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**EFFESUS SYMPOSIUM**

ENERGY EFFICIENCY FOR EU HISTORIC DISTRICTS SUSTAINABILITY

# SMART MANAGEMENT AND INTEGRATION OF RENEWABLE AND ENERGY EFFICIENCY SOLUTIONS IN HISTORIC BUILDINGS AND DISTRICTS

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**April 8th, 2016 - Salone del Restauro, Ferrara, Italy**

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# Presentation structure

Towards repository of solutions for DSS

- Workflow
- Energy efficent solutions in historic buildings
- Renewable energy solutions
- Repository

Development of new solutions

- Physical interventions
- Smart management initiatives

Demonstrations of smart management

- Budapest case study
- Santiago de Compostela case study

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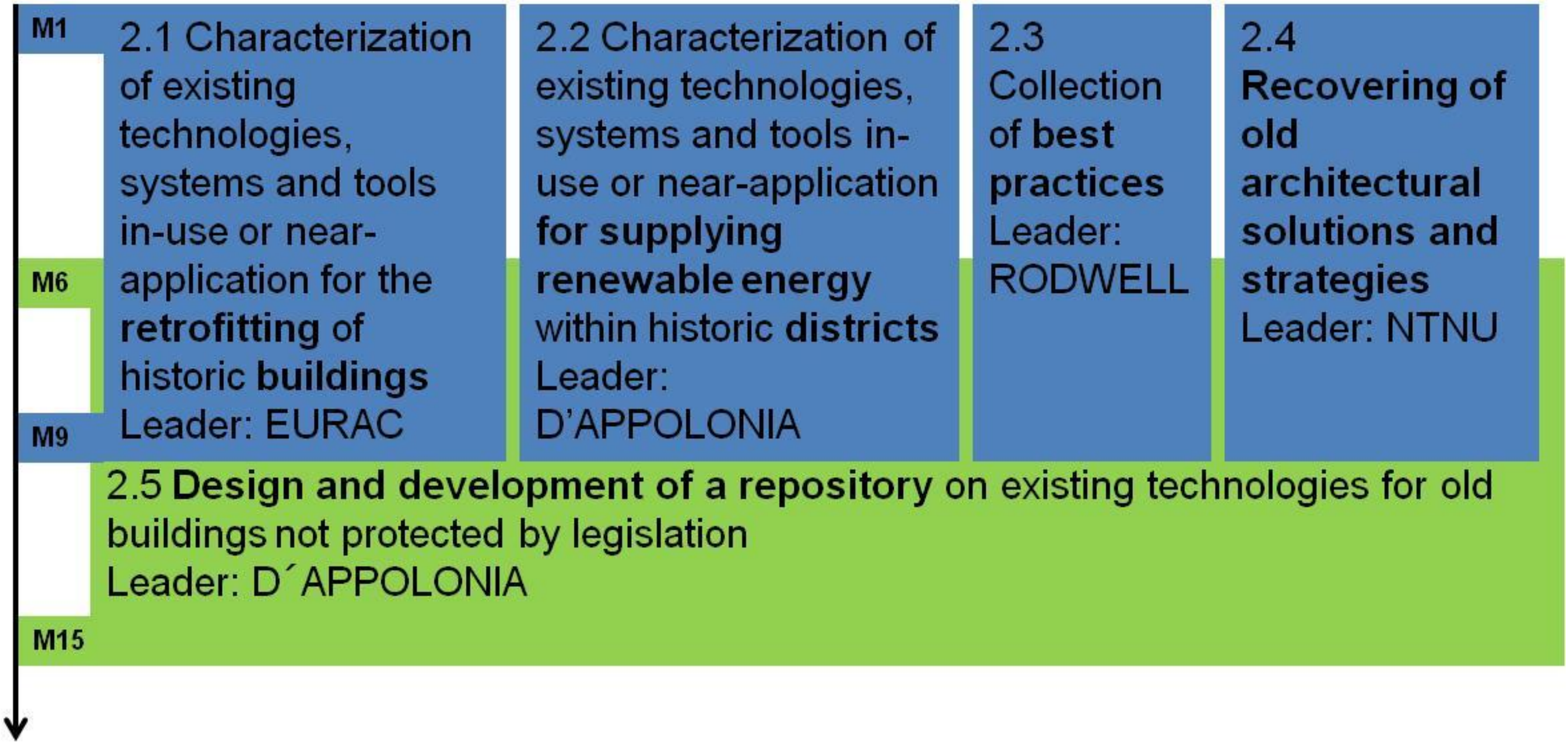
# TOWARDS REPOSITORY OF SOLUTIONS FOR DSS

