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DEMAND SIDE RESPONSE FOR LOW CARBON PATHWAYS

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Outline

Motivation

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Energy transition

Diversification (security of supply);

Environmental impacts (energy efficiency, renewables, new technologies – RES, CCS…);

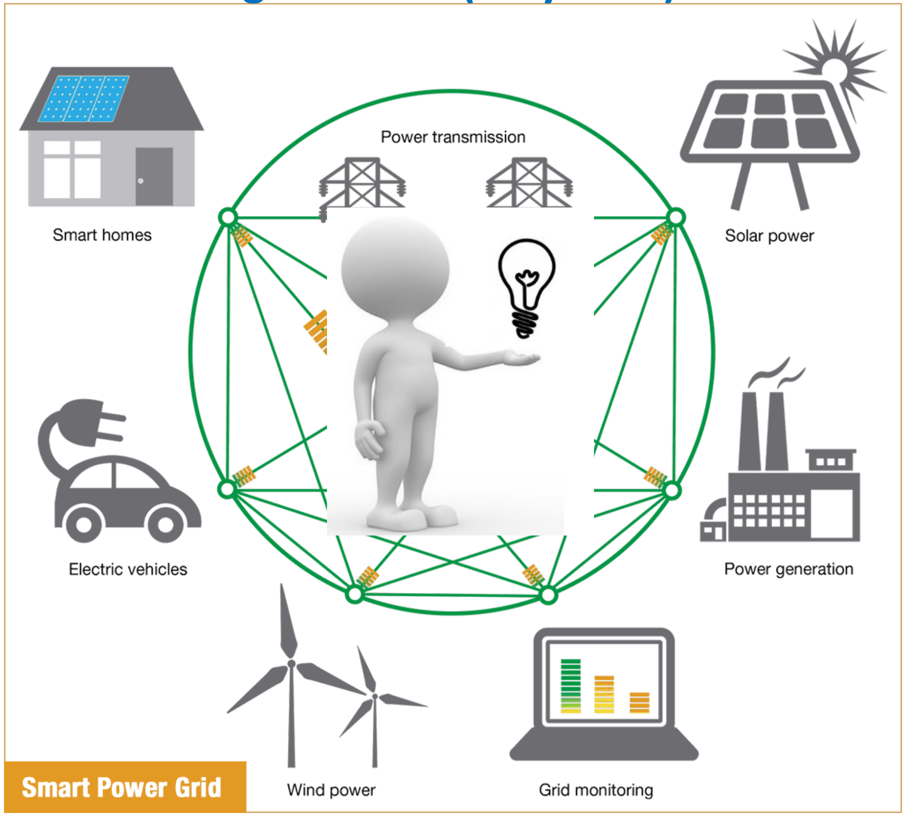
Competitiveness (low prices + internal energy resources + smart energy management)

“Smart energy” products, services, businesses …

Human interaction becomes a large part of the system – “prosumer” (V2G, RES, DR…);

Social acceptance and **people engagement** in the system (and market)

The grid of the (very near) future



Adpated from http://www.news.gatech.edu/features/building-power-grid-future

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Motivation

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Challenges

"**Energy end-use** is the least efficient part of the global energy system and has the largest improvement potential. Improving end-use efficiency also leverages proportionally greater reductions in the energy resources needed to provide for human needs."

Arnulf Grubler, Charlie Wilson, ...& Hugo Valin (2018) "A low energy demand scenario for meeting the 1.5 °C target and sustainable development goals without negative emission technologies" *Nature Energy* , Vol. 3, 515–527

The IPCC expert meeting (Ethiopia, April 2017) highlighted this need to gain new insights into issues related to **human behaviour and choices** and to give greater emphasis to **demand-side options** and their role on low carbon pathways.

IPCC (2017) *Meeting report - IPCC Expert Meeting on Mitigation, Sustainability and Climate Stabilization Scenarios* Addis Ababa, Ethiopia, 26–28 April 2017

Motivation

Challenges

The Smart Grid deployment will have key role in implementing the energy transition through the integration of large-scale RES technologies, storage systems and **Demand-Side Management (DSM) strategies**

Managerial measures to influence the load demand

Demand Response

Changes in electric usage by end -use customers from their normal consumption patterns in response changes in the price of electricity over time or to any other incentives.

