TESSE²B
the smart energy storage

Thermal Energy Storage Systems

for energy efficient building an integrated solution for residential building energy storage by solar and geothermal resources

Exploitation of research results and transfer to market

5th Workshop

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Aim of social survey

Analysis and understanding of consumers' behavior and perspectives in different EU countries concerning:

1. **Perceived benefits** of the TESSe2b technology;
2. **Perceived adoption intention** of the TESSe2b technology;
3. **Willingness To Pay** (WTP) for the TESSe2b technology;
4. **Acceptable payback period** for the investment in TESSe2b technology.

Survey

A. Online survey: June 2016 – February 2017

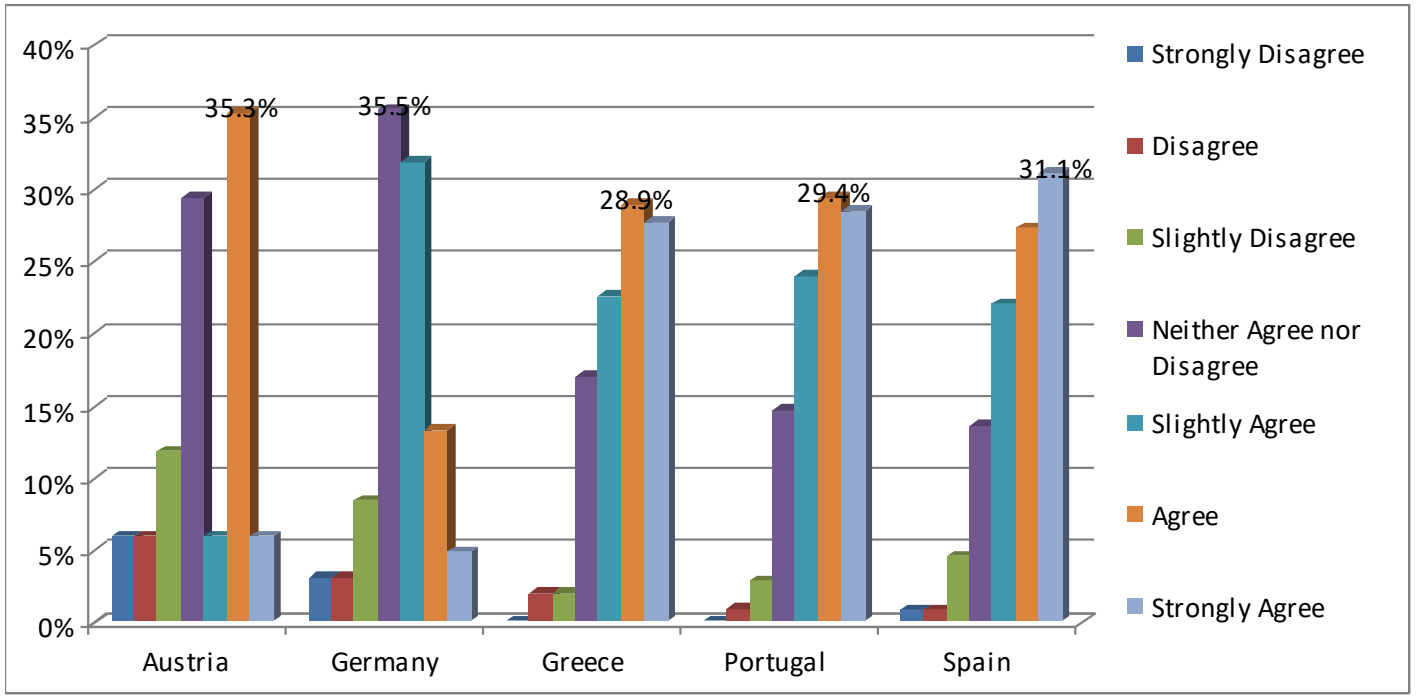
B. 600 responses →
- Greece: 159
- Portugal: 109
- Spain: 132
- Germany: 166 (mainly students)
- Austria: 17

C. Analysis using SPSS 24.

Descriptive statistics

	Austria	Greece	Portugal	Spain	Germany
Residential area	40% Town or small city	> 40% big city			
Housing type	41% detached single-unit house	>44% in flat			
Year of construction (or large renovation)	35% 1990-1999	Around 25% 1970-1989			20% Don't know
Energy sources for space heating	> 40% Natural gas	49% Heating oil	50% Electrical	> 40% Natural gas	
Energy sources for space cooling	88% No	72% Electrical	> 50% No		
Energy sources for domestic hot water	41% Electrical	50% Solar panel	28% other	> 50% same as heating	
Feel about household's income nowadays?	Around 50% coping on present income				
Total monthly income	47% 2000-2500€	26% 1000-1500€	22%500-1500€	29% 1000-1500€	38% < 500€
Total household income percentage used for energy costs	> 33% between 5 and 10%				Don't know