## Workflow



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# Energy efficient solutions in historic buildings

## Inventorization of existing solutions and assessment of historic value compatability

### Categories considered

Retrofit step → A - Baseline Assessment

Retrofit issue → B - Energy Management

- A - Baseline Assessment
- B - Energy Management
- C - Airtightness
- D - Ventilation
- E - Daylight and solar loads
- F - Solar reflectance of external materials
- G - Thermal performance of external envelope
- H - Moisture performance
- I - Thermal Mass of building
- J - Retro-Commissioning HVAC (RCx)
- K - Electrical Equipment
- L - Water usage
- M – Energy storage
- N - Handover & evaluation

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# Energy efficient solutions in historic buildings

## Information on each retrofit measure

| | |
|---|---|
| Retrofit Step & Issue | F - THERMAL PERFORMANCE OF EXTERNAL ENVELOPE |
| Potential Retrofit Measure | **F1.1.3 – Insulation of an existing cavity** |
| Metric | U-value: W/m2K |
| Commentary | Reduce heat loss and gain / improve comfort |
| | <br>[source: New4Old Technical Guideline]<br>IMG_F113.jpg |
| WHAT<br>short description | In old buildings there exist often cavities which have been left void. These can be filled with loose, hydrophobic insulation material if the outer layer is intact (such as granulaited mineral insulation, hydrophobised cellulose or perlite). Vapour calculation is necessary |
| WHY | **Advantages**<br>No visual impact<br>**Disadvantages**<br>Driving rain protection of outer surfaces needed |

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# Renewable energy solutions

| Renewable Energy technologies | | | Applicability: Building level | Applicability: District level |
|---|---|---|---|---|
| **Solar** | PV | Roof-mounted panels | x | |
| | | PV tiles | x | |
| | | PV cells (included inside glazing) | x | |
| | | Panels sited on the ground | x | x |
| | | PV modules incorporated into walls or used on the building facades) | x | |
| | Solar collectors | Solar collectors on the roof | x | |
| | | Solar collectors field | | x |
| | PV/T mounted on the roof | | x | |
| **Wind** | Large scale wind turbine | | | x |
| | Micro scale wind turbine | | x | |
| **Hybrid system (solar + wind)** | | | | x |
| **Air** | ASHP | | x | |
| **Ground** | GSHP | | x | |
| **Biomass** | Biomass boiler | | x | |
| | Biomass plant | | | x |
| **CHP** | CHP plant | | | x |
| | *Organic Rankine Cycle – ORC system* | | x | x |
| **Seasonal Thermal Energy Storage (STES)** | Tank Thermal Energy Storage (TTES) | | | x |
| | Pit Thermal Energy Storage (PTES) | | | x |
| | Borehole Thermal Energy Storage (BTES) | | x | x |
| | Aquifer Thermal Energy Storage (ATES) | | | x |
| | Thermalbanks: shallow ground thermal storage | | x | x |

| | | |
|---|---|---|
| **District Heating** | | x |

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# Renewable energy solutions

