccio. The first column indicates the total energy consumption of a public service office building built in October 2011. The second column indicates the total energy consumption of the building on-line. The third column indicated the space heating or the cooling energy consumption and the last column the rest of the energy consumption. On the top right corner, the external and inside temperature are indicated.

Residential buildings

In residential buildings it is up to the inhabitants to keep track of their energy consumption. The only thing that can be done by institutions from outside is to increase awareness through campaigns.

In **Ajaccio**, there is an organization who informs the citizens in Ajaccio about energy savings and renewable energy system. This organisation is financed by ADEME, it is one of the so called energy information offices (espace info energie).
Specific to the cRRescendo project: it was found that some tenants are interested by the solar hot water system installed in the social housing buildings. Some of them are checking the energy bill to see how much money they have saved after the installation of the solar hot water system.

In **Almere**, as part of the cRRescendo project, each inhabitant has received an ‘energiegewicht’ booklet, with a lot of practical information and tips on energy savings.

5. CONCLUSIONS

Conclusions on the performance

In this report, first monitoring results have been presented of all cRRescendo communities: Ajaccio, Almere, Milton Keynes and Viladecans. The nature of the work done and buildings built varies quite a lot in each of the communities. In addition, the extent to which monitoring results were available to get a good picture of how the cRRescendo funded buildings and plants and the community as a whole performs also varies considerably. The summaries per community are as follows:

In **Ajaccio** mostly refurbishment of apartment buildings, in total some 420 apartments, has taken place. The new apartment building in the historic city center (BEST table 1, 8 apartments) is finished but not monitored yet. The new public service office building (BEST table 4) is not built yet and therefore not monitored. Monitoring results of refurbished apartment building are too limited to draw any conclusions at this time. With one year monitoring more can be said about this category, about the newly built apartment building and about the 350 m^2 of solar collectors that have been installed on various buildings. For the new public service office building still no data will be available by the end of the project. All cRRescendo buildings and installations are expected to save 20% (2.5 GWh_{prim}) in primary energy compared to business as usual when all buildings have been built.

In **Almere** some 1800 single family dwellings and 300 apartments have been built within cRRescendo. Homes have been built in three efficiency categories: eco, solar and 'passive'. Monitoring results show that overall the performance of the homes is well in line with the expectations. For Eco Houses the heat consumption tends to be even lower than specified, because they were brought up to the same insulation level as the Solar Houses. In addition, the Solar Island has been built, producing enough heat for the tap water needs for some 1000 households. The Solar Island is performing somewhat less than expectation, but some checks in the monitoring system still need to be done to confirm this. Monitoring of 37 kWp of photovoltaics and 9 non residential buildings is still to come.
Based on the monitoring results collected thus far, the Almere cRRescendo project has saved 30% (14 GWh) of primary energy compared to a business as usual situation. The floor area of the homes ended up larger than originally anticipated. This happened especially in NPW and to the largest extent in the areas where private commissioners built their houses. Such effects could cause the total energy demand for homes to keep rising, despite a substantial increase in efficiency.
According to the original specifications 19% (9GWh_{prim}) would have been saved.

In **Milton Keynes** a new apartment building with 441 apartments and a new commercial building have been built. In addition, a 3 MWe combined heat and power generation plant is now in operation. The apartments perform in line with Concerto specifications, but the commercial buildings consume substantially more electricity as well as heat. The CHP is performing at a lower efficiency level than foreseen due to larger periods of partial load operation thanforeseen. Nonetheless, based on the monitoring results to date, 30% primary energy (5.8 GWh_{prim}) has been saved in the project compared to business as usual. This includes the PV-system on the bus station that is due to be built in the fall of 2011. It should be noted that savings calculations are based on savings in heat and electricity consumed in the cRRescendo buildings. For the

CHP alone without the buildings, using the same primary energy factors, savings would amount to 9.2 GWh_{prim} (16% savings with respect to business as usual).

In **Viladecans** two public service buildings have been newly built and two buildings have been refurbished. One municipal technical service building is still to be built. Preliminary results of monitoring of the four buildings show mixed performances, varying from 5% increase in primary energy consumption of day care centre la Pineda (BEST table A) to 25% reduction for refurbished Cultural Center Pablo Picasso (BEST table E). Some problems were encountered with the monitoring of the sports facilities Torre Roja (BEST table D). The PV-system (117 of the 342 kWp) performs according to expectations.
Based on the monitoring results to date, 77% primary energy (0.5 GWh_{prim}) has been saved in the project. These large savings are primarily due to the 117 kWp PV-system. According to the original specifications, including the to be built municipal building and including all 342 kWp PV, 79% (0.8GWh_{prim}) would have been saved.

