100% Renewables

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

GREENPEACE

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

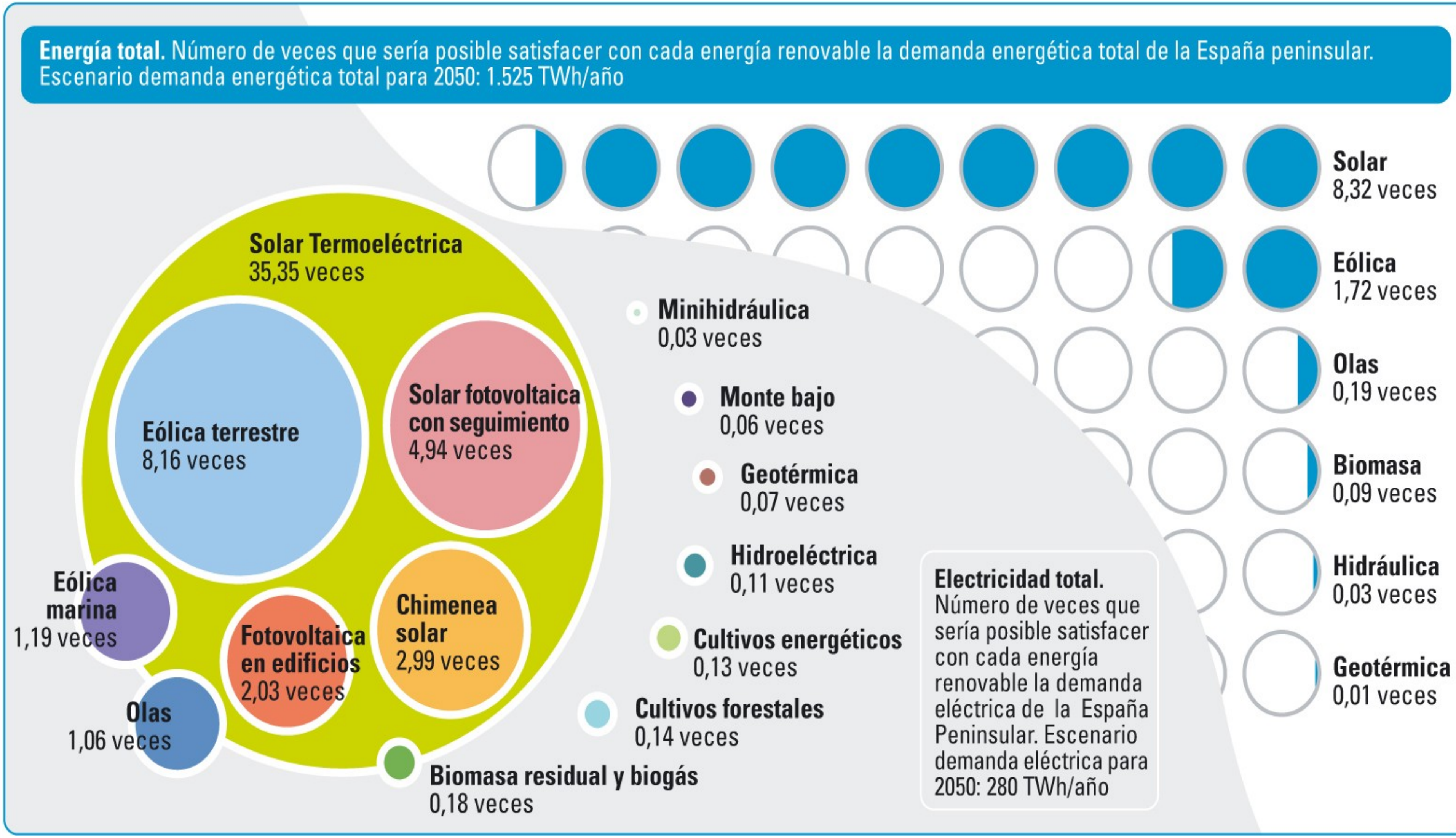
4. Power generation system analysis

“Renewables 2050” report

Electricity generation potential with renewable sources:

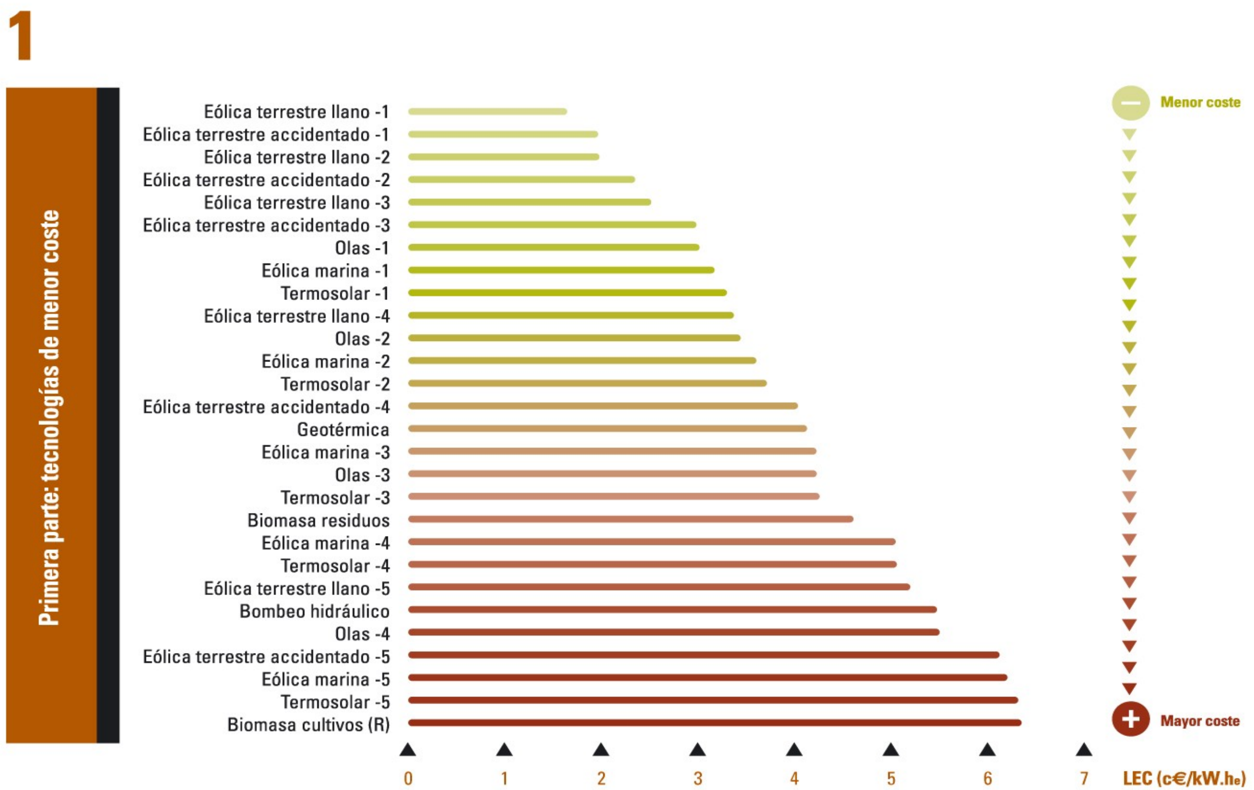
- 56.42 times peninsular electricity demand 2050
- 10.36 times peninsular total energy demand