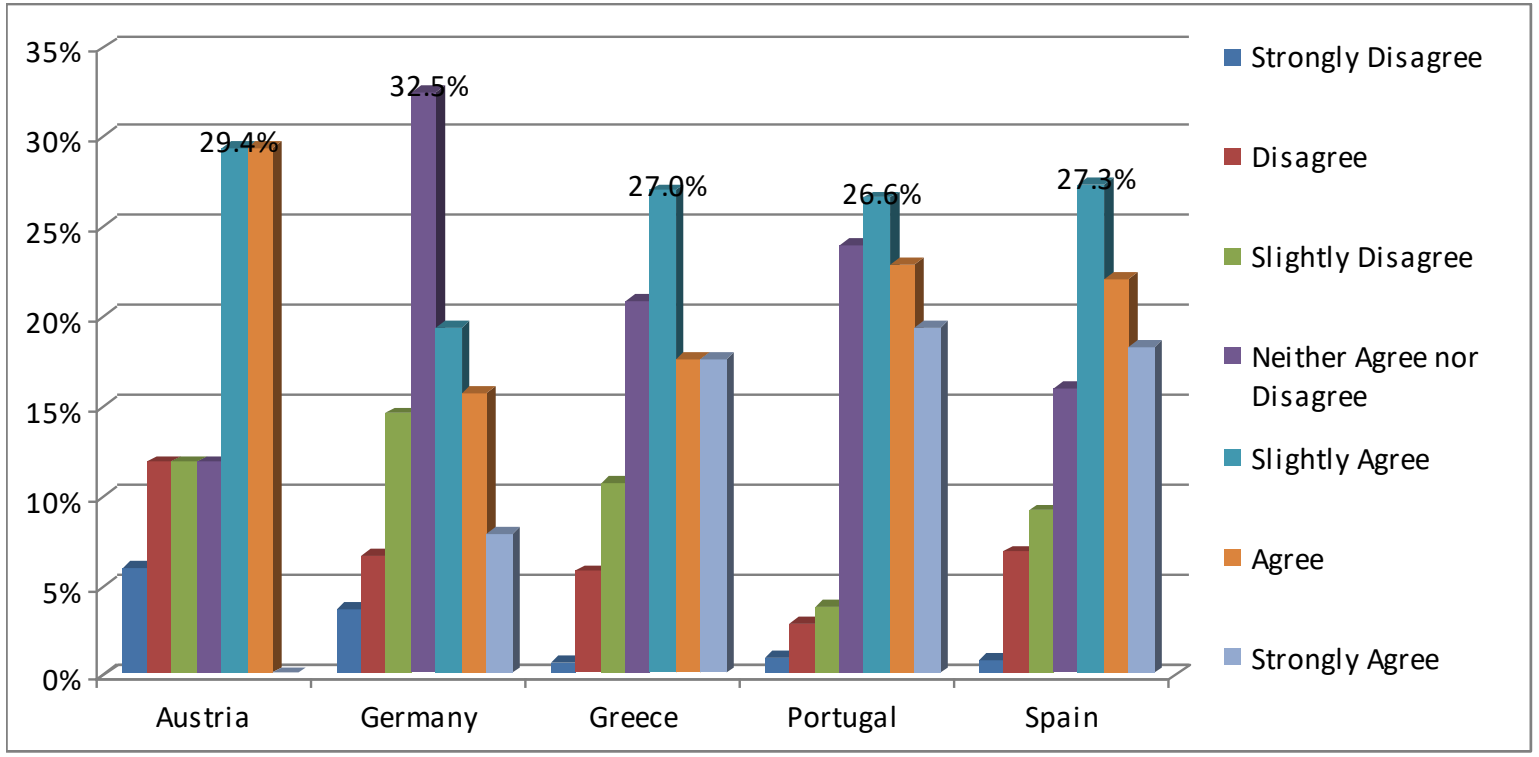
Perceived benefits of TESSe2b solution (improvement of quality of life, reduce of energy expedinture, increase of disposable income, empowerment (in terms of their autonomy and freedom of choice) in the energy security and contribution to a change of mentality in the direction of the self-sustainability of the building(s).



