L'Integrazione tra i modelli di sistemi energetici di lungo termine e le procedure di pianificazione urbana:

Il caso studio di Torino

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OUTLINE OF THE ACTIVITY

Emerging research limitations

Contribute in providing a theoretical framework to integrate long-term energy system models into urban energy planning practices.

LIMITATIONS

LACK of MEDIUM-to-LONG PLANNING VISION

Actions are generally thought, designed and implemented looking at the short-term without a clear and comprehensive objective.

LACK OF CROSS-SECTORAL ANALYSIS

Most of the current urban energy planning applications are single-sector focused, but urban areas are composed of multiple interconnected sub-systems.

PREPARATION PHASE.

- Identify and involving relevant stakeholders
- Setting the objectives, selecting methods and tools
- Data collection and harmonization

DETAILED ENERGY MODELING PHASE.

- Optimization approach

CASE STUDY APPLICATION

City of Torino

DISCUSSION

Discussion and reflections on existing barriers and highlight of future needs.

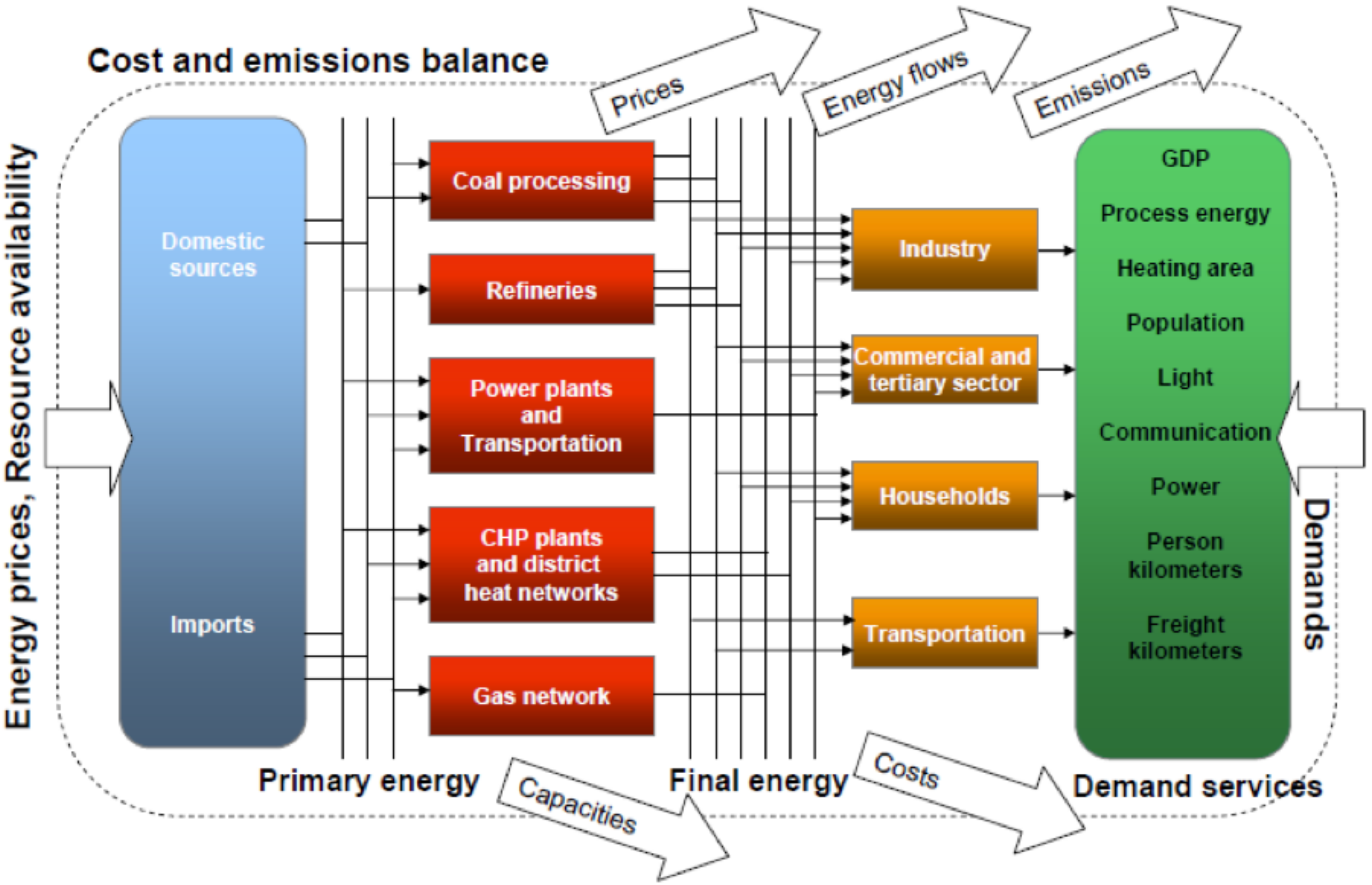
THE REFERENCE ENERGY SYSTEM

Energy system representation

RES definition

a network description of the energy system that captures all the activities involved in the entire supply chain by taking the technological characteristics of the system into account . This approach is often associated to optimization methodologies as linear programming.

Each “box” represents the principal characteristics of the technology (technical and economic).



INVOLVING STAKEHOLDERS

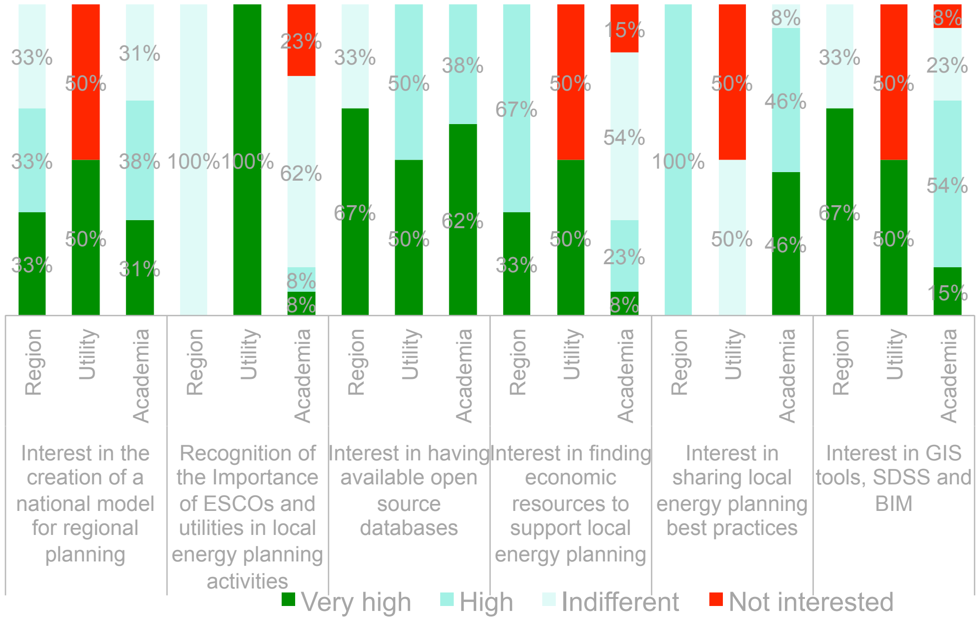
Identify and involving relevant stakeholders

Interest
All the people/ institutions/ organizations interested and directly involved in the energy planning activity

Power
All the people/ institutions/ organizations that may affect the realization of the project

Data owner
All the people/ institutions/ organizations that own useful information on the area

Passive
All the people/ institutions/ organizations that are directly affected by the energy planning measures



Relevant stakeholders

The most relevant stakeholders, identified as the Municipality, the district heating utility company and the Consorzio per il Sistema Informativo (Consortium for the Information System, CSI) were contacted individually.

