

An aerial photograph of a wind turbine tower and nacelle. The tower is white with a blue logo on the left side. The nacelle is white with an orange and white striped tip. A small green boat is docked at the base of the tower. The background is a vast, green, hilly landscape.

# 100% Renewables

A renewable electricity system  
for mainland Spain and its  
economic feasibility.

**GREENPEACE**

[www.greenpeace.es](http://www.greenpeace.es)

## Greenpeace Spain's "Energy Revolution" project

### Goal and Methodology

### "Renewables 2050" report

### "Renewables 100%" report

- **Cost analysis**
- **Example of 100% renewable mix to meet all power demand**
- **Summary of outcomes**
- **Conclusion**

## Greenpeace Spain's "Energy Revolution" project

### Questions to answer:

- Is it possible to avoid climate change? Are we on time?
- Is it possible to shift clean for dirty energies? What about a specific country, such as Spain? How much of the energy consumed in Spain could come from renewable sources?
- Would power be available anytime (day and night, winter and summer) and anywhere (country and town, industries and residential and commercial buildings) it is demanded? What happens when the sun is not shining and wind is not blowing?
- How many renewable plants would we need and how should they be operated? Where should they be sited?
- Would a renewable-based system cost more?

## Goal and Methodology

### **Goal:**

To quantify and evaluate technically the feasibility of a scenario relying on renewable energies for the power generation system in mainland Spain.

## Goal and Methodology

### **Methodology**

1. Analysis of capacity and generation ceilings (Renewables 2050)
2. Cost analysis
3. Temporal analysis
4. Power generation system analysis

**“Renewables 2050” report**

# Renovables 2050

A report on the potential of  
renewable energies in peninsular  
Spain



**“Renewables 2050” report****Description of the study:****Power generation system feasibility technical analysis**

- in Spain's mainland
- with maximum possible contribution from renewables
- restrictions: resource availability, environment, land uses, demand-generation-transport time coupling
- horizon 2050

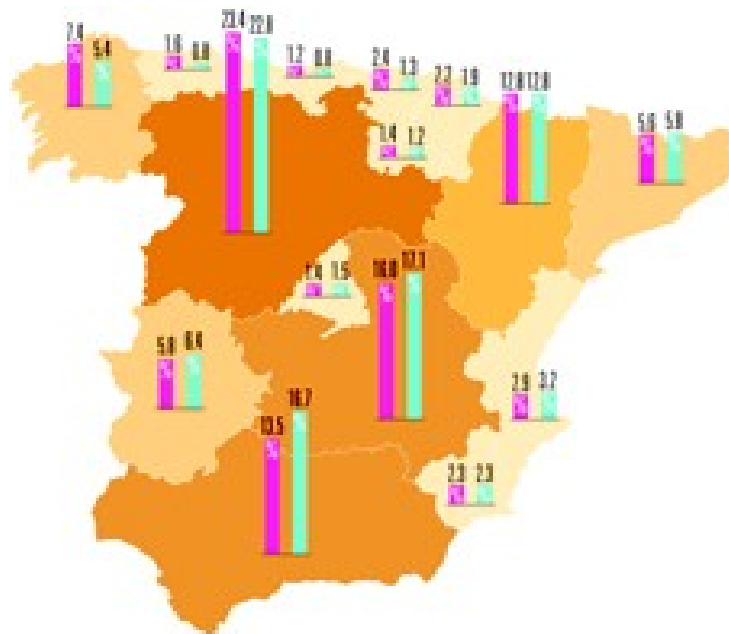
**Outcomes: “Energy Revolution”****First report: “Renewables 2050” (Capacity and generation ceilings)**

**“Renewables 2050” report****Methodology:**

- **Population and energy demand scenarios 2050**
- **Renewable technologies:  
situation and performance in 2050**
- **Environmental, social and technological  
restrictions over available geographic areas and  
kinds of land**
  - **Land availability (Geographic Information  
System)**
- **Maximum contribution from each of them:  
capacity and generation ceilings**