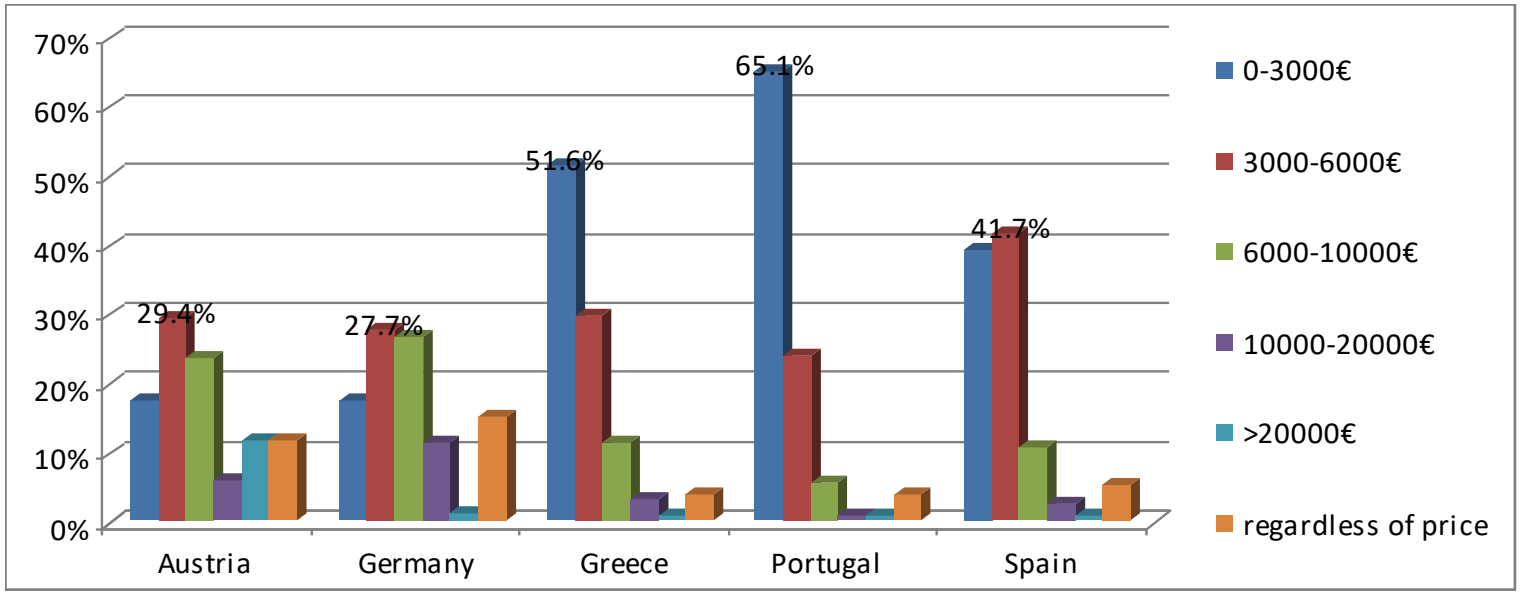
- > 29% agree in Austria, Greece and Portugal
- 31% strongly agree in Spain
- 35% neither agree nor disagree in Germany

Intention of adopting the TESSe2b solution (confidence with the idea of adopting TESSe2b solution in the future, comfortable with the idea of adopting TESSe2b solution in the future, easy to adopt TESSe2b solution in the future, intense to use the TESSe2b solution in the future and prediction that they will use the TESSe2b solution in the future)

- 27% agree in Greece, Portugal and Spain
- 30% slightly agree and agree in Austria
- 32% neither agree nor disagree in Germany