These summaries clearly show the diversity in the community projects as well as the monitoring results:
For Ajaccio, projected primary energy savings compared to business as usual are comparatively modest but nonetheless significant, based on efficiency measures as well as renewable energy, both heat and electricity.
For Almere, project primary energy savings are substantial both in % as in GWh_{prim}, primary achieved by increasing efficiency in buildings but also a significant portion in renewable heat.
For Milton Keynes savings are considerable both in % as in GWh_{prim}, to a modest extent by increasing efficiency in buildings and to a large extent by efficient generation of heat and electricity by the CHP.
For Viladecans, the percentage of primary energy savings is huge in % and modest in GWh_{prim}, primarily achieved by renewable electricity and to a modest extent by efficiency measures.

It is interesting to note that electricity is becoming the largest consumer of primary energy in buildings. For the services sector this was already the case in the reference situation, but with efficient buildings this is now also the case for residential buildings, even in northern climates like the Netherlands and the UK.
The most efficient homes built are the 'passive' homes in Almere, with a total final energy consumption of about 70 kWh/m^2. The most efficient non-residential building is refurbished Cultural Center Can Amat in Viladecans, with (based on preliminary data) a total final energy consumption of more than 90 kWh/m^2.
For three out of five non residential buildings monitored consumption turned out to be significantly larger than expected. Even though discrepancies could be caused by something as basic as operational hours, it clearly shows the need to monitor, understand and manage the consumption in non-residential buildings.

Conclusions on the monitoring

Over the course of this project, a number of lessons learned can be drawn from the monitoring process and results.
Concerning the process:

- As cRRescendo had no other choice than to follow the plans in the building process and as those plans kept changing, it was impossible to make detailed monitoring plans far ahead, even though it was originally anticipated to do it like this. Therefore, in practice, in the end it was decided to wait until the dust of the building process had settled down and final buildings plans were mostly known (and actually built) before starting the monitoring.

- At the start of the project, it was foreseen to compile results of all communities in one large monitoring database, in the detail and time resolution that it was collected for each of the buildings and plants. This would have enabled data analysis on various aggregation levels. However, due to the credit crisis, the number of buildings decreased. In addition, the development of the database foreseen for cRRescendo, that was supposed to be a generic monitoring database for a multitude of projects other than cRRescendo, was cancelled. This prompted us to switch to a simpler approach, working with spreadsheet templates per community, gathering average BEST table results on a monthly basis, and having each of the communities decide on their own approach for detailed data handling.
- Monitoring always sounds so simple that the effort it takes tends to be underestimated. In practice, several practical hurdles need to be taken. This requires a substantial efforts. In case inhabitants are involved, they need to agree on monitoring results to be gathered, in some cases actively contribute (e.g. filling in meter readings on a website or provide utility bills), or in other cases just be at home when people come by for meter readings. When this is done on a voluntary basis, it requires a substantial communication effort. This has been underestimated in some cases.

On the monitoring results and interpretation:

- Enormous variation in heat as well as electricity demand was found for apartments and houses. In Ajaccio, a range of a factor of 10 in heating demand was found. In Almere, a range of a factor of 4 was found. If such ranges were only caused by variation in set temperatures in the homes, it is estimated that a 12ºC range in set temperature is required, which is huge. In practice, variation in occupancy will probably also be part of the explanation for these variation. It would be interesting to look into this in more detail. In Almere, where results from more detailed monitoring will become available this year, it may be possible to check to what extent these two factors (set temperature and occupancy) explain such a large range.
- Monitoring Almere shows that below 6% monitored results become unreliable. As this also holds for non-residential buildings this poses a problem: how to verify the performance of individual non-residential buildings? Electricity consumption is largely dependent on type of non residential buildings, as well as occupancy and operational hours. These parameters need to be known better in order to do a proper comparison. Alternatively, it is necessary to do averaging over more buildings (just as for the homes and apartments) in order to arrive at results that can be compared with expected values. In case of refurbishment, it could have helped to perform monitoring before refurbishment. This was done in Ajaccio (but unfortunately no data in the new situation are available yet) but not in Viladecans.
- In data interpretation an issue with changed floor area compared to specifications was encountered. As not all flows scale linearly with floor area (namely hot water and electricity consumption), the original BEST table data had to be updated using as realised floor area's.

Recommendations for the Concerto Premium database

Concerning usage of data in databases:

Within the Concerto Programme a database will be built that will hold all Concerto Data. It will not only hold technical monitoring data but also costs. Assuming this database will be publicly available, the question is how this database compares to other database with energy consumption data. For example, the Odyssee Mure database reports total consumption of heat and electricity for homes in several categories in all EU countries . The same holds for building categories in the services sector. In principle, if total floor

area's are also given (which is not always the case), average consumption per m^2 for a given building type in a given country can be determined.
The Buildup.eu database on the other hand reports on best practices in building energy consumption. It contains a lot more information than energy consumption, including building specification.
Perhaps the passive homes in Almere would be an interesting best practice for large scale very low energy house building. Perhaps there are more Concerto buildings that qualify for 'best practice'. However, most cRRescendo buildings are in between average buildings and best practice buildings. What is the use for reporting energy consumption data of such buildings in an external database? The comparison of original ambition and final consumption is probably interesting for an analysis point of view, to be done by Concerto Premium. For a publicly accessible database the relationship between realised extra ambition and realised extra costs would be very interesting, although also very difficult to determine. In addition, data on improved energy efficiency upon refurbishment, again related to cost, would also be very interesting.