The first workshop was held in Torino the 19th April 2016 (Politecnico di Torino LAME, 2016) with the goal of sharing best practices in integrated energy planning while the second workshop was co-organized with ENEA (ENEA and Politecnico di Torino LAME, 2017) and held in Rome the 22nd May 2017 with the objective of creating a network of energy planning stakeholders. Survey's Particpants: 3 Regional stakeholders, 2 energy utility stakeholders and 13 academic and private stakeholders

DATA COLLECTION AND HARMONIZATION

Necessary data to be collected

BUILDING STOCK INFORMATION

Geometrical data, socio-economic data, real energy consumption data, etc.

TECHNOLOGY AND ENERGY MIX INFORMATION

Energy balance, availability of local resources, technology share, etc.

ECONOMIC PARAMETER

Energy prices of commodities, O&M costs, investments costs, taxes etc.

TERRITORIAL PARAMETERS

Urban physical constraints, land occupation plans, available space for new technology installation, etc.

URBAN MAPS

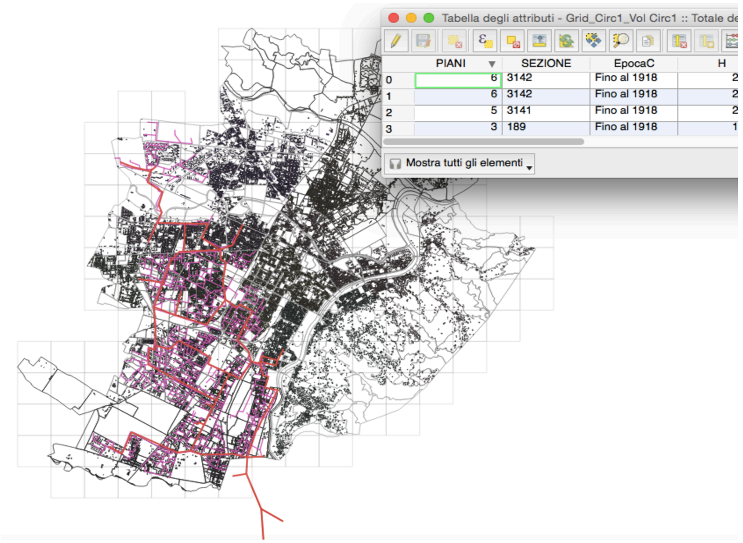
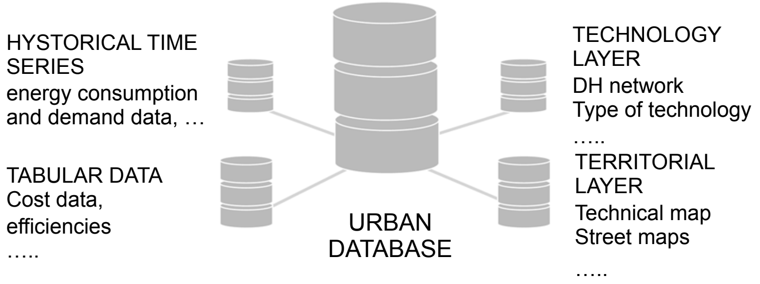


Tabella degli attributi - Grid_Circ1_Vol Circ1 :: Totale de

	PIANI	SEZIONE	EpocaC	H
0	6	3142	Fino al 1918	2
1	6	3142	Fino al 1918	2
2	5	3141	Fino al 1918	2
3	3	189	Fino al 1918	1

Mostra tutti gli elementi

DATA COLLECTION

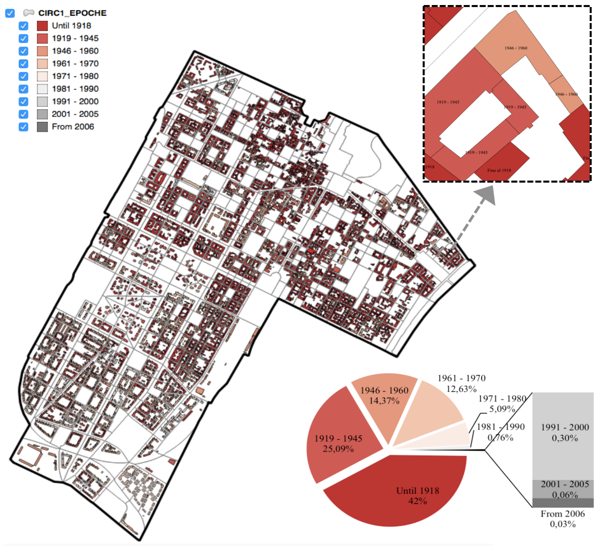


In addition, they can be derived from multiple sources: municipalities, energy utilities, market analyses, statistic institutions, government bodies, academia etc.

Preparation Phase

BUILDING STOCK DATA COLLECTION

Defining building typologies



- 62,643 occupied buildings, 202 Mm^3
- Average surface of residential apartments:75.3 m^2 with a floor height of 3.5 m
- Residential building classified according to construction period (materials) and S/V (compactness): 36 building typologies
- Non-residential buildings classified according to destination use (school, offices, industrial activities, sport activities, churches, little commercial activities)