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Objectives

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To analyse how strategies targeting the electricity consumer behaviour and possible changes on their consumer pattern can:

- play a role on electricity planning for long term scenarios
- provide a solid basis for adapting to climate change (CC) actions
- support large high renewable energy sources (RES) scenarios.

To analyse end-users awareness, motivations and willingness to participate in DR progams.

Exploratory study based on historical data for the Portuguese electricity system

Large scale survey applied to Portuguese residential consumers

Methodology

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Impact of DR (modelling, EnergyPlan, Portugal)

Parameter (year)	DR impact
Exportation	-37.5%
Importation	-17.6%
Thermal power production	-2.4%
Average load difference	8.4%

DR can not only support the inclusion of low carbon projects in the electricity system by providing the required flexibility but can also result in a reduction of the greenhouse gas emissions.

Acceptance of DR (survey, Portugal)

confident interval of 95%
marginal error of 5%

Characterization of residential consumers in Portugal
Data from Energy Services Regulatory Entity (ERSE)
Eurostat Da, Db, Dc, >Dd bands
Time of Use tariffs

Questionnaire design
Questionnaire testing

Deliver of questionnaire
CATI- Computer-assisted telephone interview

Statistical analysis
STATA

Methodology

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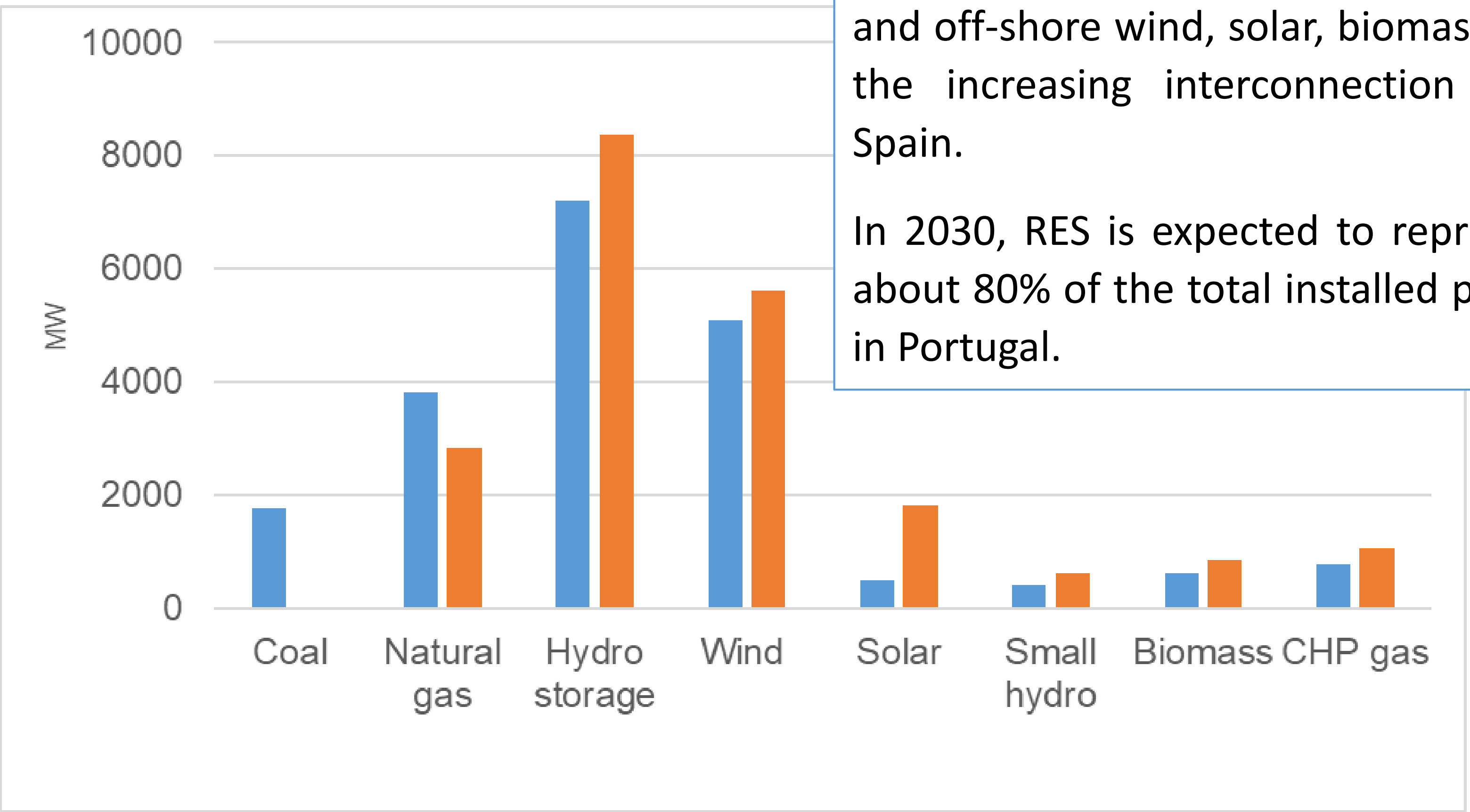
The Portuguese electricity system