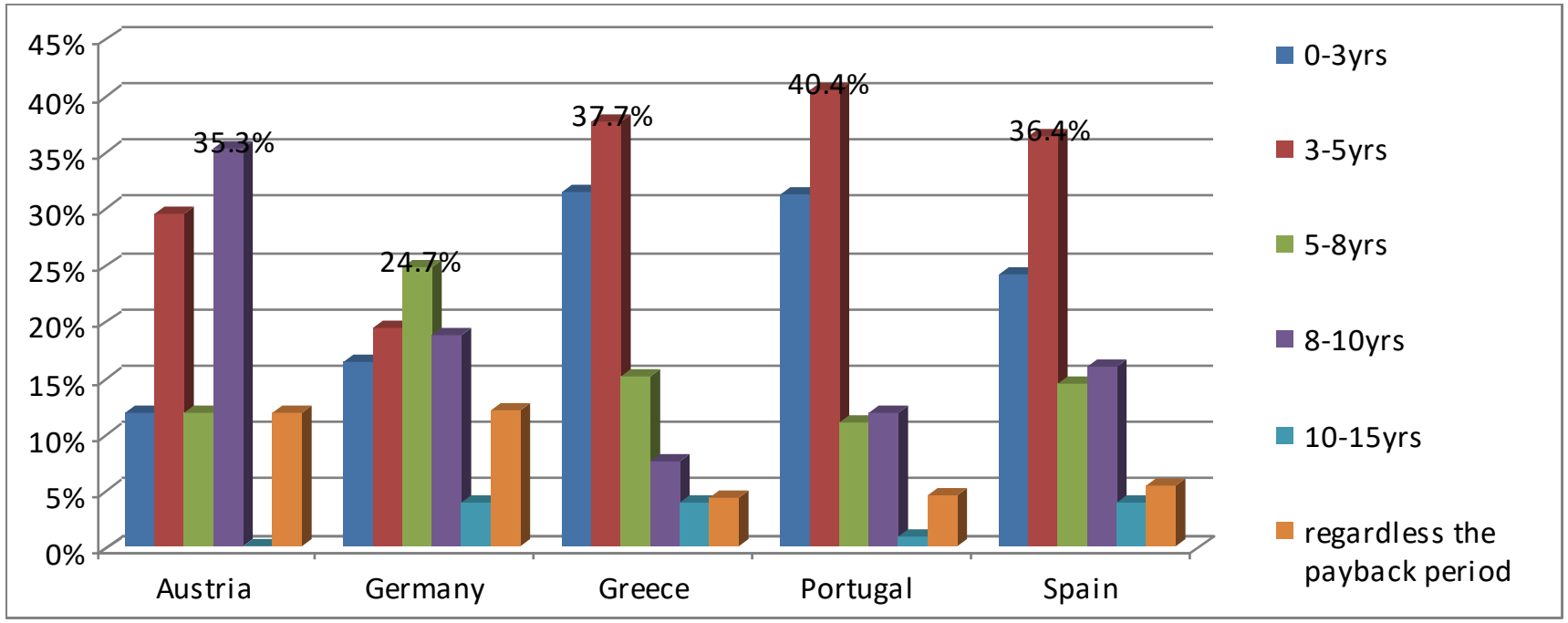


Amount I am willing to pay for TESSe2b solution in the future



- > 50% 0-3,000Euros in Greece and Portugal
- 3,000 – 6,000Euros in Spain, Austria and Germany

Acceptable payback period in order to be willing to pay for TESSe2b solution



- 38% 3-5 years in Greece, Portugal and Spain
- 25% 5-8 years in Germany
- 35% 8-10 years in Austria

Factors affecting themes under investigation

Based on ordinal logistic regressions

Socioeconomic and residence characteristics affecting the issues of **benefit perception, adoption intention, WTP and acceptable payback period** for the TESSe2b system:

(+) higher than average **income**
(+) high level of **education**
(+) **occupation** relevant to energy and/or environment
(+) **self-owned** residence
(-) residence within **urban areas**
(-) residence in **apartment building**
(+) residence with an higher than average **size**
(+) **older** residence
(+) using **conventional sources** for heating and DHW (heating oil, natural gas, electricity)
(+) spending a higher than average percentage of their **income for household energy needs**

Financial and environmental comparison

- **Financial and environmental comparison** between the TESSe2b solution and conventional heating/cooling residential systems;
- Two different sets of comparisons made for each participating country;
- **Comparisons** made between **current fuels** (heating oil, natural gas, ASHP) and **TESSe2b solution**;
- All **scenarios** include heating mode and domestic hot water, and cooling mode only where necessary;
- **Financial indicators** calculated (NPV, IRR, SPBP, DPBP, PI);
- **CO_2 saving**;
- **Sensitivity analysis**.

Austria

1st case: TESSe2b (cooling) vs. HEAT OIL (no cooling)
Total annual operation cost savings: 83.44%
CO_2 savings: 90%
SPBP: 7.5 years
DPBP: 8.5 years

2nd case: TESSe2b vs. ASHP
Total annual operation cost savings: 68%
CO_2 savings: 66%
SPBP: 15 years
DPBP: 19 years

Cyprus

1st case: TESSe2b vs. HEAT OIL+ASHP
Total annual operation cost savings: 66.7%
CO_2 savings: 53%
SPBP: 5.8 years
DPBP: 6 years

2nd case: TESSe2b vs. ASHP
Total annual operation cost savings: 56%
CO_2 savings: 55.5%
SPBP: 10.5 years
DPBP: 12 years

Germany

1st case (no cooling): TESSe2b vs. HEAT OIL
Total annual operation cost savings: 60.6%
CO_2 savings: 74%
SPBP: 18 years
DPBP: 23.5 years

