ePANACEA

Smart European Energy Performance Assessment & Certification

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Demonstration activities plans of each pilot country

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HISTORY OF CHANGES

Version	Month Year	Organisation	Comments
V1	January 2022	EASt	Version for internal review
V1.1	January 2022	EASt	Comments from review process included

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OVERVIEW OF THE ePANACEA PROJECT

After 10 years of track record, the current EPCs schemes across the EU face several challenges which have led to a not full accomplishment of their initial objectives: lack of accuracy, a gap between theoretical and real consumption patterns, absence of proper protocols for inclusion of smart and novel technologies, little convergence across Europe, lack of trust in the market and very little user awareness related to energy efficiency.

The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings that can overcome the above-mentioned challenges. The vision is ePANACEA becoming a relevant instrument in the European energy transition through the building sector.

ePANACEA comprises the creation of a prototype (the Smart Energy Performance Assessment Platform - SEPAP) making use of the most advanced techniques in dynamic and automated simulation modelling, big data analysis and machine learning, inverse modelling or the estimation of potential energy savings and economic viability check.

A relevant part of the project is to have a fluent dialogue with European policy makers, certification bodies, end-users and other stakeholders through two types of participatory actions: a feedback loop with policy makers, carried out through the so-called Regional Exploitation Boards (REBs) covering EU-27+Norway+UK on the one hand, and dialogue with end-users, established by means of specific thematic workshops, on the other.

Thanks to these participatory actions, the acceptance of the ePANACEA approach will be tested and validated in order to become aligned with and meet the needs of national public bodies, end-users and other stakeholders.

ePANACEA will demonstrate and validate reliability, accuracy, user-friendliness and cost-effectiveness of its methodology through 15 case studies in 5 European countries.

EXECUTIVE SUMMARY

This document contains a detailed description about the ePANACEA testing and demonstration activities concerning the case studies of each pilot country. It includes a description of the process and the development of the activity schedules and a detailed explanation of the milestones including descriptions of selected case studies, activity schedules, milestones and expected outcomes.

The methodology developed within ePANACEA will be demonstrated and validated in five European pilot countries (Austria, Belgium, Finland, Greece, Spain) through 15 real case studies. The demonstration of the energy assessment and certification methodology is organised in three phases starting with a case study preparation phase, continuing with a case study plan of activities and reporting phase and ending with the demonstration and validation and a final report on the evaluation of the three assessment methodologies developed within the ePANACEA project.

The selection of the case buildings is based on a set of criteria and data requirements developed for the different ePANACEA methodologies and is performed in close cooperation between the ePANACEA expert team and the building owners.

The activity schedule is a work plan specifically tailored for each test case, that structures and supports the testing process of the ePANACEA methodologies. The activity schedule is subdivided in phases and structured around milestones to clearly guide the process, from preparation of the case studies to the collection of the results. A set of predefined milestones are further supported by deadlines to secure the overall workflow across all project work areas. All test cases implement their test process according to the specified activity schedule.

GLOSSARY

TDB	Testing and Demonstration Board
BACS	Building Automation and Control System
EPC	Energy Performance Certificate
GFA	Gross Floor Area
HVAC	Heating, Ventilation and Air Conditioning
LOI	Letter of Intent
REB	Regional Exploitation Board
RES	Renewable Energy Sources
SEPAP	Smart Energy Performance Assessment Platform

1. INTRODUCTION TO ePANACEA METHODOLOGY

The holistic, accurate, flexible and modular methodology for building energy performance assessment and certification developed under the ePANACEA project is based on three energy assessment methods (Figure 1) plus a decision matrix:

- M1: Assessment method 1: Smart & performance data-driven energy performance assessment.
- M2: Assessment method 2: Simplified method based on a monthly calculation (ISO 52016) interval and its calibration.
- M3: Assessment method 3: Advanced & automated simulation modelling based on an hourly calculation (ISO 52017) and its calibration.

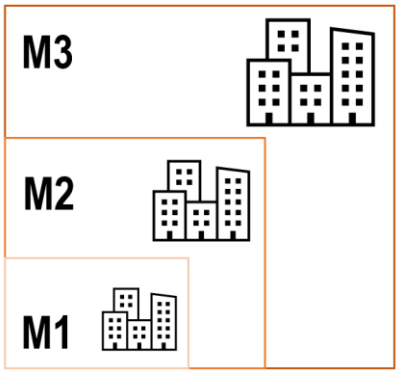

Figure 1: Schematic vision of ePANACEA's three assessment methods.