Non-Residential Buildings

6 destination uses

68.1%
Small industrial activities

18% VOLUME

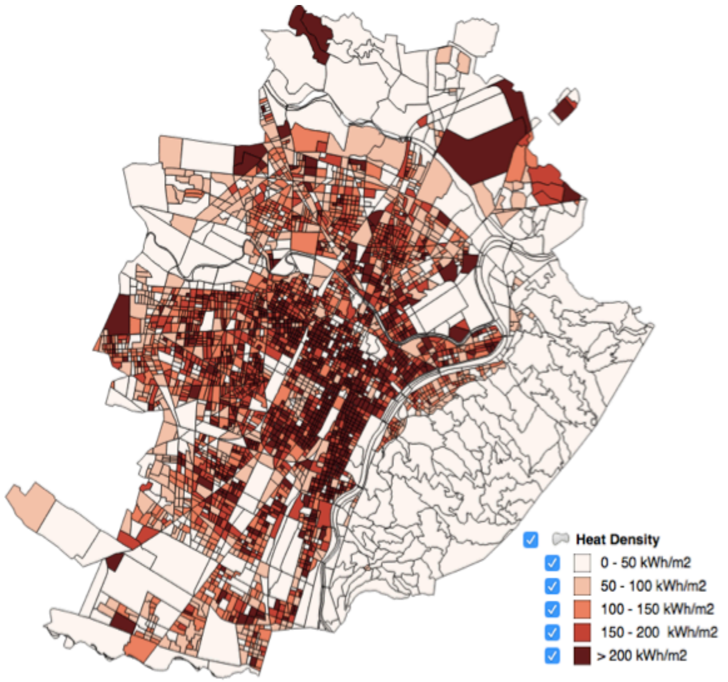
Residential Buildings

36 building typologies

93%V
Before"80s

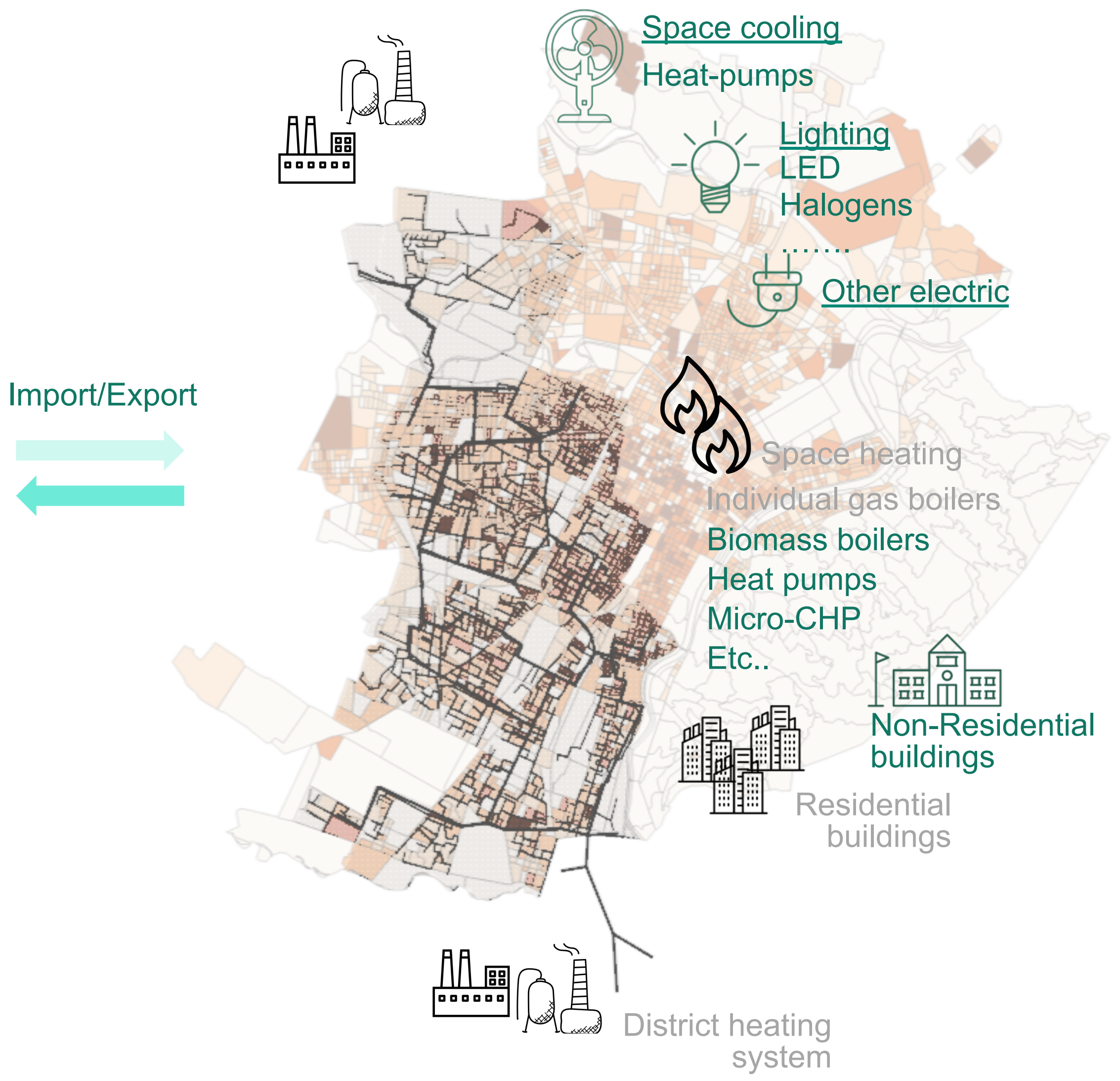
75%V
Apartment Block

82% VOLUME



OBJECTIVE

Introducing boundary conditions and the principal objective



Goal

Develop an urban energy system optimization model with original features in order to study the specific interactions between energy efficient buildings and the development of urban heat strategies.

Compared to the simulation approach, an optimisation framework takes into account the competition across multiple technologies. This model extends the analysis to the whole city, to all building services and the related technologies to supply them. It provides, therefore, a broader perspective of heat decarbonization options.

1 **01**
At a certain point, energy efficiency measures in buildings will stop being cost-effective relative to the cost of heat

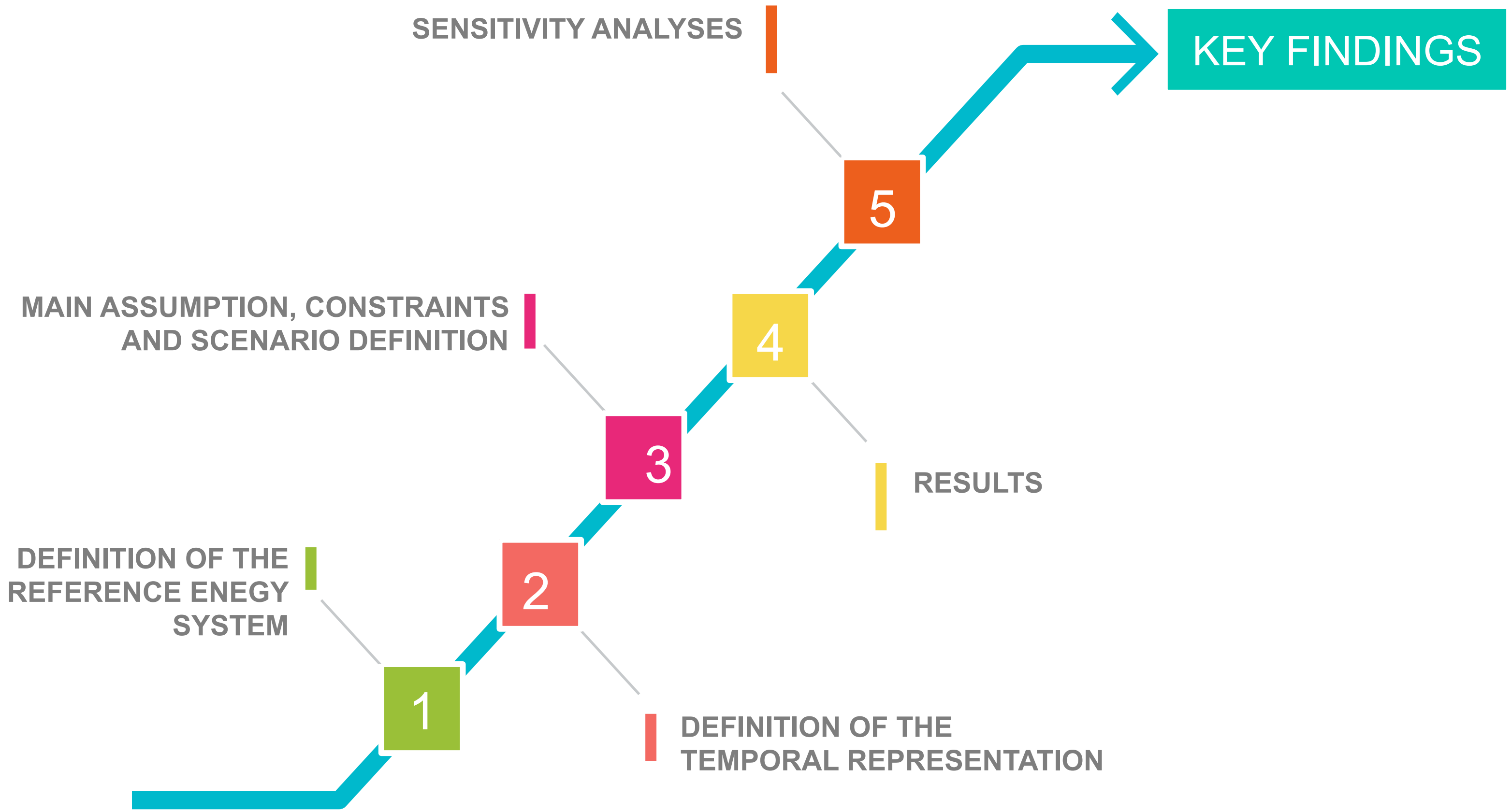
2 **02**
variation of thermal demand will impact the operation and generation strategies for DH and could influence any new investment strategies.