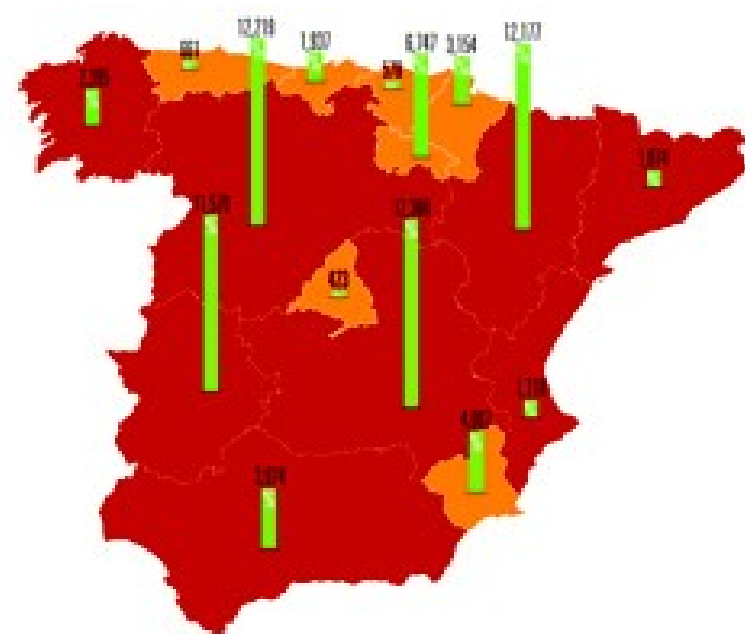
“Renewables 2050” report

Outcomes by technology: CSP



Division by Autonomous Community of capacity and electricity generation ceilings on the peninsula with this technology

- % of the capacity ceiling in each Community
- % of electricity generation in each Community
- >20%
- 15%-20%
- 10%-15%
- 5%-10%
- <5%



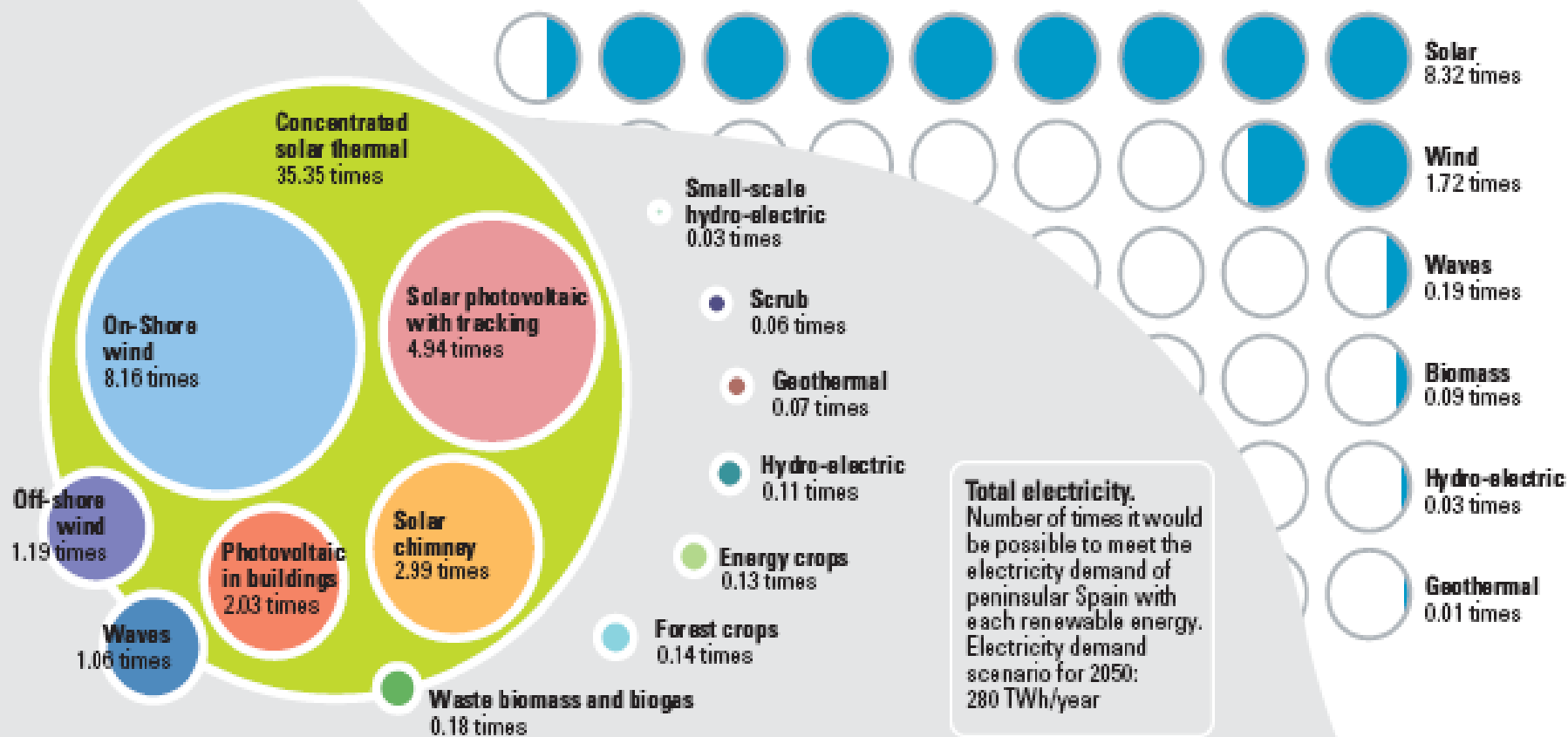
% of electricity demand that would be covered by this technology in 2050