“Renewables 2050” report



“Renewables 100%” report

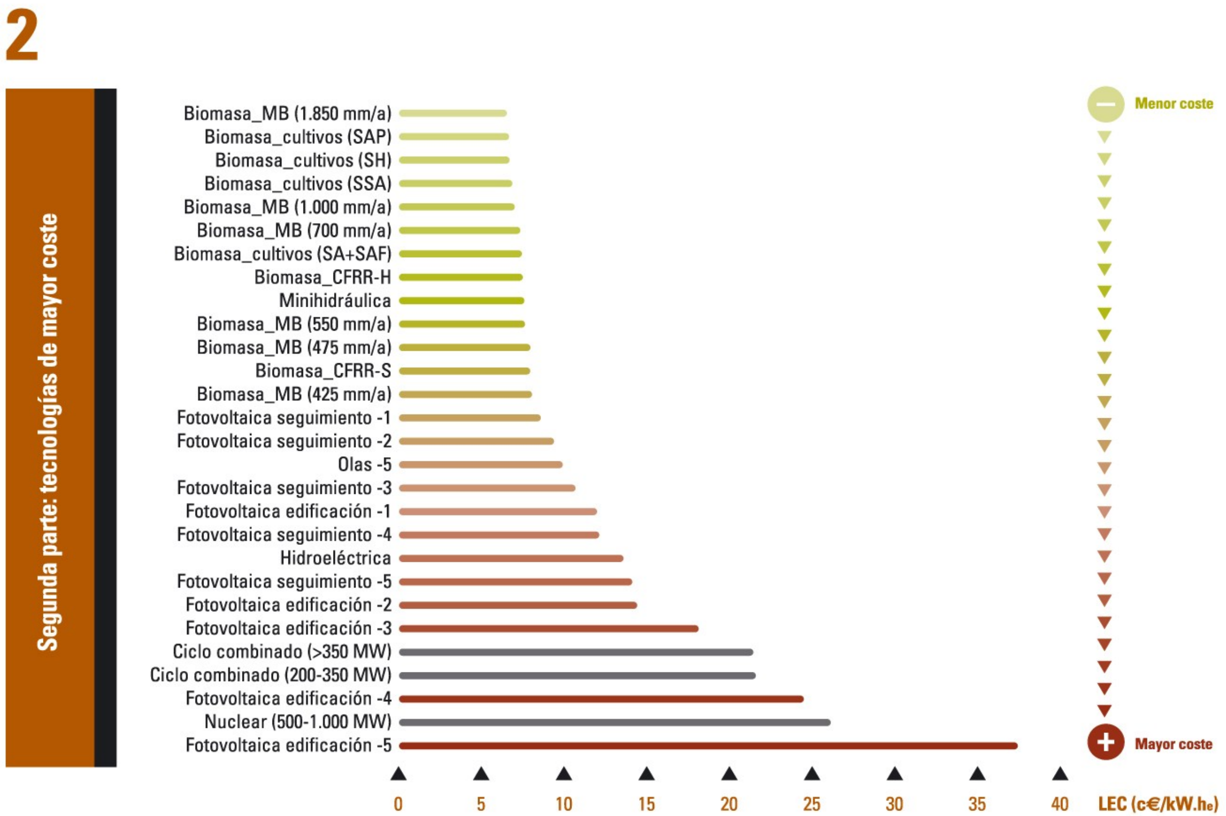
Comparison | Cost analysis



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



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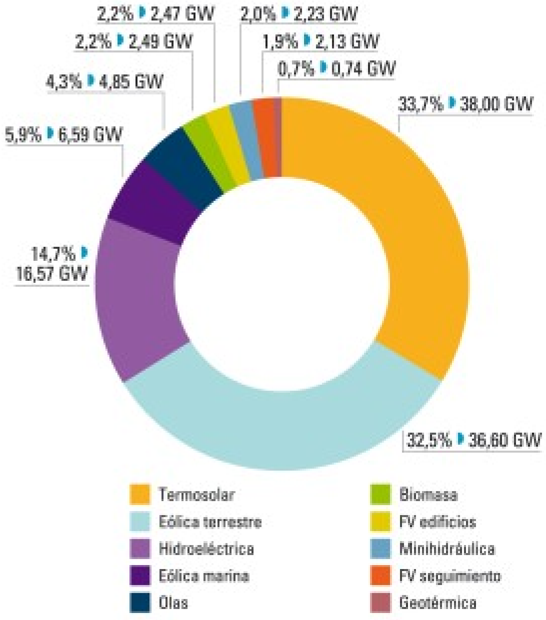
“Renewables **100%**” report