ANNEX A MONTHLY RESULTS AJACCIO

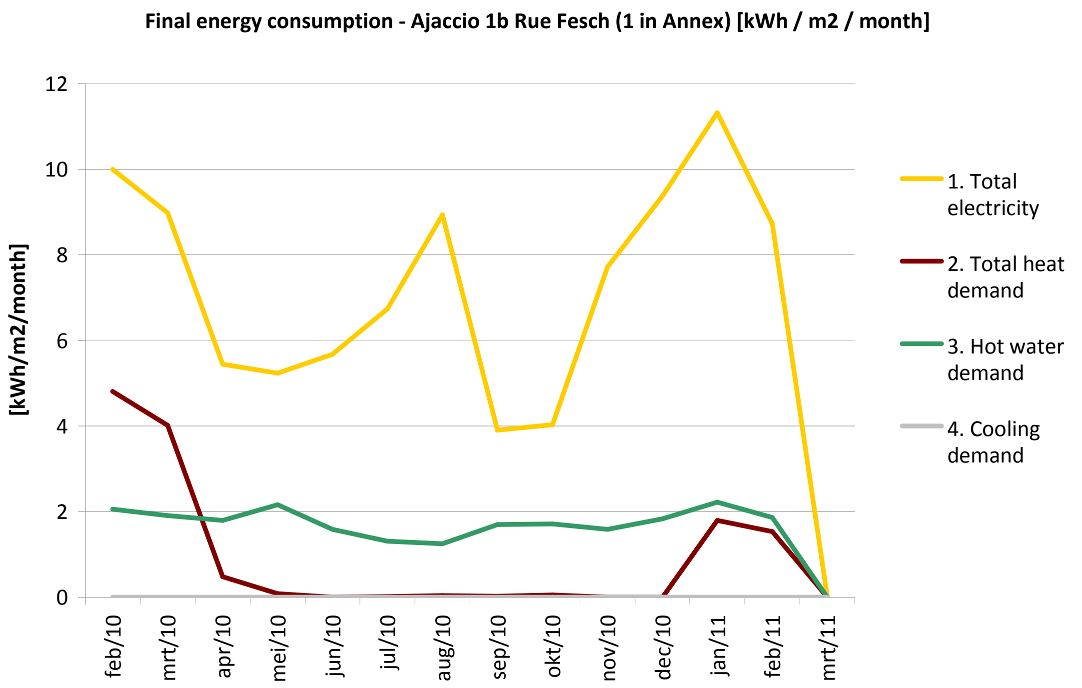


Figure A1. Monthly electricity consumption, heat demand and hot water demand BEST 1 (Rue Fesch) averaged over .. apartments, before renovation. The energy carrier for heat is electricity.

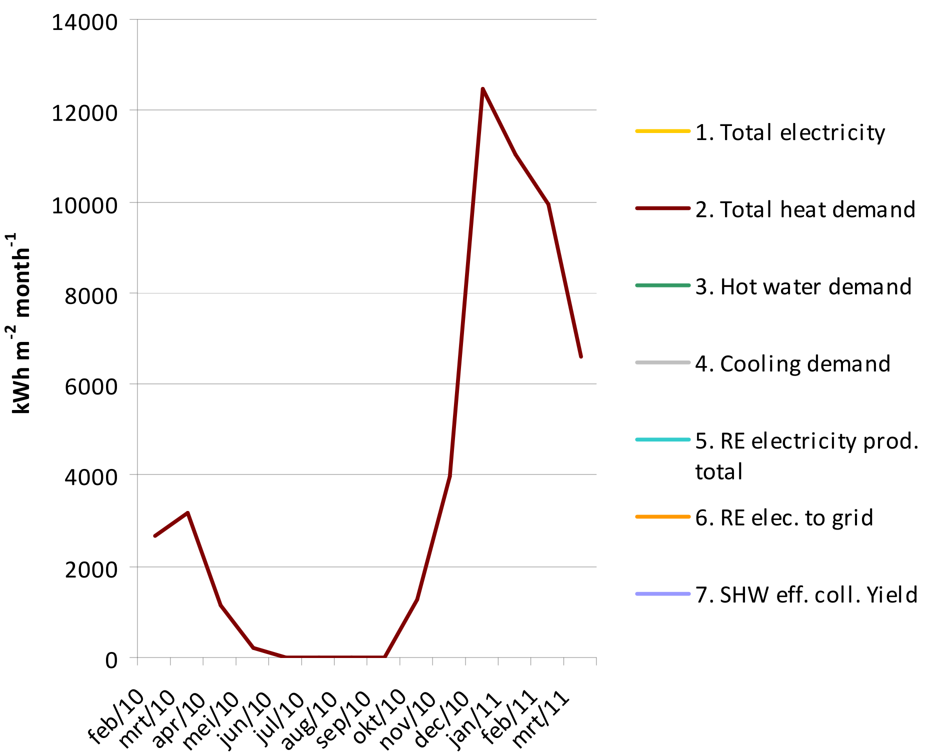


Figure A2. Monthly heating consumption BEST 2-Monte e Mare part averaged over .. apartments, after renovation.