The whole ePANACEA methodology, based on these three different energy assessment methods and its decision matrix for the selection of the most suitable one for each assessment object, will be integrated on the SEPAP (Smart Energy Performance Assessment Platform) for testing and validation purposes.

The vision for the modular and flexible methodology development is an evolution of the three assessment methods from the more simplistic to the more complex one, according to the building and/or assessment requirements, e.g., innovative energy assessment with compliance of accuracy and standard requirements, integration of smart and novel technologies or use of real measured data. A graphical overview of the three methods and responsible partners is shown in Figure 2.

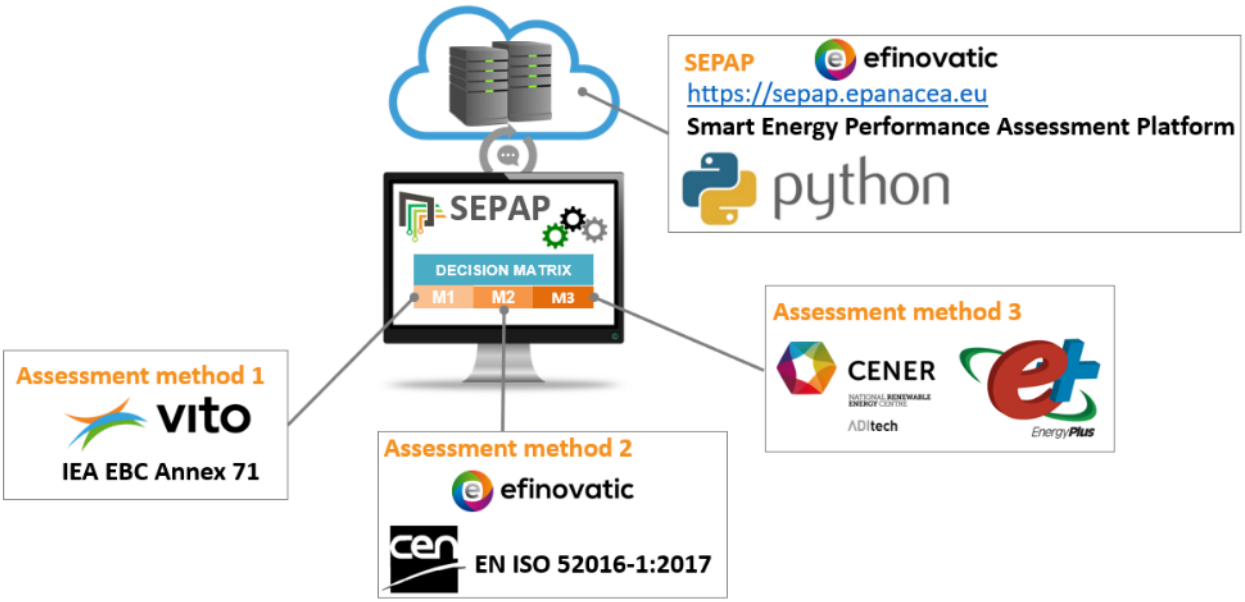

Figure 2: Overview of ePANACEA's three assessment methods (source CENER). November 2021

Each assessment method can include techniques that stem from a lower complexity level. The following synergies between the three assessment methods will be exploited:

- Use of monitoring data
- Data acquisition
- Advanced user behaviour modelling
- Sensitivity analysis
- Semi-automated calibration based on machine learning techniques
- Inclusion of novel and smart technologies

The first module uses on-board monitored (OBM) data, leveraging the increasing smart dimension of the energy management systems of the buildings, and inverse modelling approaches to assess the building energy performance.

The second module is based on the monthly method of ISO 52016, considering that the smart technologies are increasingly presented in the buildings, artificial intelligence and machine learning for automated assessments as well as advanced models of the occupation profiles.

Finally, the third and more complex module of the ePANACEA methodology is the advanced & automated simulation modelling based on dynamic simulation for EPCs. Advanced dynamic simulation techniques allow a high level of accuracy as well as quality outputs, including:

(i) the prediction of building energy performance (e.g. corrected by climate),
(ii) disaggregation of consumption per energy service and/or type of fuel,
(iii) identification of energy efficiency measures and
(iv) estimation of potential energy savings and economic viability calculation.

2. OVERVIEW OF SELECTED CASES

The ePANACEA methodology with its three Assessment Methods has a high level of innovation, which will contribute to a more accurate and cost-effective energy assessment and certification of buildings. The use of actual consumption data and actual performance data (e.g., indoor temperatures) is necessary to develop more accurate models which can reduce the gap between energy performance simulation and real performance of buildings. The purpose gathering and monitoring data is to collect input for the development of ePANACEA Assessment Method 1, 2 and 3

Testing real case studies ensures the practical feasibility of the ePANACEA methodology. The three ePANACEA assessment methods will be tested using 15 buildings or building units (3 per pilot country).