3 **03**
Lots of low carbon and high efficient distributed generation alternatives are market available

4 **04**
Adding electricity consumption and looking at wider synergies

OPTIMIZATION APPROACH: METHODOLOGY

Schematic of the methodology



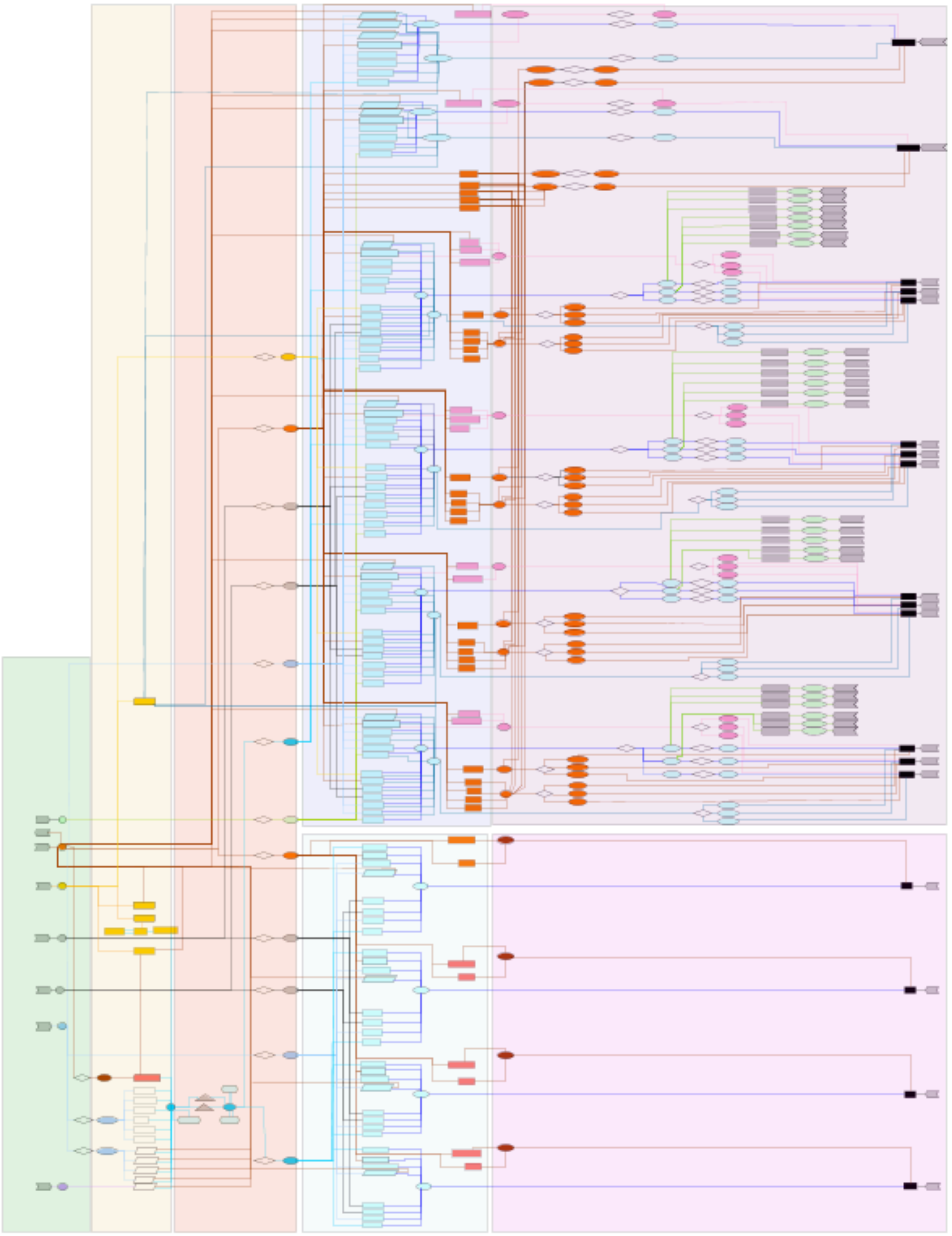
OVERVIEW OF THE REFERENCE ENERGY SYSTEM

Milestones years

307 process, 197 commodities, 13168 data

Each “box” represents a new or existing technology and it is described by techno-economic variables that can be optimized, constrained or defined as input