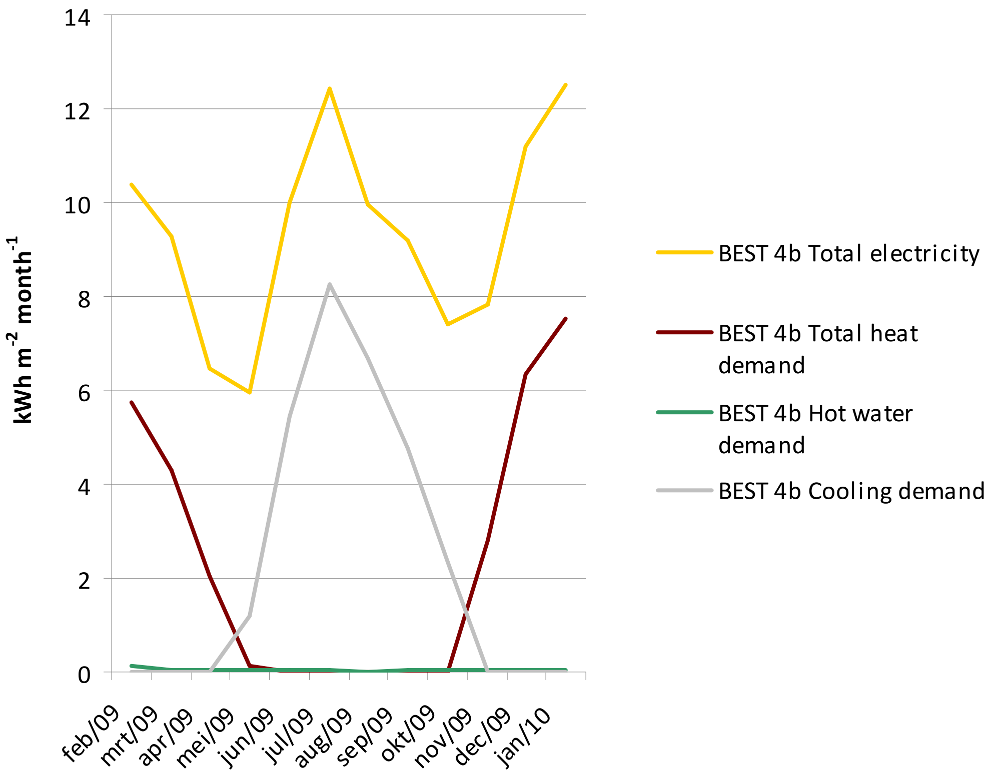


Figure A3. Monthly electricity consumption BEST 4 (public office building in St. Jean), before renovation. The energy carrier for heat as well as cooling is electricity.

Annex B Monthly Results Almere

For Almere some monthly data are available. It should be noted though that for the BEST tables, that the monthly BEST table averages presented here could be different from those used later for determining yearly values, as a new filter was used (filtering for at least have a year of data per home).

Solar Island Monthly data

year	month	Zon GJ
2010	2	
2010	3	
2010	4	
2010	5	780.6
2010	6	1482.2
2010	7	1590
2010	8	851.3
2010	9	688.5
2010	10	457.6
2010	11	52.4
2010	12	2.2
2011	1	61.4
2011	2	178.9
2011	3	993.7
2011	4	1592.3
2011	5	1490.1
2011	6	1257.7
2011	7	1060.6