- % of demand in each Community
- Communities self-sufficient for their 2050 electricity demand with this technology
- Communities that could generate the entire peninsular electricity demand with this technology

**Total.** Capacity ceiling = 2739 GW – Electricity generation ceiling = 9897 Twh/y (3534% of 2050 peninsular electricity demand)

“Renewables 2050” report

**Total energy.** Number of times it would be possible to meet total energy demand in peninsular Spain with each renewable energy.  
 Total energy demand scenario for 2050: 1,525 TWh/year



**“Renewables 2050” report****Conclusions:**

**Electricity generation potential with renewable sources:**

- **56.42 times peninsular electricity demand 2050**
- **10.36 times peninsular total energy demand**

**Most abundant renewable resources are those linked to solar energy**

**Wind power potential is much bigger than current planning targets**

**Biomass: maximum efficiency in use must be prioritised**

**Infinite options exist to make a 100% renewable electricity generation mix**

**It would be technically feasible to supply 100% of total energy demand with renewable sources**

“Renewables 100%” report

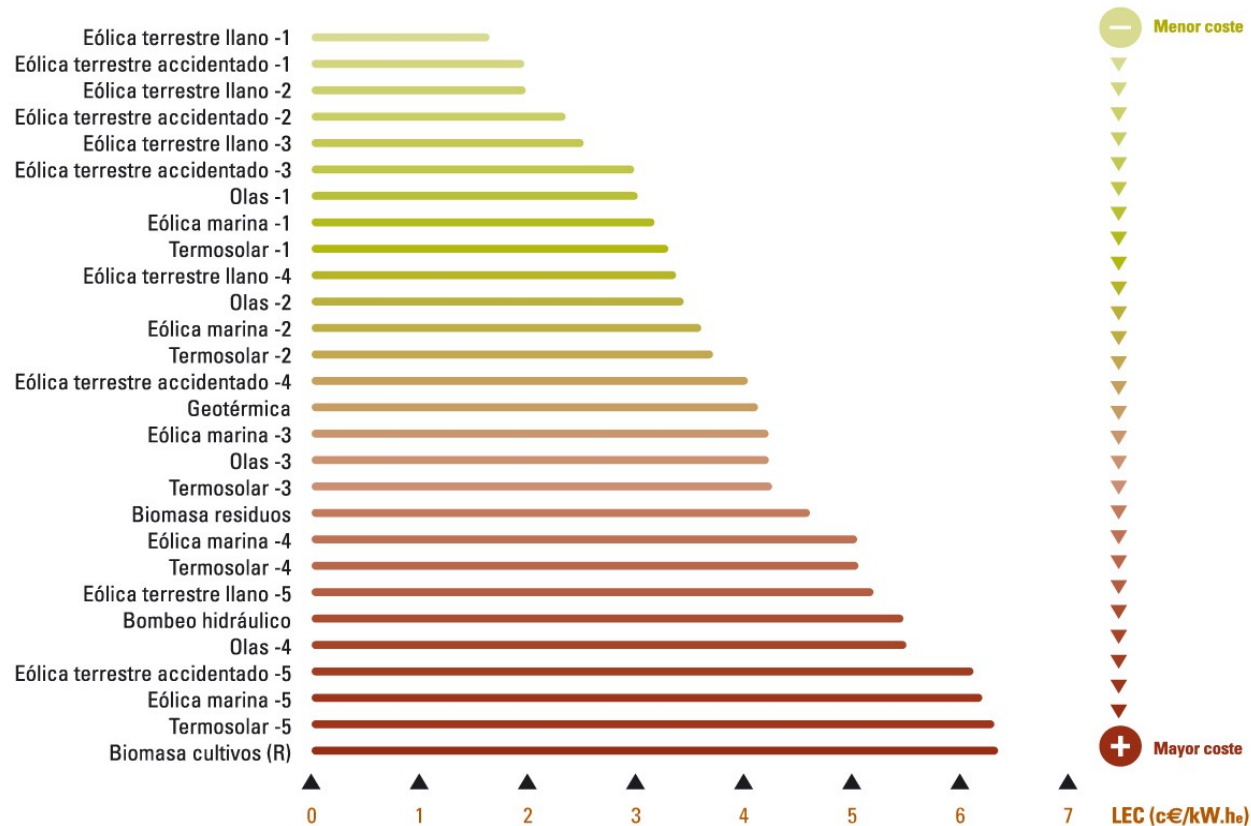
Comparison

Cost analysis

Part One: lower cost technologies

1

Primera parte: tecnologías de menor coste



R- Regadíos. MB- Aprovechamiento monte bajo. SAP- Secano alta productividad. SH- Secano húmedo. SSA- Secano semi-árido. SA+SAF- Secano árido y sistema agroforestal. CFRR-H- Cultivo forestal de rotación rápida (zona húmeda). CFRR-S- Cultivo forestal de rotación rápida (zona seca)