| Renewable Technology | | Protected Historic Building: in any location | Protected Historic Urban District | Unprotected Building in Protected Historic District | Unprotected Building in Unprotected Historic District | Cost estimation |
|---|---|---|---|---|---|---|
| Solar technologies | Photovoltaic solar panel (PV) | Matching PV tiles may be potentially compatible at all roof surfaces.<br>PV cells included into glazing might be also compatible.<br>Instead, incorporating PV modules into walls or for shading façades might be very difficult to be implemented.<br>Solar panels incompatible on publicly visible surfaces (at least) or mounted on the roof. Would require problematic building-by-building negotiation with the heritage authorities. | Urban block or district solar panel rather than individual building systems preferable, thereby limiting the impact and interventions on the fabric of individual buildings and the need for building-by-building negotiations. | More potential for building-by-building systems, especially at non-publicly visible surfaces. | Subject only to any general planning regulations that regulate the appearance of buildings, otherwise unrestricted. | For PV tiles, PV cells included into glazing and PV modules incorporated into walls, medium cost |
| | Solar collectors (all types) | Panels incompatible on publicly visible surfaces (at least). Would require problematic building-by-building negotiation with the heritage authorities. | Urban block or district collector systems preferable, thereby limiting the impact and interventions on the fabric of individual buildings and the need for building-by-building negotiations. | More potential for building-by-building systems, especially at non-publicly visible surfaces. | Subject only to any general planning regulations that regulate the appearance of buildings, otherwise unrestricted. | Not available[1] |
| | PV/Thermal Solar System (PV/T) | Panels incompatible on publicly visible surfaces (at least). Matching PV/T tiles may be potentially compatible at all roof surfaces. | As above | As above | As above | For PV/T tiles, medium/high cost |

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# TOWARDS REPOSITORY OF SOLUTIONS FOR DSS

## Effesus Repository

### Existing technologies for the retrofitting of historic buildings

List of the retrofit technologies

### Existing technologies supplying renewable energy within historic districts

Renewable Energy Systems (RES) - production
Renewable Energy Systems (RES) - storage
District heating and cooling
Complementary Tools
Complementary Tools Example

### Indicator List

Renewable Energy Systems Indicators
Retrofit technologies Indicators
District heating and cooling Indicators
Stes Indicators

### Climate analysis - Passive retrofitting solutions

Climate analysis - Passive retrofitting solutions

### Best Practices

Best Practices

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## Physical interventions

- Insulating mortars
- Ventilated windows
- Aerogel based cavity wall insulation
- Transparent reflective coatings

## Smart management solutions

- Indoor climate solutions
- Renewable energy usage

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## Algorithms for comfort based indoor climate control:

- As far as concern $CO_2$ and pollutants, the ventilation rate is increased when measured values are close to or upper the threshold limits; on the contrary, it is reduced to the minimum background air change level for that type of space when contaminant level decreases
- Algorithms for illumination control are essentially based on occupancy control (occupancy sensors drive the lighting controllers in an on/off mode) and daylight harvesting (daylight sensors drive the dimmers of the light sources adjusting their outputs to a given set point). Illumination management systems allow the programming of several illumination scenarios to adapt the illumination level
- Strategies for energy conservation in HVAC systems are usually directly integrated in the control systems of the HVAC systems. The algorithms are differing in function of the HVAC systems itself and the strategy selected
- The different control strategies need to be integrated in a Building Management System (BMS). Interactions between the respective controllers can be very complex and priorities need to be set

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# DEMONSTRATION IN EFFESUS PROJECT: BUDAPEST CASE STUDY

- Main building of the Budapest University of Technology and Economics: demonstration area is one classroom situated on the 3rd floor facing West with two traditional double sash windows; the classroom alongside with same size and properties is being used as reference (heating and lighting systems, as well as windows kept as such)
- Windows have been replaced with new ventilated and insulating ones
- The building is heated by central heating system. The heating system had been modified to allow the temperature of the room to be controlled and the energy consumption to be measured separately from the rest of the building.
- The original lighting system had one zone, controlled centrally in the classroom. The new illumination system has three zones (one zone per row of 4 lighting fixtures) of fluorescent lamps controlled by digital dimmable ballasts of the DALI type. Intensity of illumination is set zone by zone according to measurement of luminance and presence sensors mounted on suspended ceiling.
- The classroom did not have any mechanical ventilation system. The ventilation rate of the new windows is indirectly regulated by the speed of the exhaust fan installed in the test room.
- The demonstration windows were designed to be equipped with roller shades for better visual and thermal comfort. Blinds can be moved up and down by a controller.