The selection of the building cases is done in close cooperation with the building owners, taking into account the requirements of the ePANACEA methodology. In addition, the main stakeholders like the owners or the users of the buildings, involved in this process will be informed about other requirements and activities where their input is expected, such as user perception research or methodology development.

For the ePANACEA methodology development it was agreed to collect data from at least one case study per pilot country with high data availability until the end of May 2021 or August 2021 where data collection has not started yet, depending on availability of historical measurement data.

A set of criteria for the selection of case studies and data requirements was developed, based on the different categories provided in Table 1. The ePANACEA methodology will be tested on a broad range of building typologies in order to create validated assessment methods with high reliability and broad applicability as well as contribute to the development of the decision matrix.

The criteria set for the case study selection is described in report "Compendium of Testing and Demonstration Board (TDB) Meetings".

The covered timeframe of the energy consumption data (electricity, heat, etc.) depends on the frequency of the data. For high resolution data (less than 1 hour), a length of 4 weeks would be sufficient. Energy consumption with a daily or weekly frequency should be collected over a period of 15 weeks. If energy consumption data are available on a monthly basis, it would be sufficient to have approx. 2-3 years of data material. The covered timeframe and frequency of data availability will imply short-term or long-term calibration processes as well as different levels of accuracy. For testing Assessment method 1 the data (electricity, gas, solar radiation, indoor and outdoor temperature etc.,) need to be available for the same period at the same frequency (either monthly, daily or hourly data). The other methods will be able to deal with different data qualities.

Table 2 lists all selected case studies for the countries that meet the previously described criteria The case studies have been selected by the Testing and Demonstration Board (TDB), formed by technical partners of the ePANACEA consortium, as being the most suitable to support the development and testing of the ePANACEA methods. If obstacles arise during testing or data collection, the case studies can be modified.

Table 1: Overview of building characteristics of the 15 selected case studies.

Building characteristics		Pilot Country				
		AT	BE	FI	GR	SP
Climate	Atlantic		x			x
	Mediterranean				x	
	Continental	x		x		
	Boreal			x		
	Pannonian	x				
Size (GFA)	<500 m²	x	x		x	x
	500-2.000 m²	x			x	x
	>2.000 m²			x	x	x
Building Type	Single-family houses		x			x
	Multi-family apartments	x			x	x
	Offices	x		x	x	x
	Educational buildings			x		
Construction type	Light	x				x
	Moderate	x		x		
	Heavy		x	x	x	
Energy need	Heating (& Domestic Hot Water)	x	x	x		x
	Heating (& Domestic Hot Water) & Cooling			x	x	x
HVAC	Low complexity		x			x
	Medium complexity	x		x	x	x
	High complexity			x	x	
RES on site	No	x	x	x	x	x
	Yes	x		x	x	x
BACS	Low complexity		x		x	x
	Medium complexity	x			x	x
	High complexity	x		x		
Data availability	Low				x	x
	Medium		x	x		
	High			x		x
	Very high	x		x		

***GFA**: gross floor area, **HVAC**: low complexity - covering heating and domestic hot water demand with only one system (e.g., individual boilers or central heating boiler), high complexity - covering heating, cooling and domestic hot water demand with a mix of different technologies with different fuels; **Data availability**: low - design data, medium - design data, utility bills, weather data, high - design data, utility bills, weather data, short-term measurements, very high - design data, utility bills, weather data, short-term measurements, smart meters data; **RES on site**: Renewable energy sources on site; **BACS**: Building automation and control system*

Table 2: List of case studies, January 2022; feasibility will be evaluated during the testing process