Increasing reliance on renewable energy sources mainly hydro, on-shore and off-shore wind, solar, biomass and the increasing interconnection with Spain.

In 2030, RES is expected to represent about 80% of the total installed power in Portugal.

Source: Techncial data 2017. www.ren.pt

Acceptance of DR (survey)

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(1) Sociodemographic characteristics of respondents;

(2) Dynamism/ knowledge on electricity consumption;

(3) Motivational factors to engage on DR programs;

(4) Flexibility on electricity use (willingness to shift consumption).

5-level Likert scale: "totally disagree"; "tend to disagree"; "tend to agree"; "totally agree" and "does not know/ does not answer".

May-June 2018

Acceptance of DR (survey)

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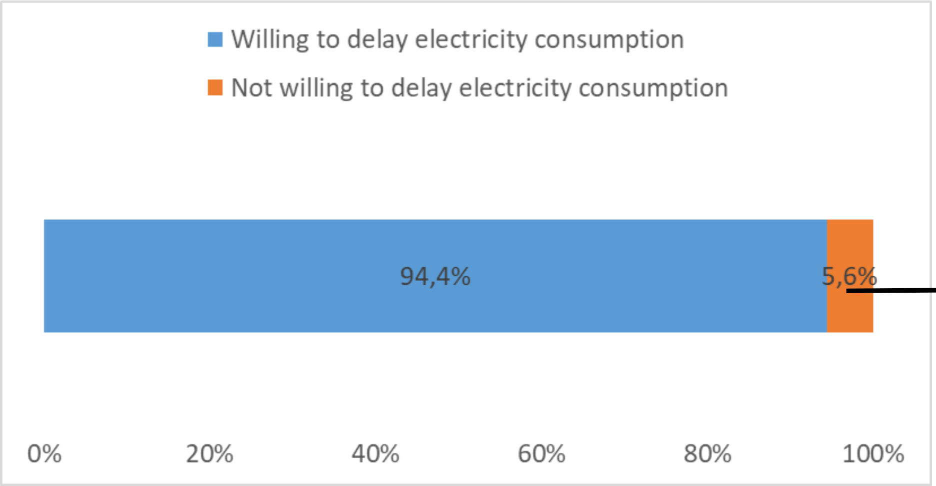
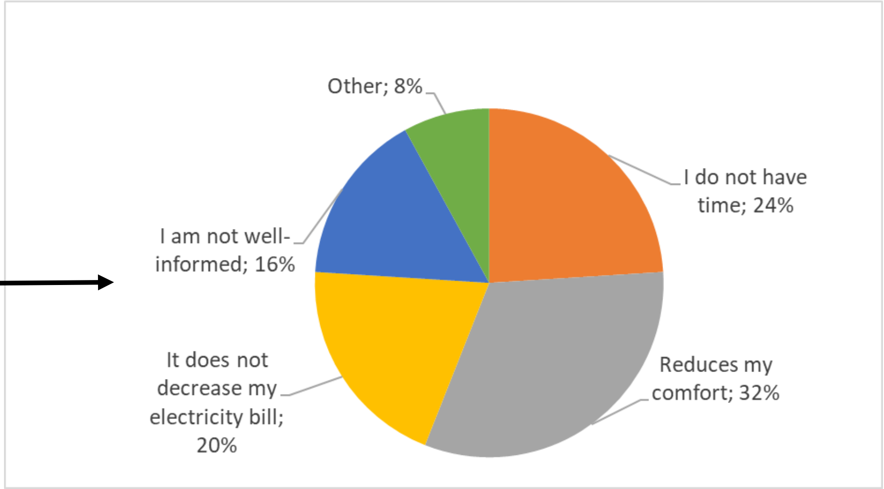
Willingness to shift electricity consumption