ANNEX C MONTHLY RESULTS MILTON KEYNES

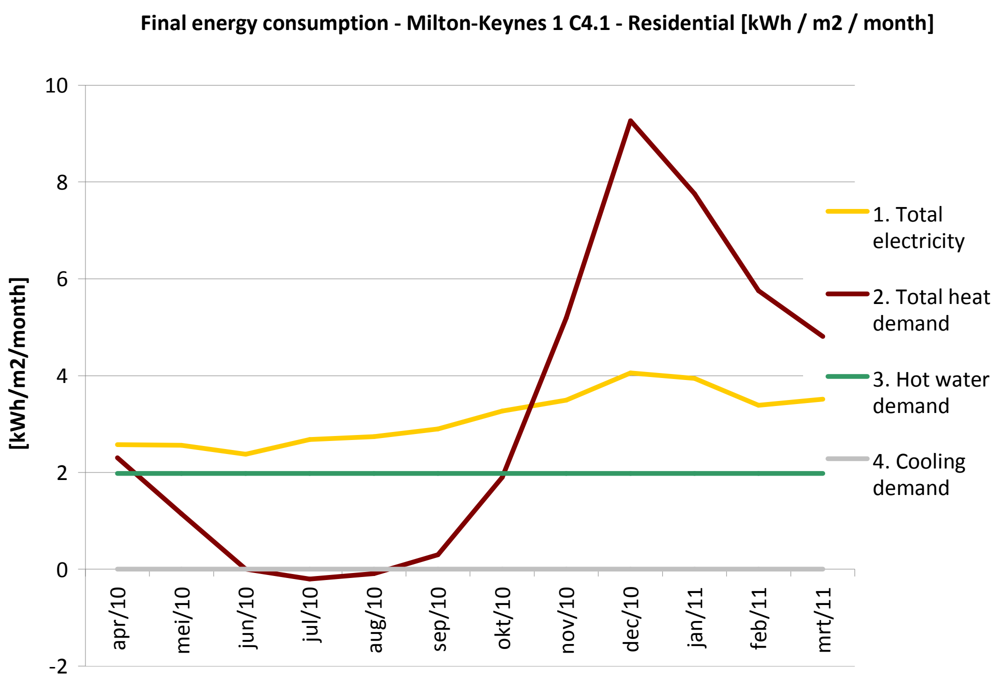


Figure C1. Monthly electricity consumption, heat demand and hot water demand BEST table A (C4.1 residential, 441 apartments). Hot water demand was calculated from heat demand in the months of June-Sept and then subtracted from total heat demand.

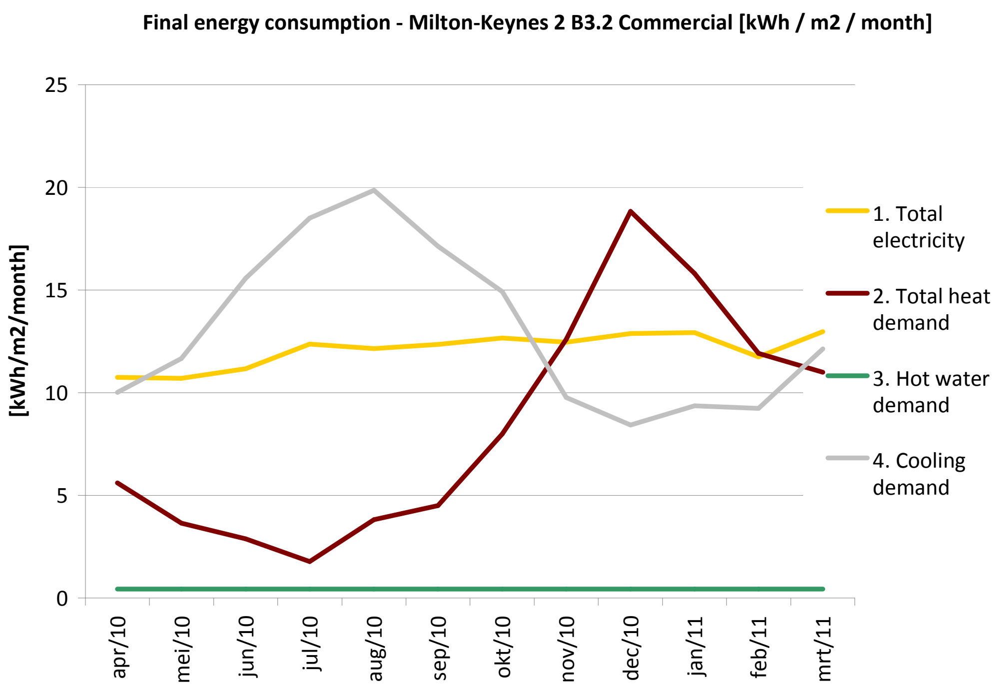


Figure C2. Monthly electricity consumption BEST table B (B3.2 Commercial, the pinnacle, 3 office buildings and some retail).