Detailed Modelling Optimization



TIME RESOLUTION

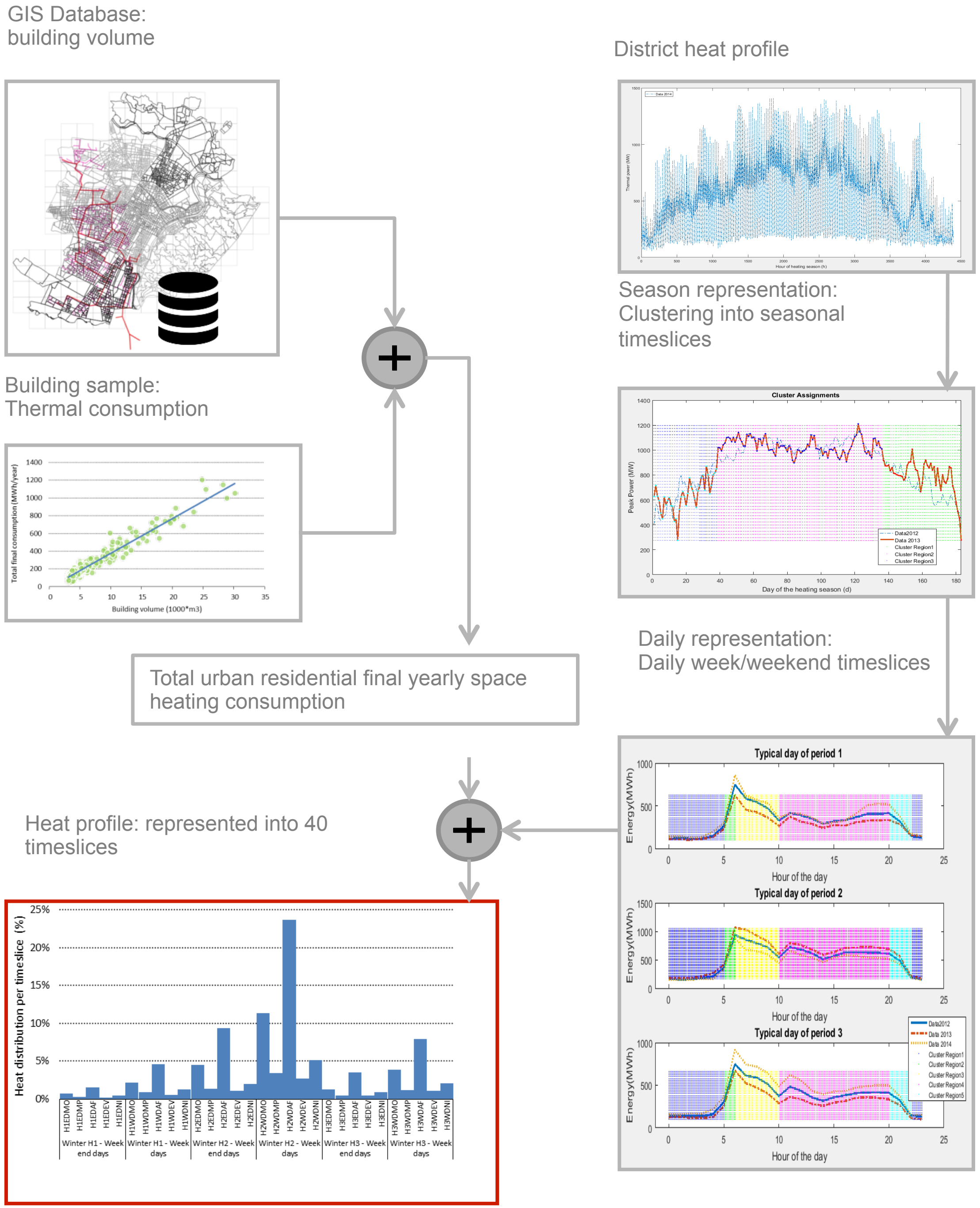
Timeslices definition

The goal is to define representative "timeslices" (Tsl) in order to aggregate temporal periods characterized by a similar load. The timeslices selection is extremely relevant for the model outcome; its definition depends on the purpose of the analysis taking into account the always existing compromise among computational time and technical resolution.

Time horizon: 2015-2050

Time periods: 9 time periods

Timeslices: 40 timeslices



Detailed Modelling
Optimization

SCENARIOS DEFINITION

Main assumptions and constraints

SCENARIOS VARIABLES

FINANCIAL VARIABLES

Discount rate

TECHNOLOGICAL VARIABLES

Fixing the share of district heated buildings

Fixing the share of renewables

Efficiencies of technologies

PRICE OF COMMODITIES

High prices
Low prices
……

POLICY RELATED VARIABLES

Environmental targets
Carbon tax
….

VARIABLES DEPENDENT FROM OUTSIDE THE CITY

Power sector decarbonization
….

CONSTRAINTS (dynamic or not)

RESOURCE AVAILABILITY

MSW
Solar energy

EXCHANGE OF RESOURCES

Export of electricity

URBAN SURFACES AND LAND AVAILABILITY

Rooftop installation
Land availability for installation

GENERATED SCENARIOS

Scenarios description

Detailed Modelling Optimization

	Baseline	S1	S2
	BASELINE	SCENARIO S1	SCENARIO S2
	40% (2030) Emission reduction*	60% (2050) Emission reduction*	80% (2050) Emission reduction*
Discount rate	5%	5%	5%
Fuel and electricity prices	High	Low	Low
Decarbonization level of the power sector	Low	High	High
RES minimum penetration	60% solar heating New buildings	60% solar heating New buildings	60% solar heating New buildings

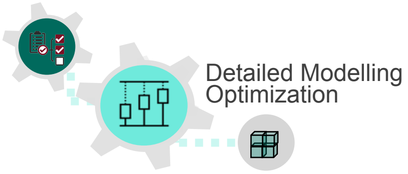
SCENARIO S2-CT
Adding a carbon tax

SCENARIO S2-DH
40-60% min share of DH

SCENARIO NO RETR
Excluding Retrofit

SCENARIO N
....