Acceptance of DR (survey)

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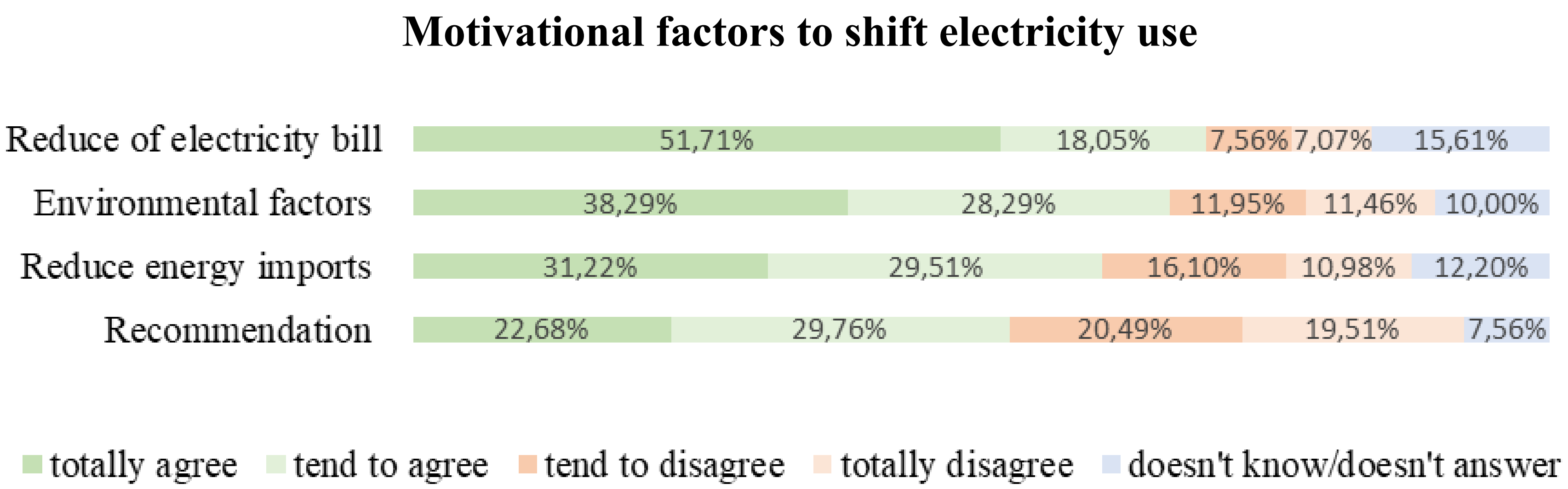


Younger respondents with **higher education** level or those engaged in a **professional activity** are more motivated to shift their electricity use driven by **environmental factors**;

Respondents with a **higher education level** and **householders** are more motivated to shift their electricity use driven by **cost factors**.

Acceptance of DR (survey)

Flexibility against cost saving potential

Significant level of **willingness** to shift the use of their domestic appliances and as such **to participate in some DR program.**

Positive relation between the increase of potential cost savings and the willingness to participate.