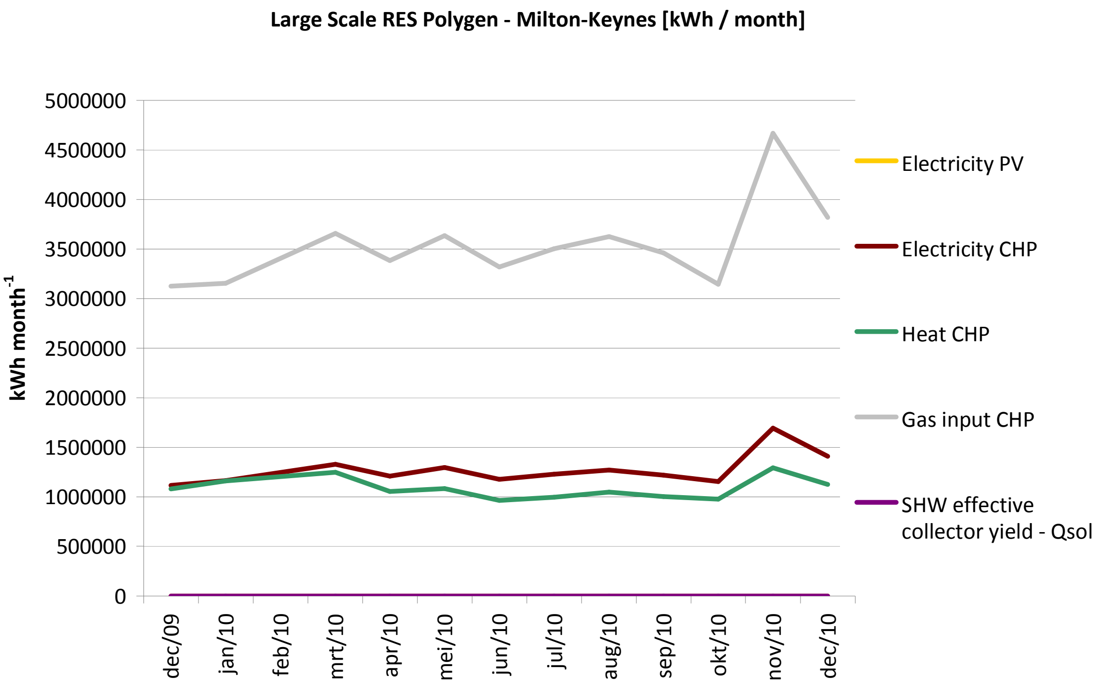


Figure C3. CHP: Monthly electricity and heat production as well as gas consumption.

Annex D Monthly Results Viladecans

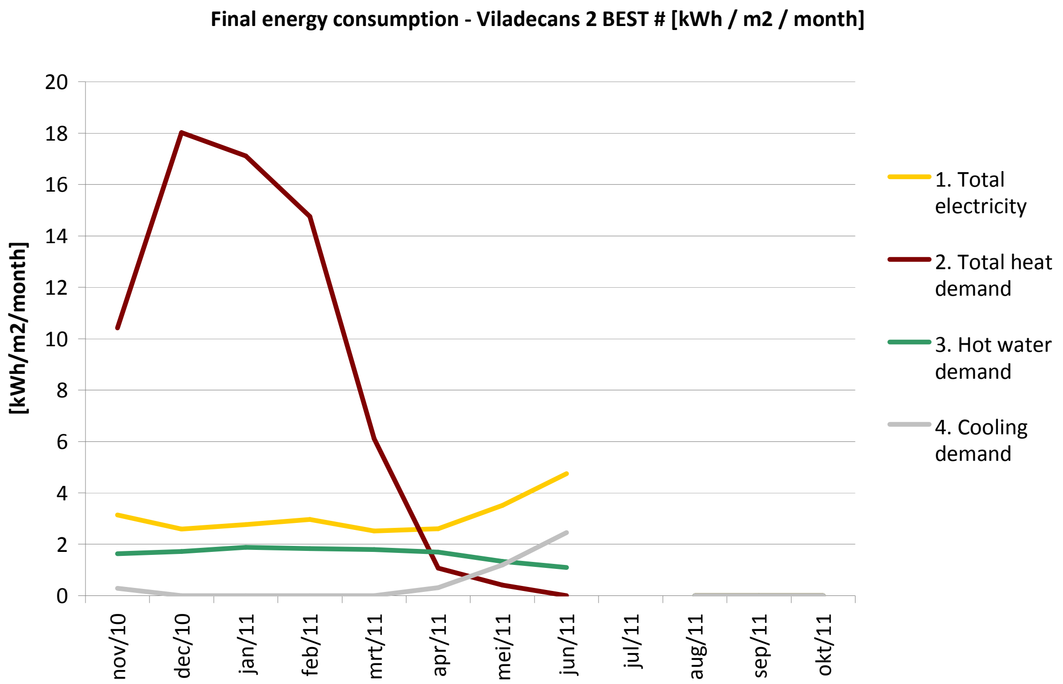


Figure D1. BEST table B, Day care centre La Piñeda, newly built. Monthly electricity consumption, heat demand, hot water demand and cooling demand.