* Compared to 1990



RESULTS

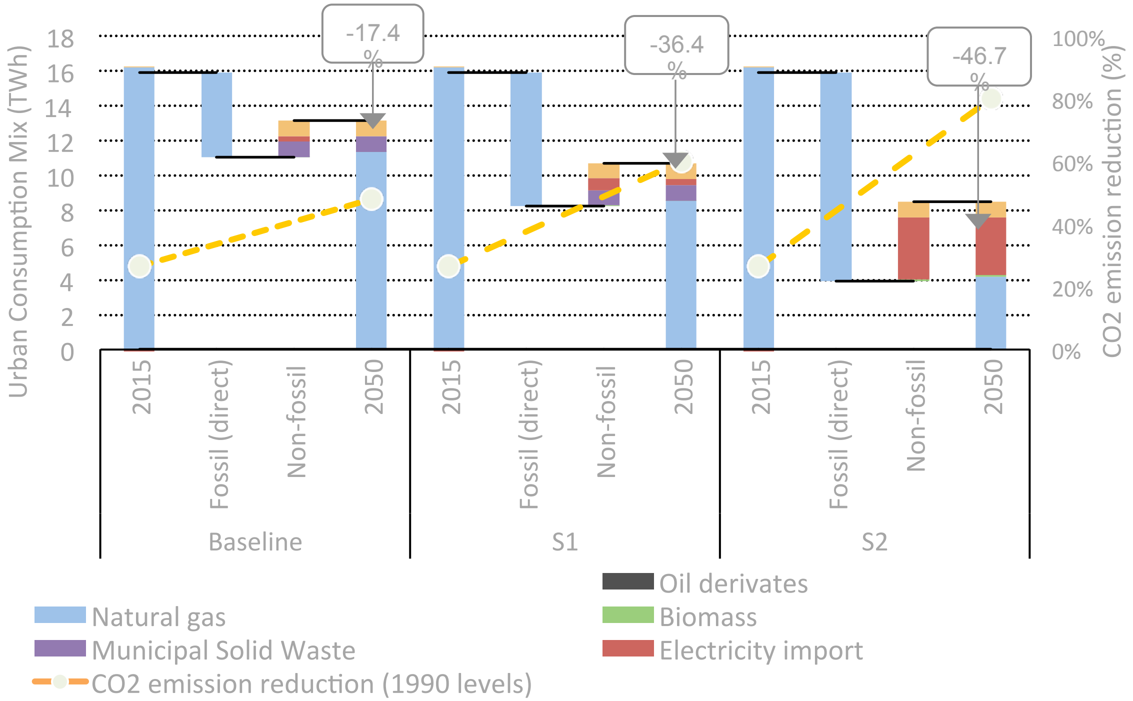
Overview

OVERVIEW

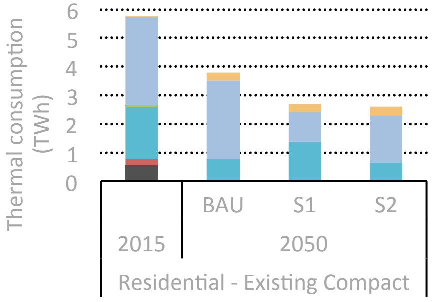
1

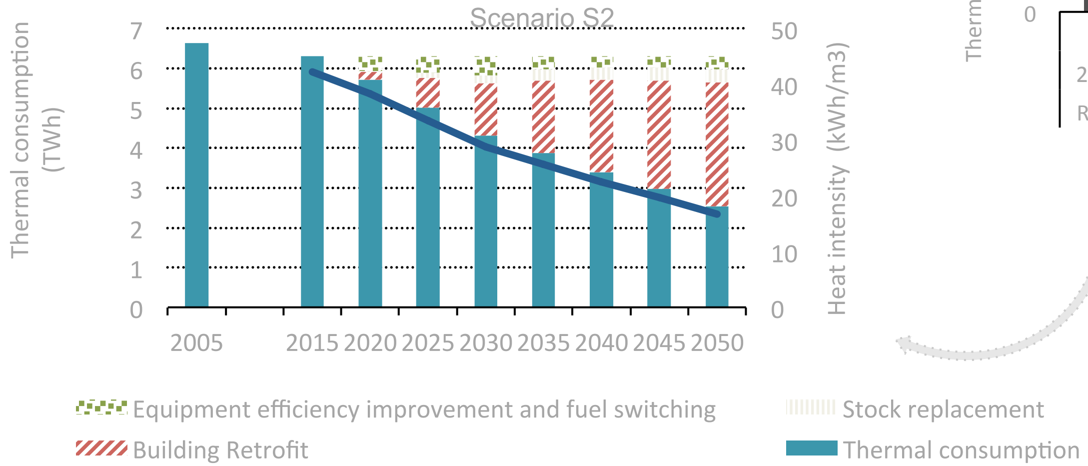
The least cost solution to satisfy energy service demands and constraints.

¬ Technology investments (capacity and related costs).
¬ Technology annual activities (input and output).
¬ Emission trajectories.
¬ Marginal prices of energy commodities.
¬ Total discounted system cost.