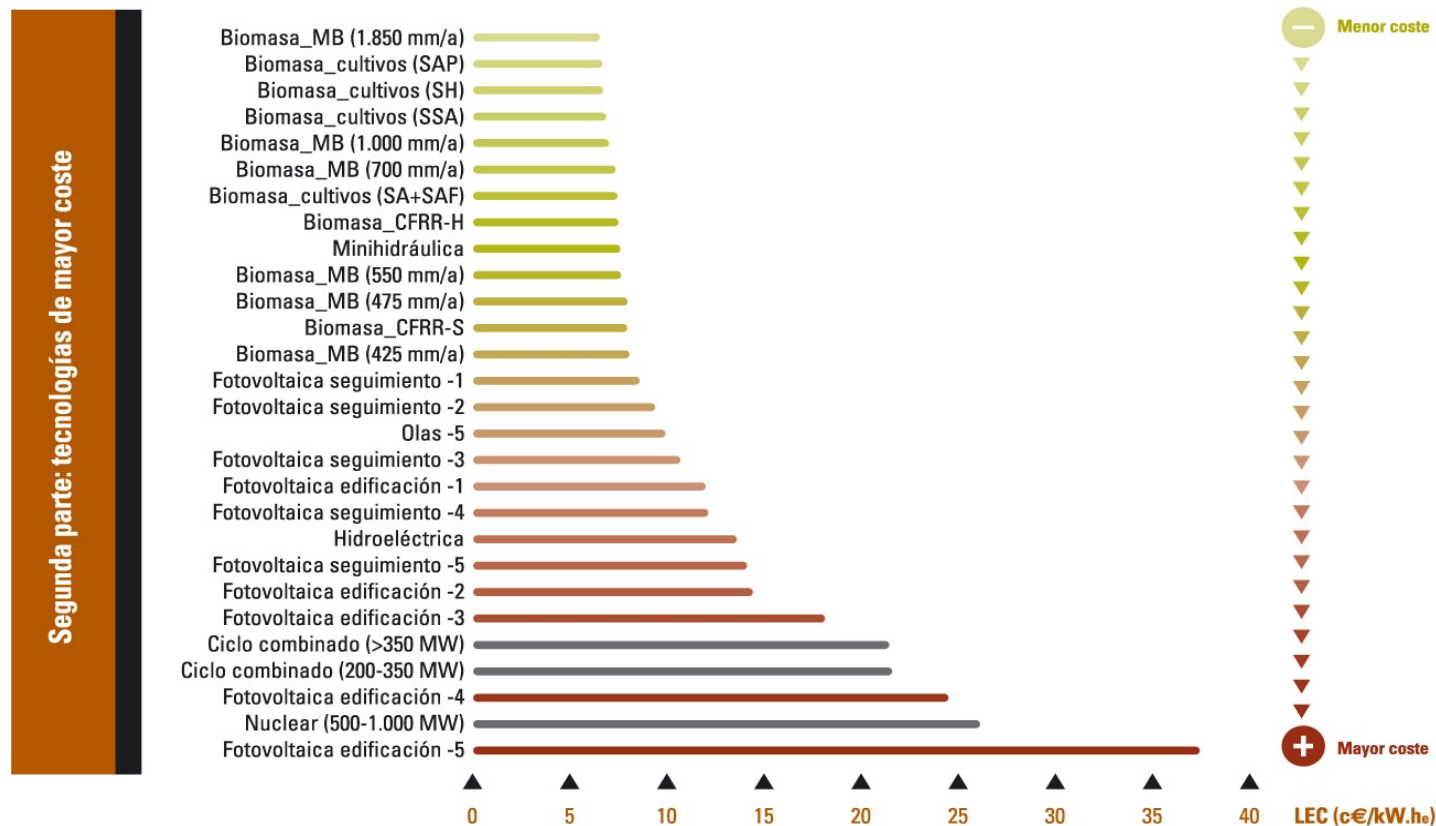
“Renewables 100%” report

Comparison

Cost analysis

Part Two: higher cost technologies