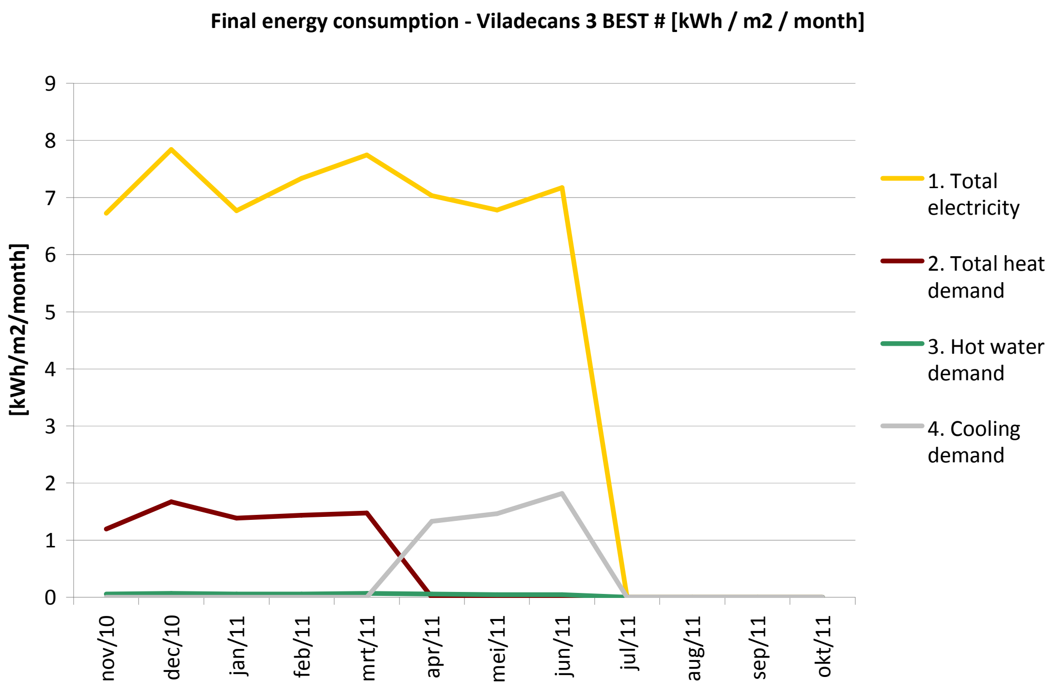


Figure D2. BEST table C Cultural Centre Can Xic, refurbishment Monthly electricity consumption, heat demand and hot water demand.

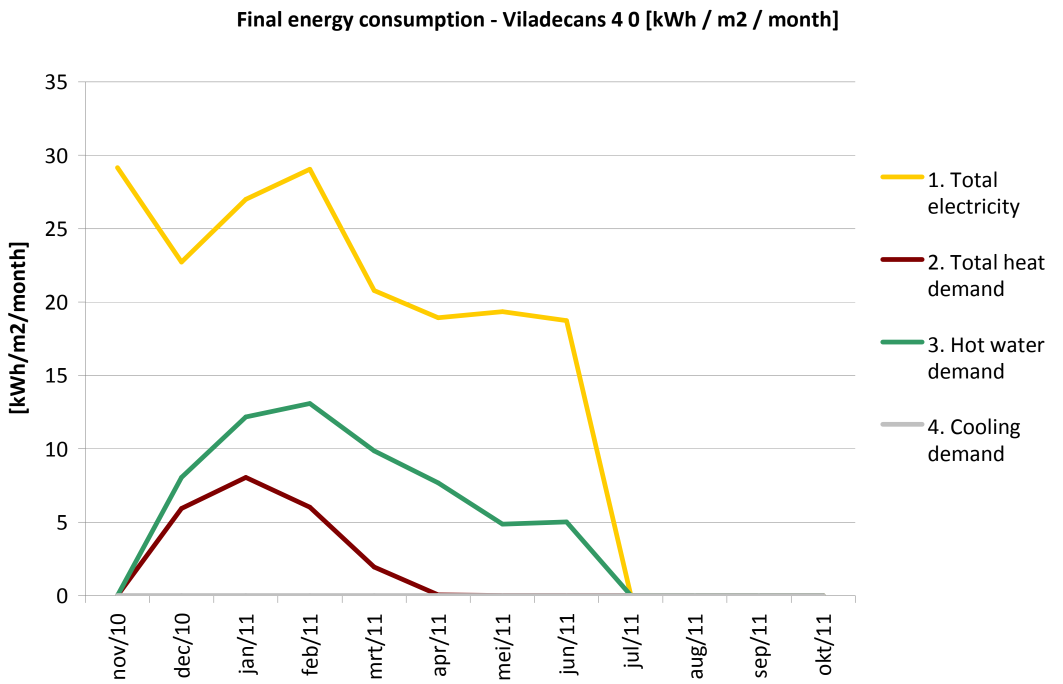


Figure D3. BEST table D Sports facilities Torre Roja, new. Monthly electricity consumption, heat demand and hot water demand.