	Case study number	Signed Consent	Data collected	Name of building	Building address (Zip code and city)	Year of construction	EPC rating for primary energy demand	Climate	Building typology	General data availability
Austria	**AT-01**	x	x	Multi-family building	AT-8063 Eggersdorf	2018	B (106,65 kWh/m²year)	Continental	Multi-family house	Very high (less than 1 hour)
	AT-02	x	x	Office building	AT-7423 Pinkafeld	2015	222,40 kWh/m²year	Pannonian	Office building	Very high (less than 1 hour)
	AT-03	x	in progress	Community building	AT-8063 Eggersdorf	2018	No EPC available	Contintenal	Office building	Very high (less than 1 hour)
Belgium	**BE-01**	x	x	Vinkenhof	2590 Berlaar	1982	D-306 kWh/m²year	Atlantic	Single family house	Low (monthly data)
	BE-02	x	in progress	Multi-family building - flat	2290 Vorselaar	1979	B-141 kWh/m² & A-83 kWh/m²	Atlantic	Multi-family house	Low (monthly data)
	BE-03	x	in progress	Terraced house	9040 Gent	1904	B-156 kWh/m²year	Atlantic	Single family house	Very high (less than 1 hour)
Finland	**FI-01**	in progress	in progress	Energy efficient office building					Office building	Very high (less than 1 hour)
	FI-02	x	x	School Eklöfska skolan	06750 Tolkkinen Porvoo	2019	B, 99 kWh/m²year	Boreal	Educational building	High (1 hour for all data)
	FI-03	in progress	in progress	School					Educational building	High (1 hour for all data)
Greece	**GR-01**	x	x	Apartment in Multi Family Building – 2nd floor	17341, Ag. Dimitrios - Attiki	1976	Class: C 197,6 kWh/m² year	Mediterranean	Multi-family house	Low (monthly data)

	GR-02	x	in progress	Office building	190 09, Pikermi – Attiki	2001	Class: B 170,8 kWh/m^2 year	Mediterranean	Office building	Low (monthly data)
	GR-03	x	in progress	Municipal Office building	17343 Ag. Dimitrios – Attiki	1970	No EPC available	Mediterranean	Office building	Low (monthly data)
Spain	**SP-01**	x	in progress	Public office building	Tomás Caballero, 1, 31006 Pamplona (Navarra)	1994	Class C: 386,59 kWh/m^{2}year	Atlantic	Office building	High (1 hour for all data)
	SP-02	x	x	Private residential building (Single family home)	31486 Egües (Navarra)	2005	Class C: 148,43 kWh/m^{2}year	Atlantic	Single family house	Low (monthly data)
	SP-03	x	in progress	Private residential building (Apartment in Multifamily block)	31600 Burlada (Navarra)	2009	Class C: 15,2 kgCO_2/m^{2}year	Atlantic	Multi-family house	Low (monthly data)

3. CASE STUDY ACTIVITY PLAN

3.1. The testing process

As already described, the methodology developed within ePANACEA will be demonstrated and validated in five European pilot countries (Austria, Belgium, Finland, Greece, Spain) through 15 real case studies. These demonstration measures pave the way for an efficient roll-out of the methodology across the EU. An extensive network of European building owners and managers has been established during the project lifetime. They have agreed to provide the data required for demonstration measures.

The demonstration of the energy assessment and certification methodology is organised in three phases as displayed in Figure 3 and already described in report "Compendium of TBD meetings". Hereby twenty-one (21) building owners and managers expressed their commitment to provide the necessary data for testing and validation activities, covering approx. 7.000 different buildings.

As a preliminary work, 15 buildings were chosen from a pre-selected group of buildings in phase one called the case study preparation. A Testing and Demonstration Board (TDB) formed by technical partners of the ePANACEA consortium selected the appropriate case study buildings guided by the methodology requirements concerning data and/or technology availability (e.g., measured data, RES on-site, BACS, etc.). The activity was developed in close cooperation with the owners, managers and building end users and, where relevant, energy providers or other stakeholders. The case studies include 15 buildings covering a wide range of external characteristics such as climate zones, country specific cultural, social and economic characteristics as well as different data availability.

Based on the outcomes of the case study preparation phase, a detailed plan for the steps in the testing and validation of the methodology for each case study was defined. The plan consists of the activity schedule, descriptions of selected case studies, and expected outcomes. Within this, the progress of the development of the building energy assessment and certification methodology will be continuously monitored by application to the case studies.