2



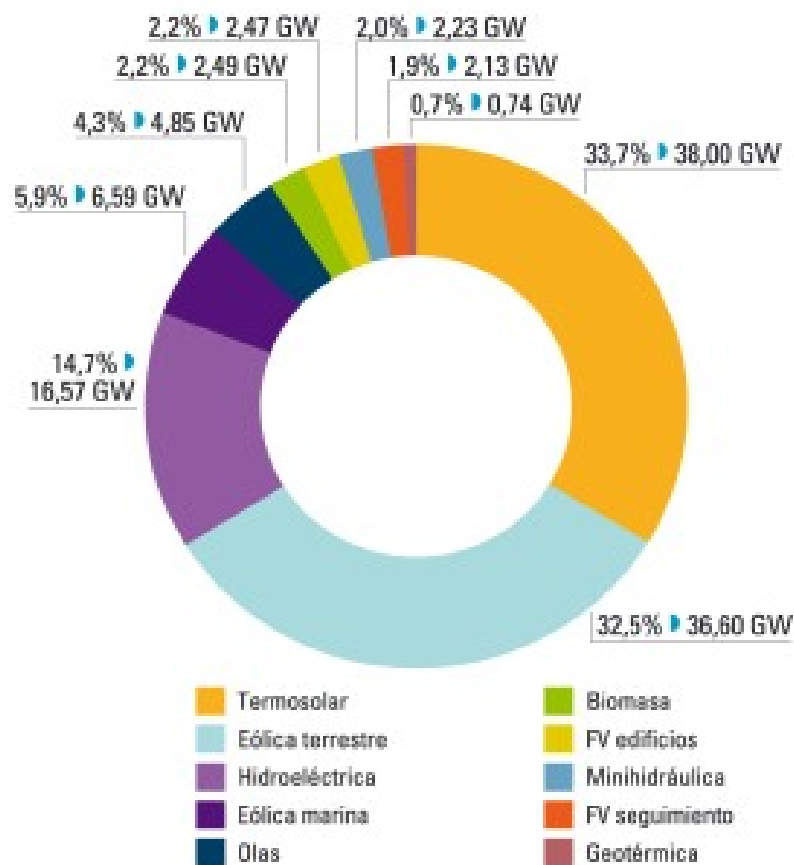
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“Renewables 100%” report