COMPACT BUILDINGS
86.8% of the stock volume





RESULTS

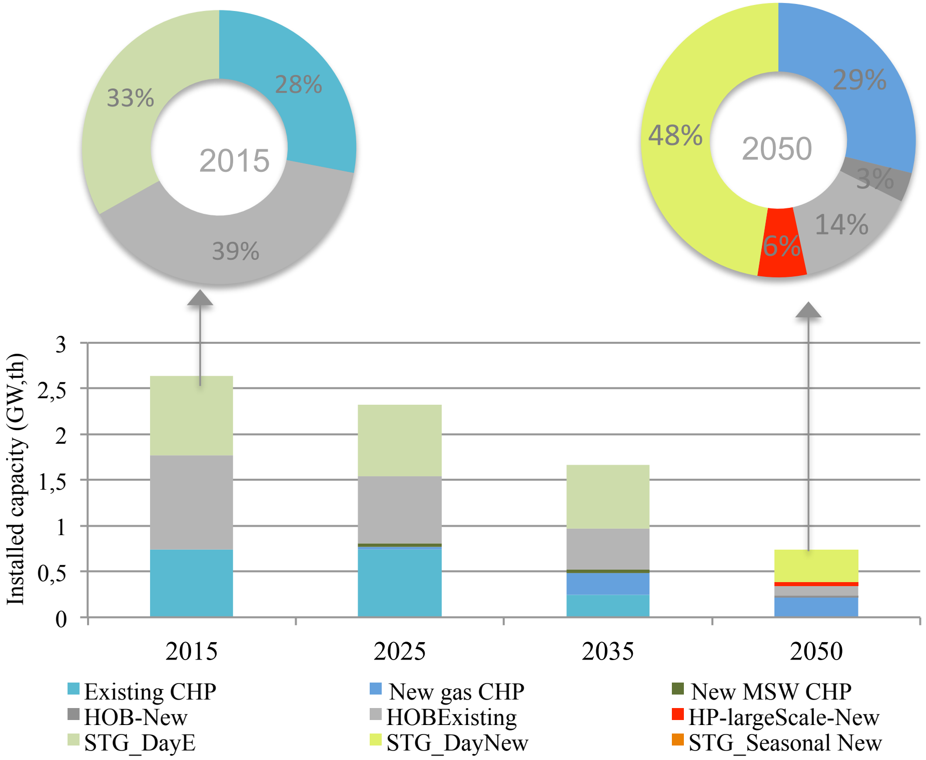
District heat generation mix

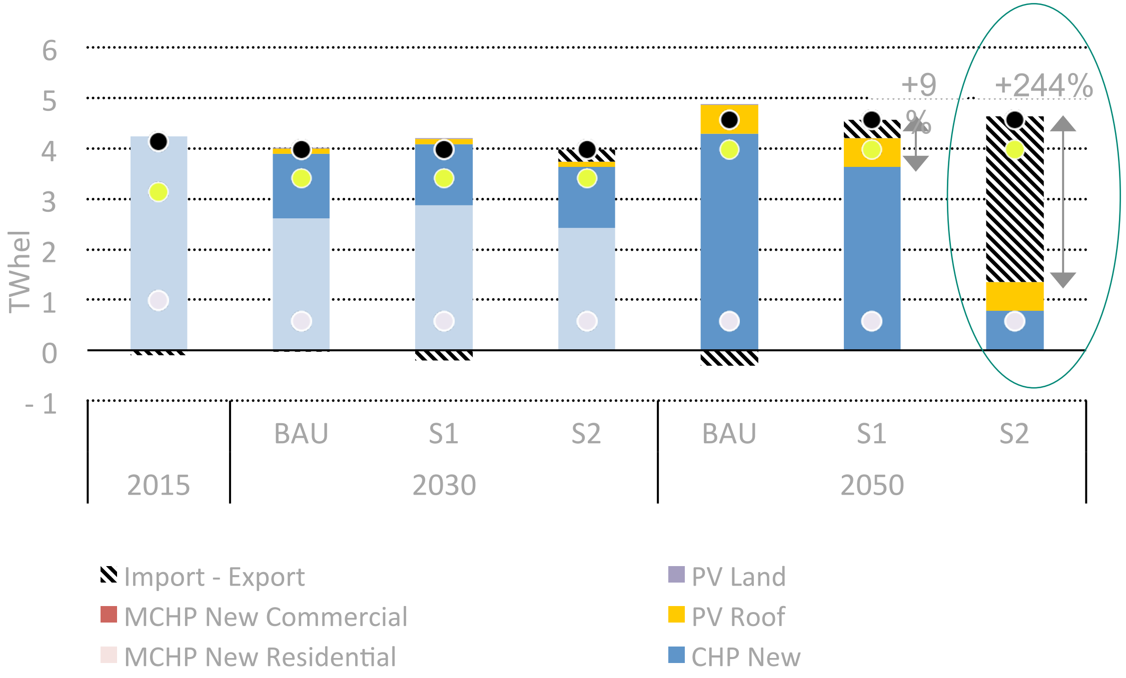
Detailed Modelling Optimization

1

DISTRICT HEAT AND ELECTRICXITY GENERATION MIX

Scenario S2



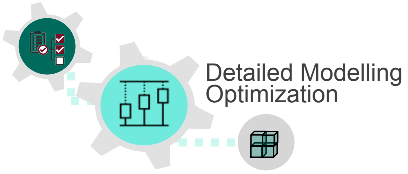


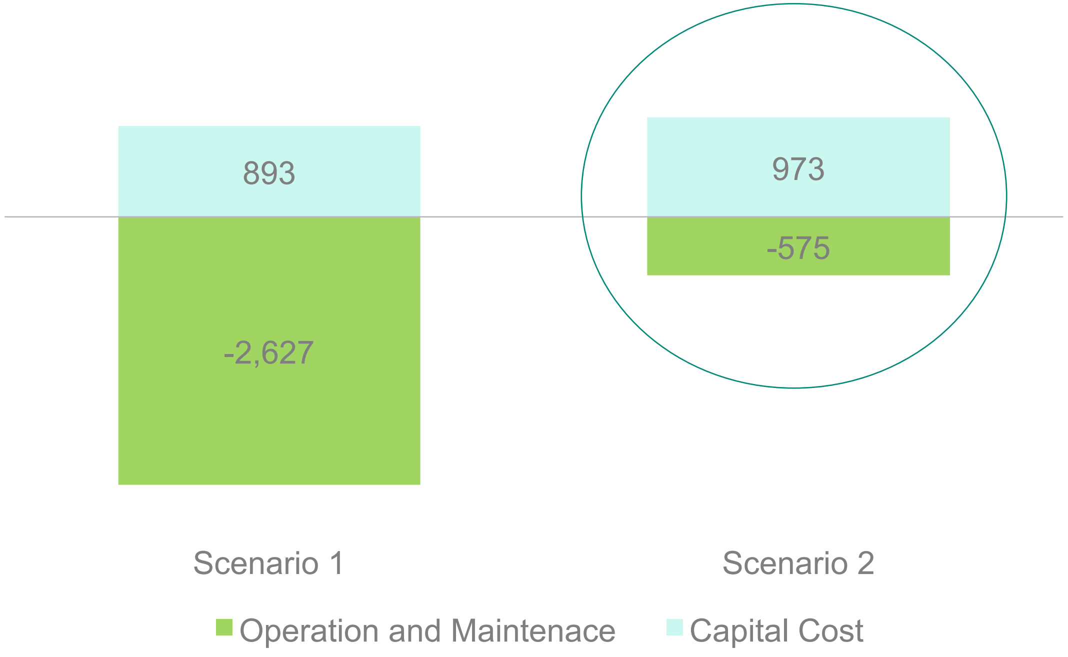
Scenario S2, characterized by the lowest thermal demand and by higher environmental targets, cannot reach the emission reduction level with the proposed district heating technologies

The increased import of “electricity” is also driven by heat savings correspondent to a reduced capacity needs in the heat sector, reducing the capacity of installed CHP units

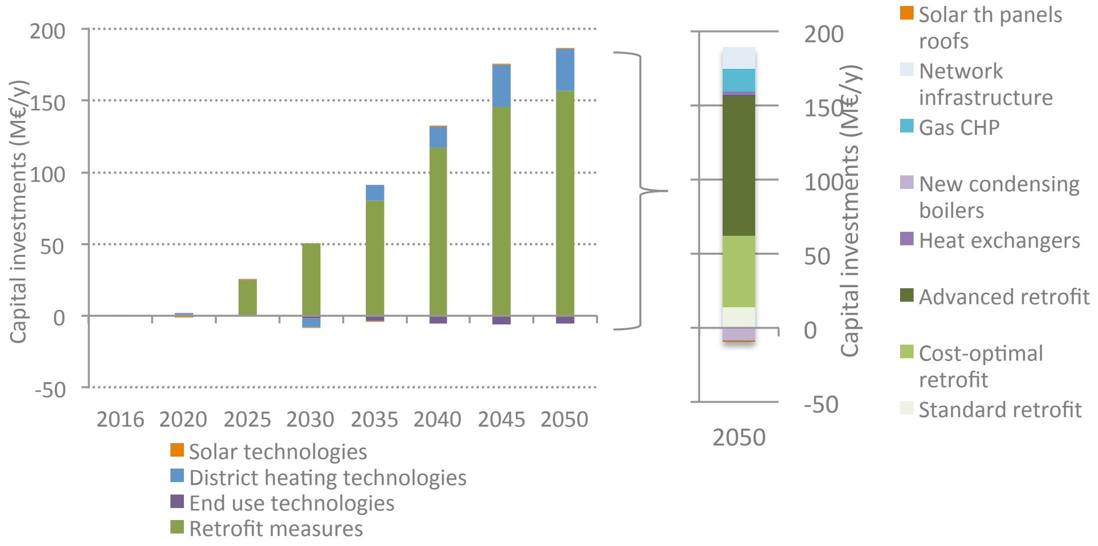
RESULTS

Financial evaluations to support decarbonization





Discounted Total System Cost compared to Baseline. Billion €



Not discounted investments – Baseline compared to S1

2 FINANCIAL EVALUATIONS

Consistent opportunities are available in order to meet the decarbonization targets and contemporary provide improved building services at reasonable added costs

RESULTS

Key trends

2 principal trends:

!

(i) The reduction of urban consumption is achieved by fuel switching, efficiency improvements and energy conservation;

The CO_2 targets can be reached through a mixture of building retrofit measures (advanced in the later periods), solar PV and solar thermal, district heat from low carbon sources together with heat pumps, high efficiency gas and (for single families only) biomass boilers. District heating strategies require coordination with energy efficient buildings together with a shift to low carbon solutions (integrating heat pumps, renewables and storage technologies).

(ii) An increased level of electrification

In absolute value, electric consumption does not increase too much, but tit cover a higher share (energy efficiency improvement in lighting and appliances). For example substituting electric water heaters with solar thermal systems, and inefficient light bulbs with LED lamps. The decarbonization of the power sector, key pre-requisite to reach the environmental targets.

Sensitivity: together with the discount rate that impacts on investments choices, the most relevant variable is the decarbonization of the power sector influencing the gas/electricity ratio, and the share of district heating.

KEY OUTCOMES OF THE DETAILED MODELING PHASE

Optimization approach

METHODOLOGY

USEFUL INFORMATION

What can you do with…?

- Definition of energy plans, scenarios analysis, analysing the role of some technologies

Why should you use it…?

- Integrated demand-supply analysis, cross-sectoral evaluations, long-term.

When should you use it..?

- When a target needs to be reached (back-casting), policy analysis.

Who can use it…?

- Energy experts.