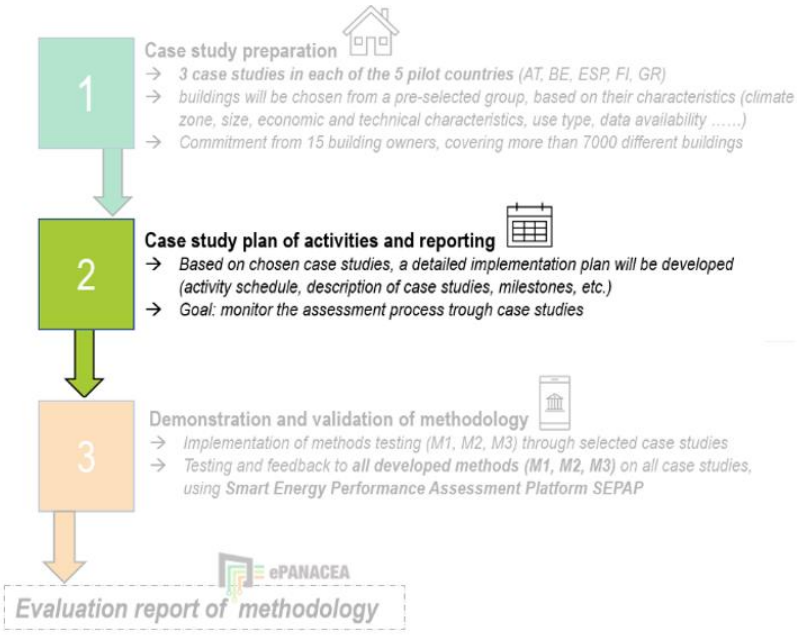

Figure 3: The 3 phases of the demonstration of the ePANACEA energy assessment and certification methodology

3.2. Activity schedule and milestones

The activity schedule is a work plan made for each test case that structures and supports the testing process of the ePANACEA methodologies. The activity schedule is divided into phases and structured around milestones, as defined below, to clearly guide the process, from preparation of the case studies to the collection of the results:

- Milestone 1 (M1): Selection of the case study (deadline November 2021)
- Milestone 2 (M2): Signed consent form
- Milestone 3 (M3): Publication of case study at ePANACEA webpage
- Milestone 4 (M4): Data collection finished
- Milestone 5 (M5): Demonstration and validation activities finished (deadline February 2023)
- Milestone 6 (M6): Report on validation results finished (deadline February 2023)

An example of an activity schedule is shown in Figure 4. For the sake of completeness, the activity schedules of 13 cases (two finish case studies missing, final confirmation in progress, problems with consent form because of ownership change) are included in the ANNEX of this document.

Prior to undertaking any further action, the owners of the case study objects signed a declaration of consent which allows the collection and storing/processing of personal data in compliance with the applicable GDPR rules, i.e. ensuring that it is treated with the utmost care and it will not be changed, misused, or passed on to third parties. According to this, the anonymized energy consumption relevant data (e.g. electricity and heat consumption, measured room temperatures, building equipment, type of use, user behavior, etc.) will be shared with the ePANACEA research team (project consortium) for the purpose of achieving the research objective (testing and validating the ePANACEA method). Additionally, the owners hereby gave consent to the case studies being published at the ePANACEA webpage (https://epanacea.eu/) together with a photograph and a short description.

The next step is the collection of relevant data for the selected cases. The collection process includes accompanying data (EPC, plans, blower door, etc.) and measurement data for energy consumption, indoor conditions, etc. For several test buildings, data was already available. For other cases, measurement devices for comfort and energy values were installed to start the collection process. Finally, the data shall be prepared for further analysis.

After this, the demonstration and validation phase is expected to start in June 2022, where the three assessment methods will be tested through the TDB. As each one of the three assessment methodologies follow an individual work schedule themselves (Method 1 expected to be ready in June 2022, Method 2 in September 2022, Method 3 in December 2022), also the testing process will have three different starting points.

Case study plan of activities - AT-1 (Austria)

Case study number	AT-1
Country:	Austria
Partner:	EASt
Case study description:	
Multi-family building (light construction) on the countryside with 8 flats and approx. 27 residents; very high data availability with measurement data (heat, electricity, temperatures, etc) of less than 1 hour, 150 kW biomass boiler and 40,2 kWp PV system incl. 47 kWh lithium-ion-battery storage	

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Month of ePANACEA		2021												2022												2023					
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
Milestone	**Activity**	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
	Collection of potential cases																														
M1	**Selection of case study (DL month 18!)**											!																			
M2	**Signed consent form**																														
M3	**Publication at ePANACEA webpage**																														
	Data collection																														
	Accompaying data (EPC, plans, blower door etc.)																														
	Measurement data for energy consumption, indoor temperature																														
M4	**Data collection finished**																														
M5	**Demonstration and validation activites (DL month 33!)**																										!				
	Testing Assessment method 1 (method ready in month 25)									testing for D4.1																					
	Testing Assessment method 2 (method ready in month 28)																														
	Testing Assessment method 3 (method ready in month 31)																														
M6	**Report on validation results finished (DL month 33)**																										!				
	Presentation of results to case study owner																														

Figure 4: Exemplary case study plan of activities - AT-1

4. TESTING PROCESS: NEXT STEPS

Data collection as well as testing and validation of the ePANACEA methodology for energy assessment and certification will take place in the third testing phase. The focus is on validating the methodology under real conditions, identifying bottlenecks and improving the assessment methodology. The methodology will be updated according to the results of the demonstration activities. In addition, the tests will provide feedback to the SEPAP and the related ePANACEA decision matrix that is intented to provide guidance or recommendations on choosing the most suitable method for a specific building type, providing reasonable accuracy and uncertainty levels.