Example

100% renewable mix

Technology diversity



Installed capacity by technology

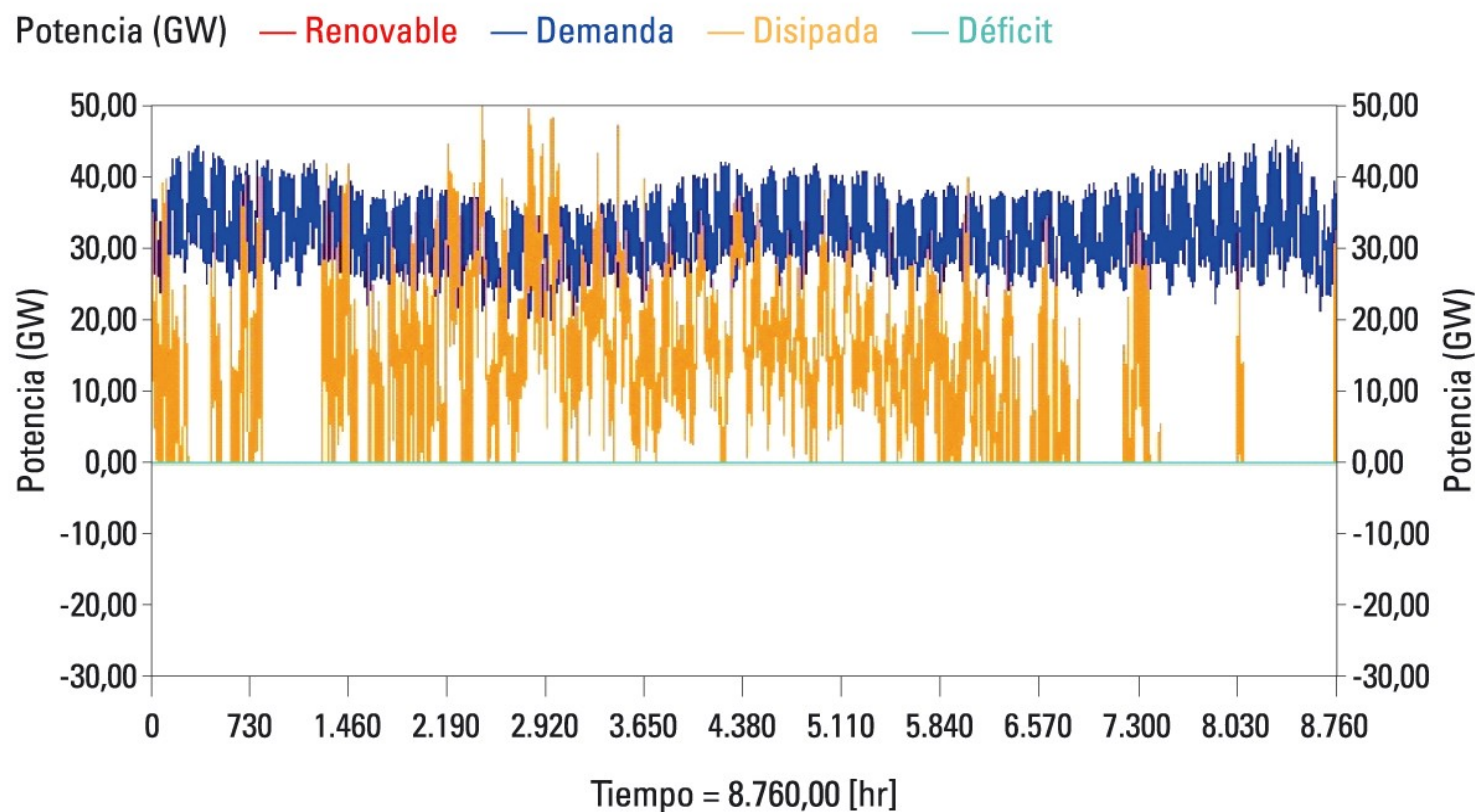
Main characteristics of the mix:

Installed capacity	112,68	GWp
Available energy	396,49	TWh/a
Solar Multiple (SM)	2,5	
Accumulation capacity	1,5	TWh
Meeting demand (SR)	100	%
Energy shortfall in relation to annual demand	0	%
Energy to be dissipated in relation to annual demand	34,4	%
Available generation in relation to annual demand	141,6	%
Energy contributed by biomass	3,9	TWh/a
Maximum deficit capacity	0	GW
Maximum dissipated capacity	60,9	GW
Annual electricity cost (LEC) with no hydro investment	4,51	cent/kWh
Solar-biomass hybridization	No	
Mini-hydro operation	Base	
Fraction used of the onshore wind power capacity ceiling	4	%
Fraction used of the thermosolar capacity ceiling	1,353	%
Land occupation	2,47	%