2nd case (no cooling): TESSe2b vs. NAT GAS
Total annual operation cost savings: 62.6%
CO_2 savings: 63.6%
SPBP: 17 years
DPBP: 22 years

Greece

1st case: TESSe2b vs. HEAT OIL+ASHP

Total annual operation cost savings: 69%
CO_2 savings: 49%
SPBP: 5.6 years
DPBP: 6 years

2nd case: TESSe2b vs. NAT GAS+ASHP

Total annual operation cost savings: 58.7%
CO_2 savings: 43%
SPBP: 8.5 years
DPBP: 10 years

Poland

1st case: TESSe2b vs. HEAT OIL+ASHP

Total annual operation cost savings: 83%
CO_2 savings: 51%
SPBP: 9.26 years
DPBP: 10.5 years

2nd case: TESSe2b vs. NAT GAS+ASHP

Total annual operation cost savings: 54.7%
CO_2 savings: 34.8%
SPBP: >25 years
DPBP: >25 years

Portugal

1st case: TESSe2b vs. HEAT OIL+ASHP

Total annual operation cost savings: 79%
CO_2 savings: 79%
SPBP: 4.5 years
DPBP: 5 years

2nd case: TESSe2b vs. NAT GAS+ASHP

Total annual operation cost savings: 78%
CO_2 savings: 72%
SPBP: 5 years
DPBP: 5.38 years

Spain

1st case: TESSe2b vs. HEAT OIL+ASHP

Total annual operation cost savings: 79%
CO_2 savings: 75%
SPBP: 5.8 years
DPBP: 6.34 years

2nd case: TESSe2b vs. NAT GAS+ASHP

Total annual operation cost savings: 70%
CO_2 savings: 68%
SPBP: 9 years
DPBP: 10.5 years

UK

1st case (no cooling): TESSe2b vs. HEAT OIL

Total annual operation cost savings: 71%
CO_2 savings: 76%
SPBP: 19 years
DPBP: >25 years

2nd case (no cooling): TESSe2b vs. NAT GAS

Total annual operation cost savings: 71%
CO_2 savings: 67%
SPBP: 18.5 years
DPBP: 25 years

Comparison's main findings

- **Operation cost savings** range from 55% to 83%;
- **CO_2 savings** range from 35% to 91%; they depend on CO_2 conversion factors for electricity, natural gas and heating oil in each country;
- **SPBP of TESSe2b system** is between 5 and 10 years when **compared to heating oil/ASHP & natural gas/ASHP systems**; PBP can be rather high when:
  - price of the conventional energy is very low
  - the system is not used for cooling
  - the installation cost of TESSe2b is high (e.g. solar thermal collectors delivering relatively low useful energy)
- **Compared to ASHPs**, PBP is higher compared to heating oil or natural gas, due to:
  - the common pricing of the energy used by the two systems
  - the higher efficiency of ASHPs compared to systems using fossil fuels

Sensitivity analyses main findings

- The **increase of the annual rate of electricity price** will decrease the payback period of TESSe2b system when there are **high cooling needs**.
- The **increase of the annual rate of heating oil/natural gas price** will generally decrease the payback period of TESSe2b system.
- The **increase of the building heating/cooling load** will lead to economies of scale, thus reducing the payback period of larger installations. This means that largest installations (office buildings, hotels, etc.) are of **high interest**.
- The decrease of the **installation cost** of TESSe2b will decrease the payback period of TESSe2b system; it can be reduced through the larger penetration of TESSe2b system. The factor that can really reduce the installation cost of TESS2b is the **further development of PCM market**, leading to the decrease of its price.

- Results should be treated and interpreted with caution; analysis has been based on various **assumptions** and **estimations** regarding system design, efficiencies, costs and economic indicators (inflation rate, discount rate).

Conclusions

- **Behavioural survey:**
  - **Positive** attitude towards TESSe2b **adoption;**
  - **Willingness to pay** (WTP): GR, PT, ES: up to 6000€ / DE, AT: up to 10000€;
  - **Acceptable payback period**: GR, PT, ES: up to 5 years / DE, AT: up to 10 years;
  - **Socioeconomic & residence characteristics** affecting the issues under investigation.

- **Financial & environmental comparison:**
  - **Operation cost** and **CO_2** savings;
  - **SPBP** of TESSe2b system of **5 - 10 years** when compared to heating oil/ASHP & natural gas/ASHP systems;
  - The system installation is favorable in **large scale buildings**;
  - Further development of **PCM market** can lead to lower installation cost of the system.

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Thank for your attention

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European Commission