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## Overview of the operating parameters

| PARAMETER | CONTROL | TEST ROOM | REFERENCE ROOM |
|---|---|---|---|
| Air temperature | Setting | Winter: 20°C | 20°C - centralized |
| | | Summer: 26°C | No cooling / ventilation |
| | Sensor | Sensirion | Sensirion for monitoring only |
| | Control | PID controller or controllable thermostatic valves | Thermostatic valves or general temperature control of building (?) |
| Relative humidity (monitoring only) | Setting | - | - |
| | Sensor | Sensirion | Sensirion |
| | Control | - | - |
| Illumination | Setting | 500 lux | - |
| | Sensor | Lux sensor per zone | Lux sensor for monitoring only |
| | Control | PID controller + DALI | On/off |
| $CO_2$ | Setting | Range | - |
| | Sensor | $CO_2$ sensor | $CO_2$ sensor for monitoring only |
| | Control | PID controller or on/off control of exhaust fan | Natural ventilation |

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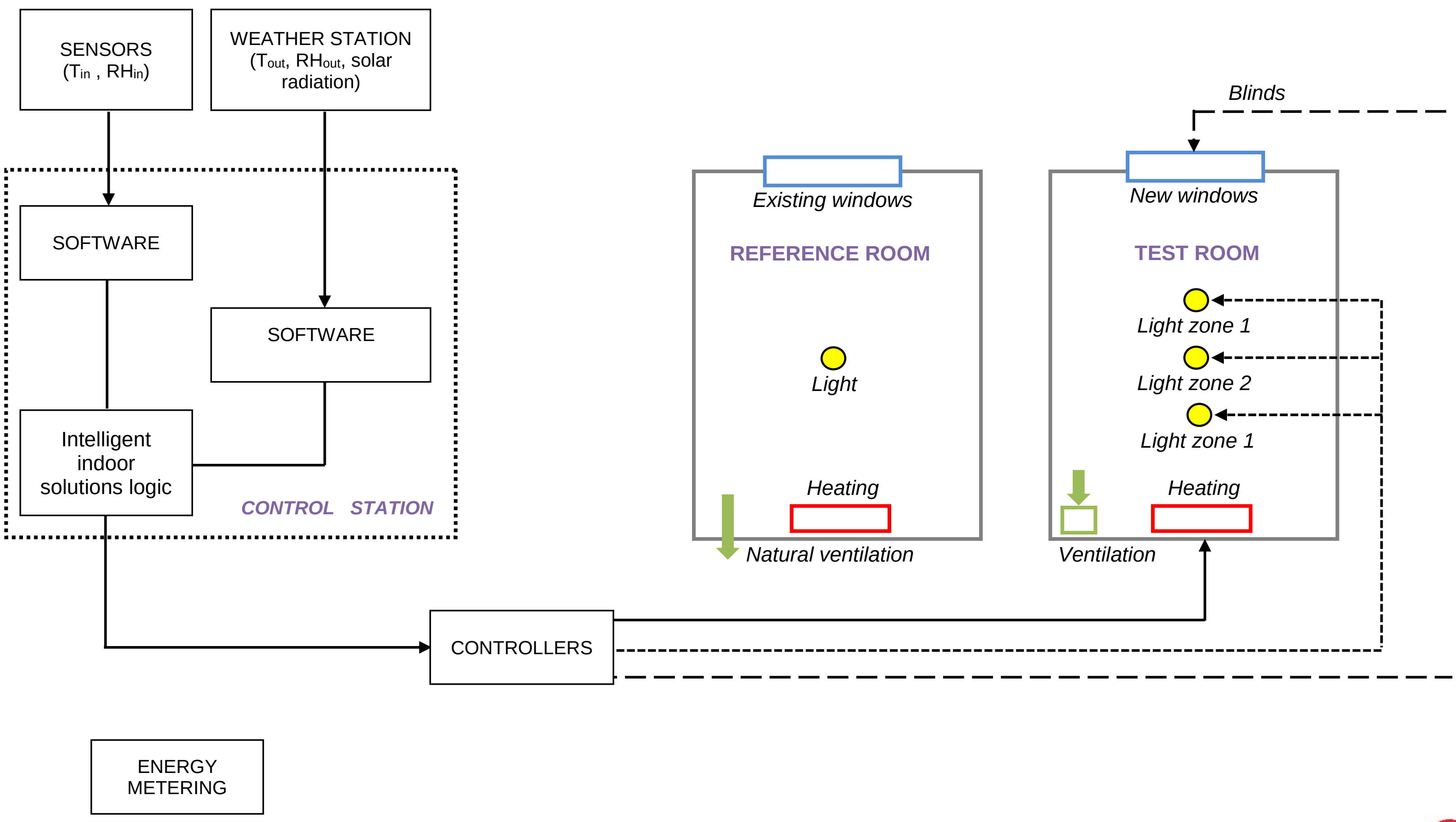
## SCHEMATIC DIAGRAM OF THE CONTROL PRINCIPLES