## “Renewables 100%” report

Example

100% renewable mix

Technology diversity

Annual hourly evolution of available power, demand, dissipation and deficit for a mix with  $SM=2.5$  with storage capacity of 1.5 TWh.  $SF=100\%$

**“Renewables 100%” report**

**Example**

**100% renewable mix**

**Technology diversity**

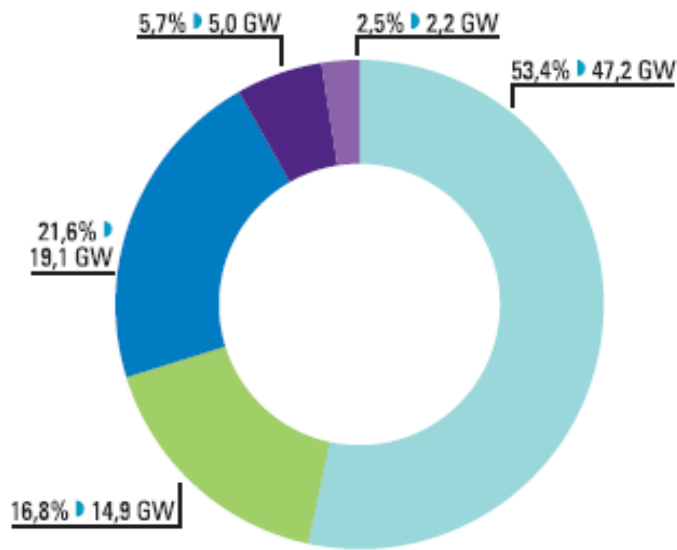


“Renewables 100%” report

Another example

Economic optimization

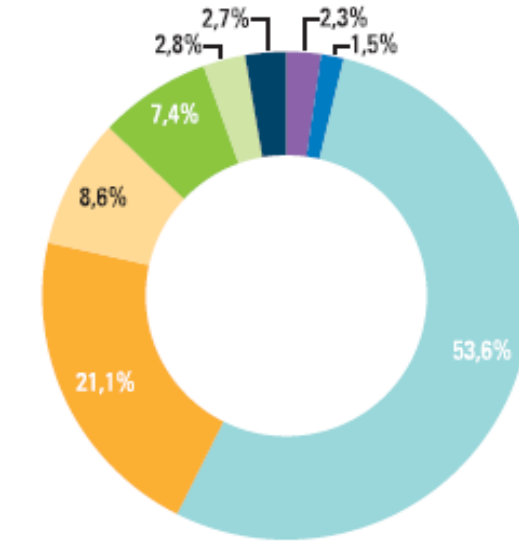
Demand-side management



- Flatland onshore wind power
- Thermosolar + residual biomass hybridization
- Regulated and flowing hydro
- Hydro pumping
- Mini-hydro

Installed capacity by technology

E = 303,9 TWh/a



- Flatland Wind Power
- Thermosolar
- Regulated Water
- Biomass at thermosolar power stations
- Existing Water Pumping
- New Water Pumping
- Mini-hydro
- Flowing Water

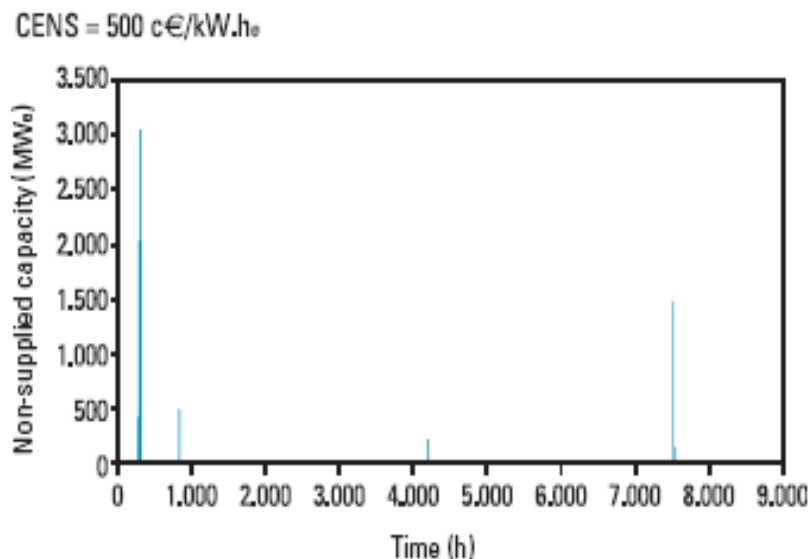
Configuration and electricity generation, mix optimized for NSEC = 500c€/kWh, SM=2.29, SF=99.993%, LEC= 2.42 c€/kWh