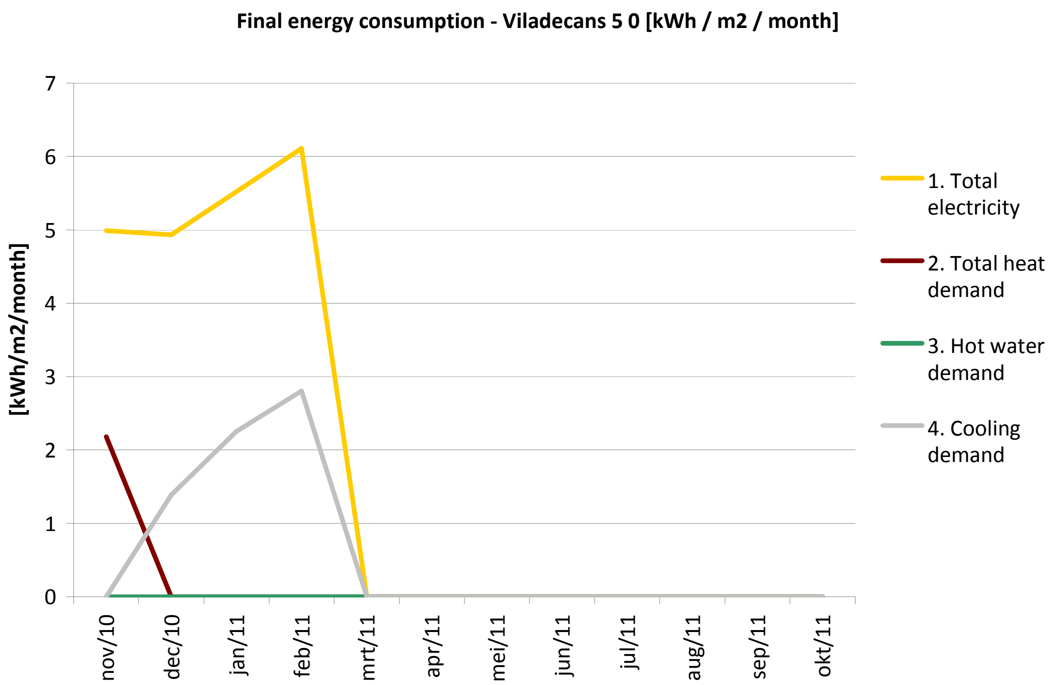
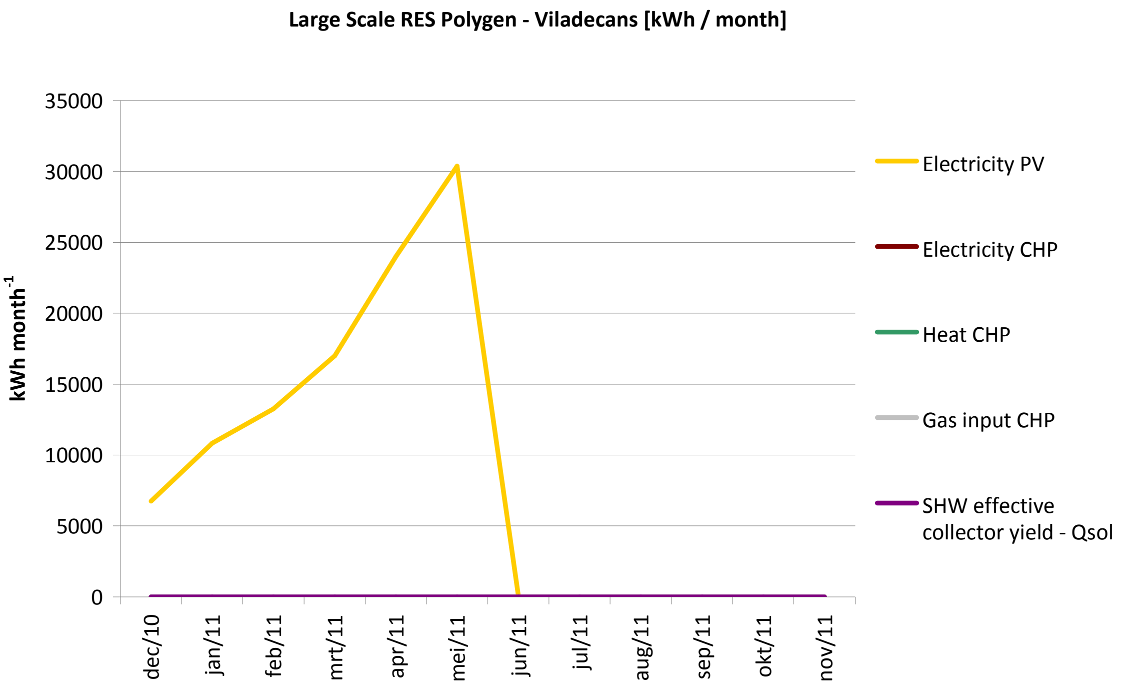


Figure D4. BEST table E E Cultural center Can Amat / Pablo Picasso, refurbishment. Monthly electricity consumption, heat demand and hot water demand.



342 kW PV system from CDS.

ANNEX E PARAMETERS AND DEFINITIONS

HDD's determined as follows (including ref).
Primary energy factor.
DHW part of electricity?
DHW part of heat demand?
Cooling part of electricity?
Heating part of electricity demand?