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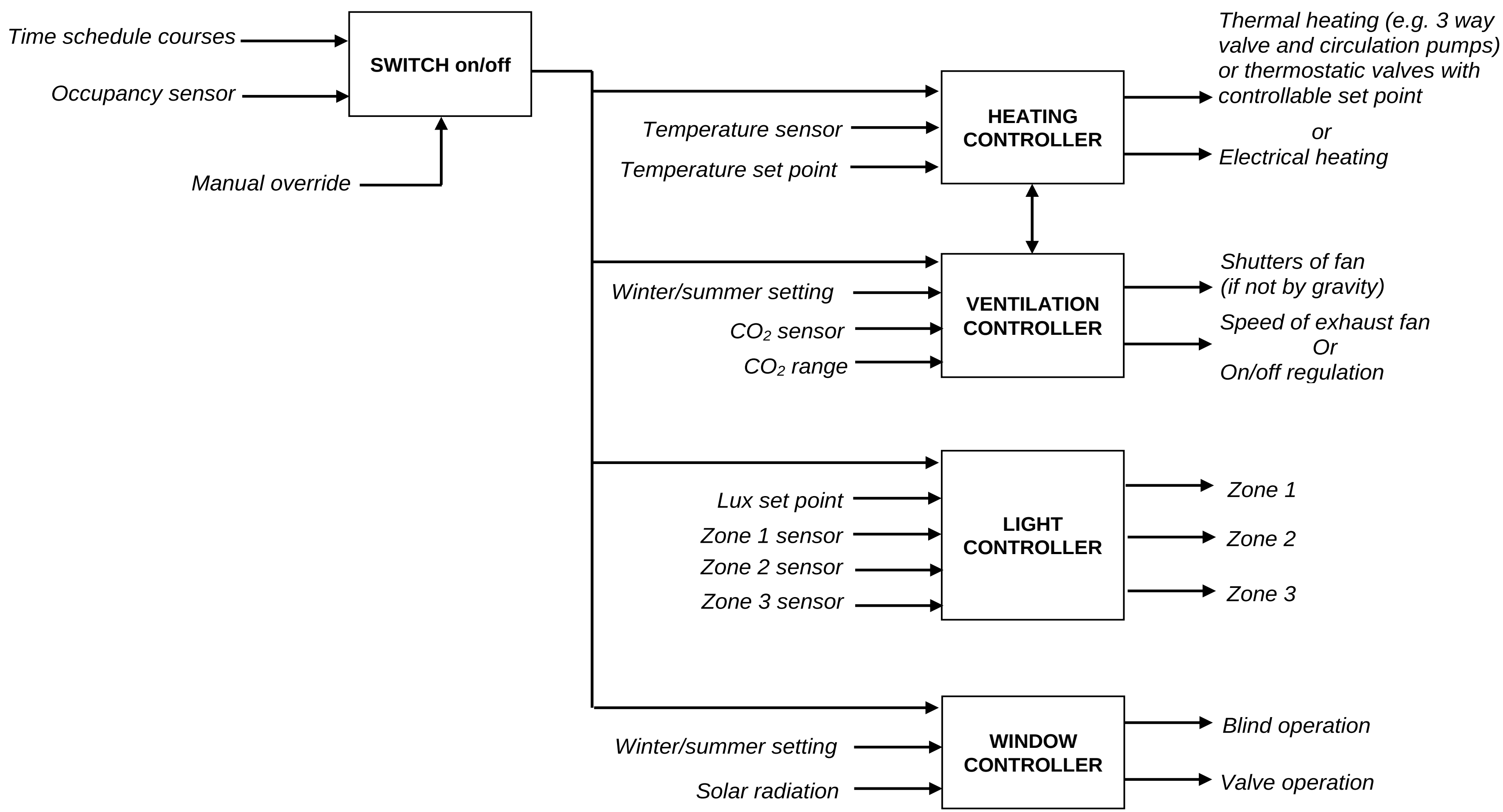
# DEMONSTRATION IN EFFESUS PROJECT: BUDAPEST CASE STUDY