“Renewables 100%” report

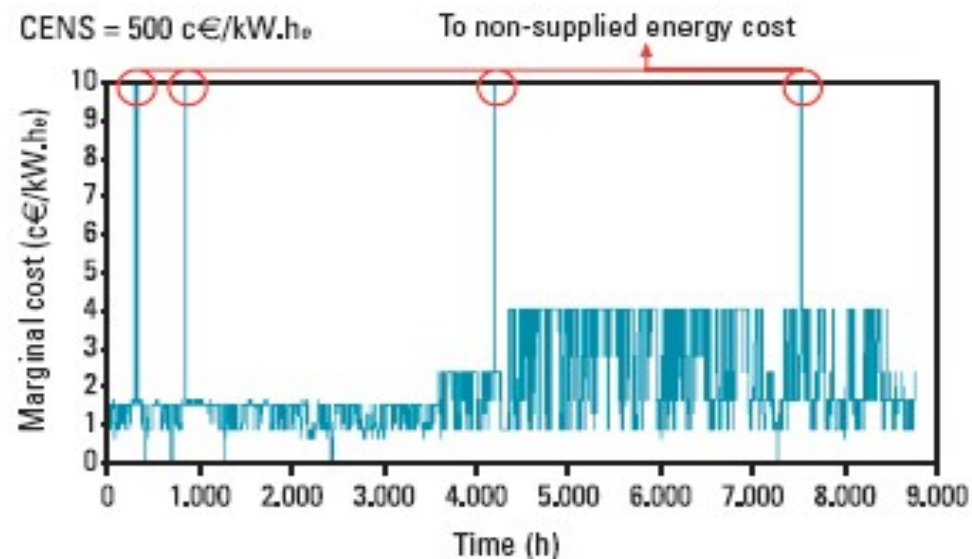
Another example

Economic optimization

Demand-side management



Annual hourly evolution of non-supplied power for an optimized mix for NSEC = 500 c/kWh, SM= 2.29, SF= 99.993%; LEC= 2.42 c€/kWh



Annual hourly evolution of marginal cost of non-supplied electricity for an optimized mix for NSEC = 500 c/kWh, SM= 2.29, SF= 99.993%; LEC= 2.42 c€/kWh

**“Renewables 100%” report****Summary of outcomes**

- **Geographic dispersion** ⇒ generation more regular on time
- **Solutions to fluctuation of available resource:** more installed capacity; regulate with biomass, geothermal, hydro; hybridate solar thermal-biomass (increases security of supply and cuts system cost)
- **There are multi-fold renewable mixes** able to meet the whole demand
- **Technology diversity** ⇒ less necessary capacity and more security of supply
- **Minimum need for energy storage**

**“Renewables 100%” report****Summary of outcomes**

- **No technology becomes dominant in 100% renewable systems at minimum life-cycle cost**
- **100% renewable mixes more economic** than current ones
- **Demand-side management:** most economic and appropriate tool to cover the few deficits
- **Planning is necessary for economically optimum mix**
- **Power grid should adapt** to a renewable system
- **Energy system integration** would get big energy savings and would cut total cost
- **Renewables will have to regulate** in order to be main elements in power generation system

**“Renewables 100%” report****Final conclusion**

- **It is feasible to raise a power generation system based 100% in renewable energies, to cover electricity demand as well as total energy demand**
- **Total costs of generated electricity are perfectly acceptable** and very favourable with regards to business as usual
- **There are enough tools to guarantee demand coverage**

**“Renewables 100%” report****Greenpeace proposals**

- **Mandatory energy planning targets for Spain:**
  - ➔ Renewables for primary energy: **30%** 2020, **80%** 2050
  - ➔ **Renewables for electricity: 50%** 2020, **100%** 2050
  - ➔ Renewables for building heating & cooling: **80%** 2050
  - ➔ Efficiency: cut demand by **20%** 2020
  
- **CO2 emission reduction targets** for the EU: **30% by 2020** re. 1990