The demonstration and validation activities will also include a cost analysis, an assessment of time and technician expertise required to perform each method on a specific building type.

The results of the test phases will be summarised in the "ePANACEA Methodology Evaluation Report". This report will provide an evaluation from different perspectives (theoretical, practical, economical and technical point of view). The demonstration of all methods on all 15 cases will provide a comparison of methods for a specific building type under real conditions.

Additionally, the report will provide a cross analysis from both a qualitative and a quantitative perspective in relation to the existing EPC systems in each pilot country and by considering national differences regarding climate, but also cultural, social and political contexts. In addition, the results from a qualitative perspective will be reviewed at the international level in close collaboration with the stakeholders concerned.

Figure 5: ePANACEA's phases of testing

Table 3: Overview of next steps until March 2023

What	When
Publication of case studies at ePANACEA webpage	January and February 2022
Data collection of all case studies (historical data or actual measurement data)	30.06.2022 (latest by 31.08.2022)
Start of testing process - Implementation of energy assessment and certification methodology 1	June 2022
Start implementation of energy assessment and certification methodology 2	September 2022
Start implementation of energy assessment and certification methodology 3	December 2022
Reports on case studies validation results of each pilot country	February 2023
Report on impact assessment from final user perspective regarding the new EPC	February 2023
Start evaluation of energy assessment and certification methodology	March 2023
ePANACEA Methodology Evaluation Report	April 2023

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Table 3: Overview of next steps until March 2023 - 15 -

ANNEX: CATALOGUE OF SELECTED CASES

Case study plan of activities - AT-1 (Austria)

Case study number	AT-1
Country:	Austria
Partner:	EASt
Case study description:	
Multi-family building (light construction) on the countryside with 8 flats and approx. 27 residents; very high data availability with measurement data (heat, electricity, temperatures, etc) of less than 1 hour, 150 kW biomass boiler and 40,2 kWp PV system incl. 47 kWh lithium-ion-battery storage	

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Milestone	Activity	2021												2022												2023				
Month of ePANACEA		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
		Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
	Collection of potential cases																													
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M4	**Data collection finished**																													
M5	**Demonstration and validation activites (DL month 33!)**																										!			
	Testing Assessment method 1 (method ready in month 25)									testing for D4.1																				
	Testing Assessment method 2 (method ready in month 28)																													
	Testing Assessment method 3 (method ready in month 31)																													
M6	**Report on validation results finished (DL month 33)**																										!			
	Presentation of results to case study owner																													

Case study plan of activities - AT-2 (Austria)

Case study number	AT-2
Country:	Austria
Partner:	EASt
Case study description:	

The office building was built in 2015 in the Austrian province of Burgenland. The gross floor area is approx. 752 m² and it is equipped with a combination of different HVAC systems: condensing heat boiler, geothermal heat pump, air conditioning and ventilation system, different heat emission systems etc. Besides office spaces it offers laboratory facilities for research purposes related to smart and renewable energy systems, BACS and building automation etc. The building is already equipped with comprehensive metering facilities (e.g. electricity consumption for different services, heat meters, indoor comfort parameters, temperatures and pressure, occupancy etc.).

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Month of ePANACEA		2021												2022												2023				
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Milestone	**Activity**	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Ju	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
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M4	**Data collection finished**																													
M5	**Demonstration and validation activites (DL month 33!)**																										!			
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	Testing Assessment method 2 (method ready in month 28)																													
	Testing Assessment method 3 (method ready in month 31)																													
M6	**Report on validation results finished (DL month 33)**																										!			
	Presentation of results to case study owner																													

Case study plan of activities - AT-3 (Austria)

Case study number	AT-3
Country:	Austria
Partner:	EASt
Case study description:	
A venue on the county side for concerts, conferences, events with the possibility to stay overnight. Walls in 11cm cross laminated timber and 36cm straw bale insulation covered with clay and roof 30cm cellulose. Very high data availability with measurement data (heat, electricity, temperatures, etc) of less than 1 hour, 150 kW biomass boiler and 40,2 kWp PV system incl. 47 kWh lithium-ion-battery storage	

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Month of ePANACEA		2021												2022												2023				
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Case study plan of activities - BE01 - Belgium

Case study number	BE01
Country:	Belgium
Partner:	VITO
Case study description:	

This single-family house is a terraced house built in 1982 and owned by a social housing company. A centralized condensing gas boiler is installed to provide space heating and domestic hot water, but the building has no ventilation system or cooling system. Since a lot of similar dwellings were constructed at the same time in the neighbourhood, a renovation concept is being developed to renovate the whole district. For the original, non-renovated state of the building, measurements are available of the indoor temperature and the total yearly energy demand.