## CONTROL SCHEME



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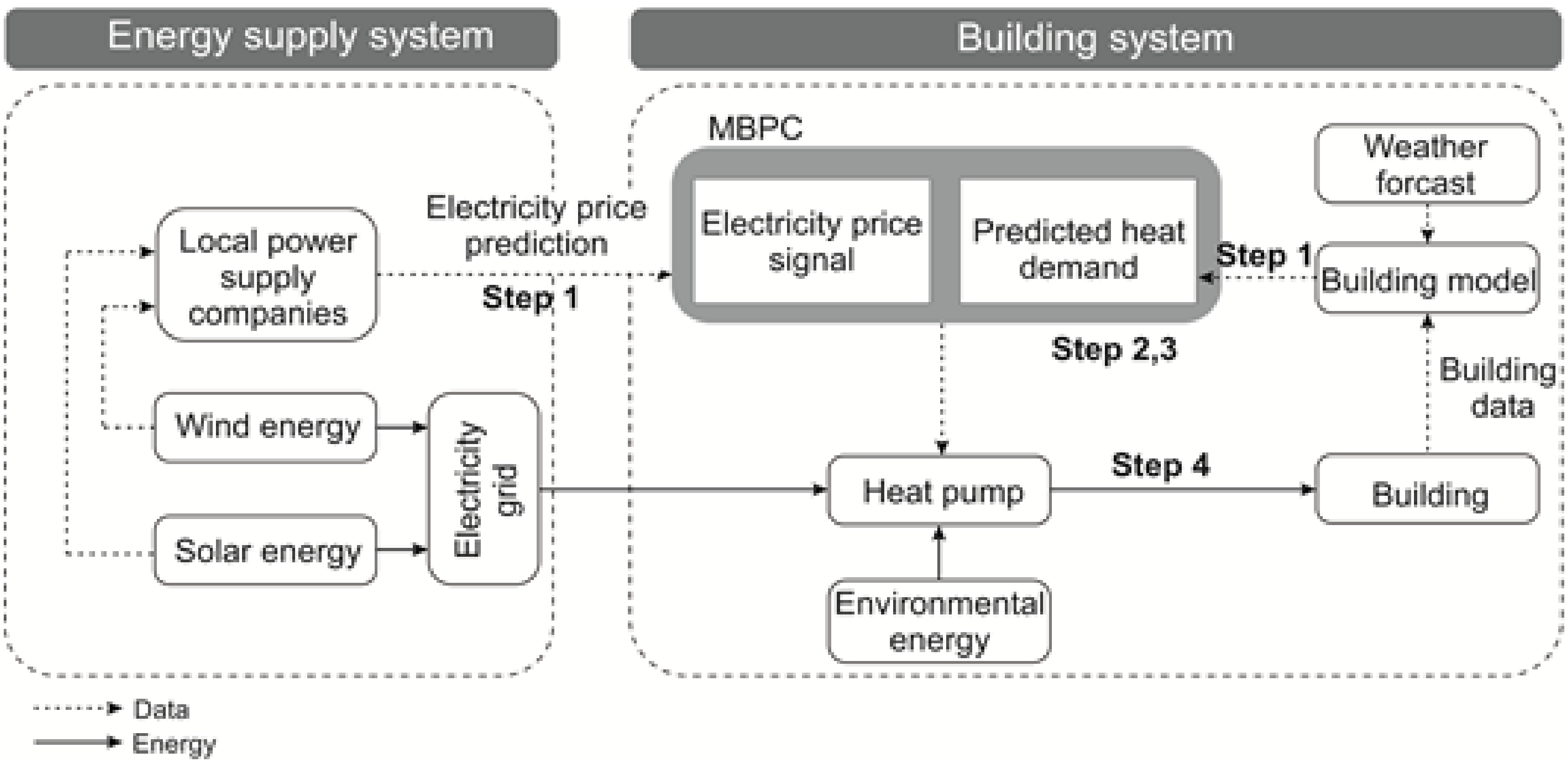
# RENEWABLE ENERGY : OPTIMIZATION OF USAGE AND COST



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# THANK YOU FOR YOUR KIND ATTENTION

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