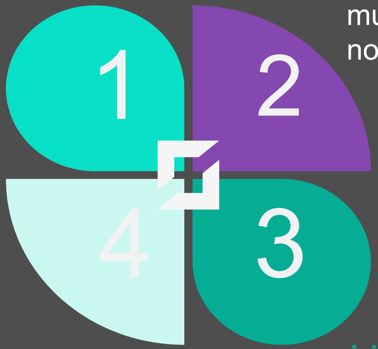
MAIN CRITICALITIES

Traditional thinking and habits

radical change in the traditional planning practice, requiring new competencies and additional people to perform it

Time consuming and high level of expertise

Time that technician of the municipality or decision makers may not dispose.



Need of transparency

This fact is crucial since it provides new opportunities for collaboration between non-experts and experts.

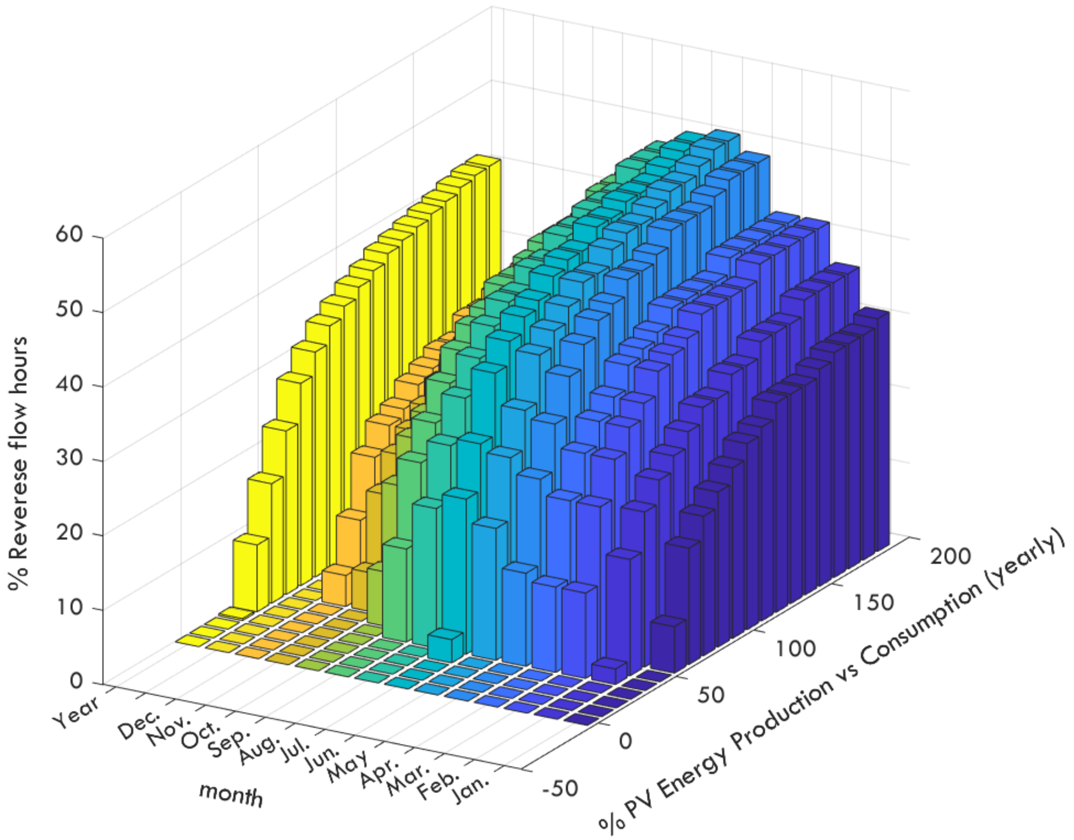
High level data

The availability and reliability of large standardized databases and public data sources are currently limited at the local level, limiting the modelling choices and requiring high efforts from local stakeholders

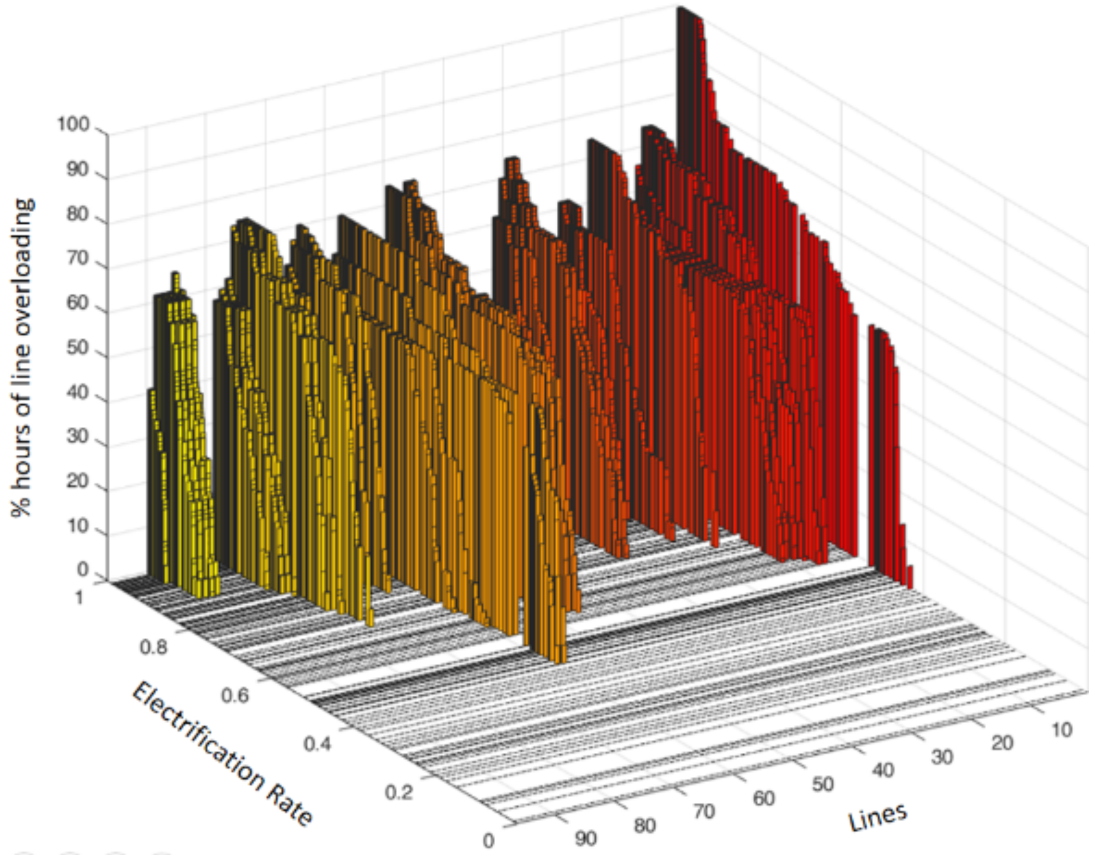
Gli scenari operativi: la modellazione delle reti urbane

Heat in the pipe project 2017-2019
Understanding the role of gas networks in the energy transition process

I flussi inversi e il bilanciamento



L’elettrificazione e i limiti di rete



THANKS FOR THE ATTENTION

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