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Month of ePANACEA		2021												2022												2023				
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
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Case study plan of activities - BE02 - Belgium

Case study number	BE02
Country:	Belgium
Partner:	VITO
Case study description:	

This multi-family apartment block was built in 1979 and owned by a social housing company. The building contains 11 units, which each have a non-condensing gas boiler for space heating and domestic hot water. No ventilation system, nor cooling system is present in the building. The social housing company plans to renovate the building, starting with replacing the old non-condensing gas boilers by new condensing ones. Before these renovation measures will be performed, the building has been monitored to evaluate the current energy performance. The indoor temperature has been measured for three months in the winter of 2020-2021 in two units of the building, and the energy demand has been gathered from the utility services.

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Month of ePANACEA		2021												2022												2023				
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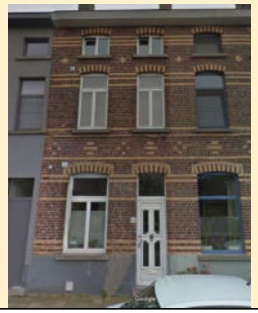
Case study plan of activities - BE03 - Belgium

Case study number	BE03
Country:	Belgium
Partner:	VITO
Case study description:	

This terraced city house was originally constructed in 1904 and was recently renovated. The old extension was replaced by an extension that is in compliance with the latest energy performance demands, the roof has been insulated, and a dormer has been added. Some air vents are installed, but the dwelling has no cooling system. This privately-owned dwelling has been deeply monitored in the winter of 2017-2018 by means of smart meters: the indoor climate was measured in all rooms, and the electricity and gas use were also monitored in detail.



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Case study plan of activities - FI-2 (Finland)

Case study number	FI-2
Country:	Finland
Partner:	VTT
Case study description:	
Educational building (heavy construction). Renovation and extension completed in 2019. Serves 180 people. District heating. 26,4 kWp PV system	

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Month of ePANACEA		2021												2022												2023				
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Case study plan of activities - GR-1 (Greece)

Case study number	GR-1
Country:	Greece
Partner:	CRES
Case study description:	

Apartment with 4 residents of a multi-family building (heavy construction) located in a southern suburb of Attica; low data availability with monthly data from utility bills (heat, electricity), 58.2 kW oil boiler, cooling provided by split units of 4.05 kW and DHW provided by solar thermal system of 2.5m2

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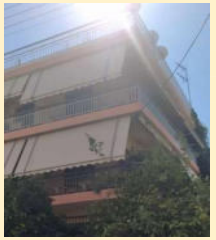

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Month of ePANACEA		2021												2022												2023				
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Case study plan of activities - GR-2 (Greece)

Case study number	GR-2
Country:	Greece
Partner:	CRES
Case study description:	

Bioclimatic two-storey office building wtih 16 occupants (heavy construction) located in the eastern Attica; low data availability with monthly data from utility bills (heat, electricity), heating and cooling provided by 24.3 kW heat pump (1st floor), 21 kW geothermal heat pump (ground floo), 35.2 kW heat pump (basement), and DHW provided by solar thermal system of 1.8m2
PV of 8.64m2

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Month of ePANACEA		2021												2022												2023				
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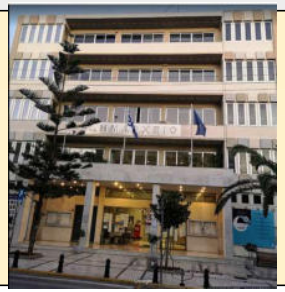
Case study plan of activities - GR-3 (Greece)

Case study number	GR-3
Country:	Greece
Partner:	CRES
Case study description:	

Municipal officce building (heavy construction) with 190 occupants and 30.000 visitors annually located in a southern suburb of Attica; low data availability with monthly data from utility bills (heat, electricity), heating provided by a gas boiler and cooling provided by split units and heat pump (ground floor)