More than half of the respondents are favourable to shift their electricity use for 1-2h, regardless of the potential cost savings and of the value of their electricity bill.

Acceptance of DR (survey)

Flexibility against cost saving potential – Dc consumers

Matrix for the willingness to accept the DR programs

Expected saving	Electricity Band consumption	1-2 hours	2-6 hours	> 6 hours
2%	DC	58%	53%	39%
4%		69%	62%	53%
6%		69%	65%	61%

Gender: **Women** are more willing to participate in some DR program.

Age: **Group 24-44** are more willing to participate in some DR program.

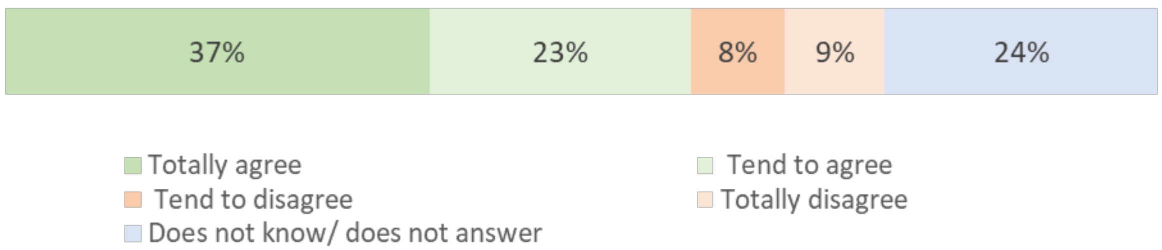
Education: People with a **higher level of schooling** are more willing to participate in some DR program.

Occupation: **Unemployed** people are more willing to participate in some DR program.

Flexibility is limited, even for high potential cost savings

Acceptance of DR (survey)

Willingness to accept the automatic control of the heating or cooling system



Sociodemographic variables do not have a statistical significant effect on willingness to accept the automatic load control.

The respondents paying **higher electricity bills** tend to be more willing to accept the automatic control for the heating or cooling system.

Conclusions and avenues for further research

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- DR can support **increasing RES** in the electricity systems;
- DR can contribute to **reduce carbon emissions** even for the exiting energy systems, through better load management.

Strongly depends on end users

- The **cost reduction** strongly motivates shifting the electricity use.
- The **environmental factors** and reducing the dependency on energy imports are also significant for the decision to engage in DR programs.

- Loading **flexibility is limited** by the time and tends de decrease if the long periods of shiffting are considered (disturbance of daily routines).
- Automatic control mode could be an interesting approach in the development of DR programs based on dynamic tariffs.

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Conclusions and avenues for further research

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Better account for human behavior and consumers choice

Considerable uncertainty about what more realistic energy scenarios still remains. **Amongst the strongest assumptions are those about consumer behavior**.

Energy modelling literature tends to **oversimplify users' behaviour** by using empirical models of appliance adoption, users' acceptance and demand curves for the evaluation of the **long-term energy systems**.

Nicolò Daina (2018) "Transport-energy systems - Modelling the user variable" *Nature Energy* , Vol. 3, 88-89.

Energy planning and modelling is frequently dominated by techno-economic thinking, which can obscure the human dimensions of energy systems. It neglects how energy consumption is essentially an outcome of routines not easily modelled and/or changed.

Chris Foulds & Toke Haunstrup Christensen (2016) "Funding pathways to a low-carbon transition" *Nature Energy* Vol. 1, 1-4

Conclusions and avenues for further research

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Better account for human behavior and consumers choice

Improved empirical models of users' behaviour are required to energy systems modelling

Scenario design
Estimate realistic responses to policies

Energy strategies

Improved empirical models of users' behaviour should guide innovation and support technological development.

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Conclusions and avenues for further research

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Energy planning for low carbon energy systems

Technological innovation is a key driver for energy systems changes.

Energy demand outcomes depend on social and institutional changes.

The endogenous representation of these energy demand trends in long term energy systems modeling remains a critical area for the research.

Multidisciplinary research agenda

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