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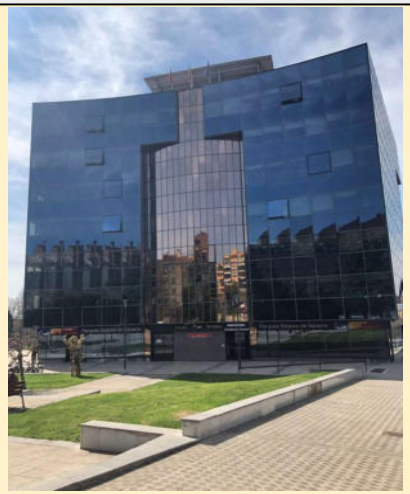
Case study plan of activities - SP-1 (Spain)

Case study number	SP-1
Country:	Spain
Partner:	CENER
Case study description:	

This public office building was built in 1994 but it has been renovated several times due to the compromise of the Government of Navarre with energy efficiency and the reduction of carbon footprint of its public buildings. Because of that, its HVAC system has been renovated and a PV roof of 27kW has been installed in 2017 in order to provide on-site renewable electricity. The gross floor area is 5.446,6 m2, with a useful floor area of 4.744 m2 that accommodate to 230 people. The original building included a glazed façade that is being gradually renovated since 2017 in order to reduce its thermal transmittance and improve users' thermal comfort. Its HVAC system is mainly composed by four condensing boilers (recently installed) for heating and one chiller of 350 kW for cooling located on the roof. The distribution and emission for heating and cooling is carried out by a 4-pipe fancoils system. Then, the building is supplied by two energy sources; natural gas for heating and electricity for cooling, lighting, distribution and other electric equipment. One of the last renovations implied the replacement of the whole lighting system by LED lamps with day lighting dimming control and presence sensors. Besides, a central BMS for building control and energy use monitoring was installed in 2020.



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Milestone	Activity	2021 8	9	10	11	12	13	14	15	16	17	18	19	2022 20	21	22	23	24	25	26	27	28	29	30	31	2023 32	33	34	35	36
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Case study plan of activities - SP-2 (Spain)

Case study number	SP-2
Country:	Spain
Partner:	CENER
Case study description:	

This detached house was built in 2005 in a rural area in the region of Navarre (Spain). This means before the entry into force of the Spanish Technical Building Code of 2006 which implies a not especially good quality of thermal transmittance of the envelope components such as facades, roofs and windows. The house is split into three storeys having a total floor area of around 300 m2. Heating and domestic hot water (DHW) services are covered by an individual system based on a condensing gas boiler. The original building did not include cooling system, but over the past years several heat pumps have been installed in different areas of the house to cover its high energy needs for cooling. It is the habitual residence of a family of five people and its owners are very interested in improving the energy efficiency of the house. Actual building data are available from gas utility bills, smart meter for electrify and data loggers for temperature and humidity monitoring installed during July-September 2021 and December 2021-February 2022.

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Case study plan of activities - SP-3 (Spain)

Case study number	SP-3
Country:	Spain
Partner:	CENER
Case study description:	

This case study is focused on the assessment of one individual dwelling located in the third floor of a multifamily apartment block of five storeys. The dwelling covers a useful floor area of 90 m2 and is occupied by a family of three members. The whole building, located in a medium-density urban neighbourhood in Pamplona (Spain), was built in 2009 meeting at least the minimum requirements of the Spanish Technical Building Code of 2006. That means that its fabric components already meet several energy efficiency criteria such as at least 6-8 cm of thermal insulation in facades and low emissivity glasses for windows. The HVAC system is centralised for the 206 dwellings of the building, including services of heating, DHW and mechanical ventilation. Two gas boilers supply to the district heating that covers energy needs for heating and DHW of each dwelling though an individual heat exchanger. The dwelling has not include cooling system at the moment due to overwarm season is reduced just a few days in summer. In this case, data monitoring is carried out by a central BMS with an almost monthly frequency with the aim of dividing up energy costs among all dwellings. Electricity use monitoring of the apartment can be carried out with hourly frequency data though the utility server connected to the smart meter of the dwelling. Indoor temperatures have been measured during several representative months of 2021 via data loggers.

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Milestone	Activity	2021 8 Jan	9 Feb	10 Mar	11 Apr	12 May	13 Ju	14 Jul	15 Aug	16 Sep	17 Oct	18 Nov	19 Dec	2022 20 Jan	21 Feb	22 Mar	23 Apr	24 May	25 Ju	26 Jul	27 Aug	28 Sep	29 Oct	30 Nov	31 Dec	2023 32 Jan	33 Feb	34 Mar	35 Apr	36 May
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