Example | **100% renewable mix**

Technology diversity



Installed capacity by technology

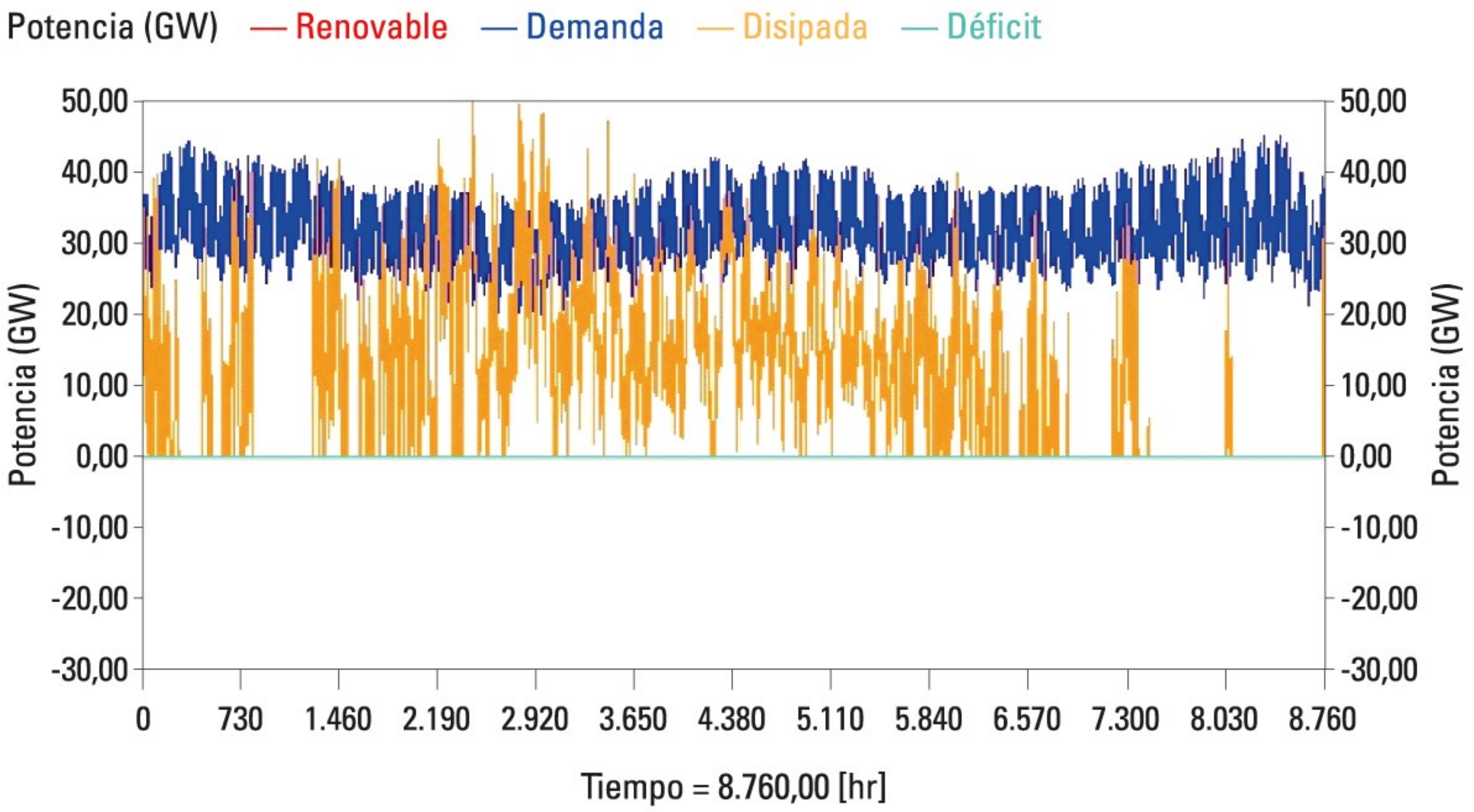
Características principales del mix.

Potencia instalada	112,68	GWp
Energía disponible	336,48	TWh/a
Múltiplo solar (SM)	2,5	
Capacidad de acumulación	1,5	TWh
Cobertura demanda (SF)	100	%
Déficit de energía en relación a la demanda anual	0	%
Energía a disipar en relación a la demanda anual	34,4	%
Generación disponible en relación a la demanda anual	141,6	%
Energía aportada por la biomasa	3,9	TWh/a
Potencia deficitaria máxima	0	GW
Potencia disipada máxima	60,9	GW
Coste electricidad anual (LEC) sin inversión hidráulica	4,51	c€/kWh
Hibridación solar-biomasa	No	
Funcionamiento minihidráulica	Base	
Fracción utilizada del techo de potencia eólica terrestre	4	%
Fracción utilizada del techo de potencia termosolar	1,359	%
Ocupación de territorio	2,47	%

“Renewables **100%**” report

Example **100% renewable mix**

Technology diversity

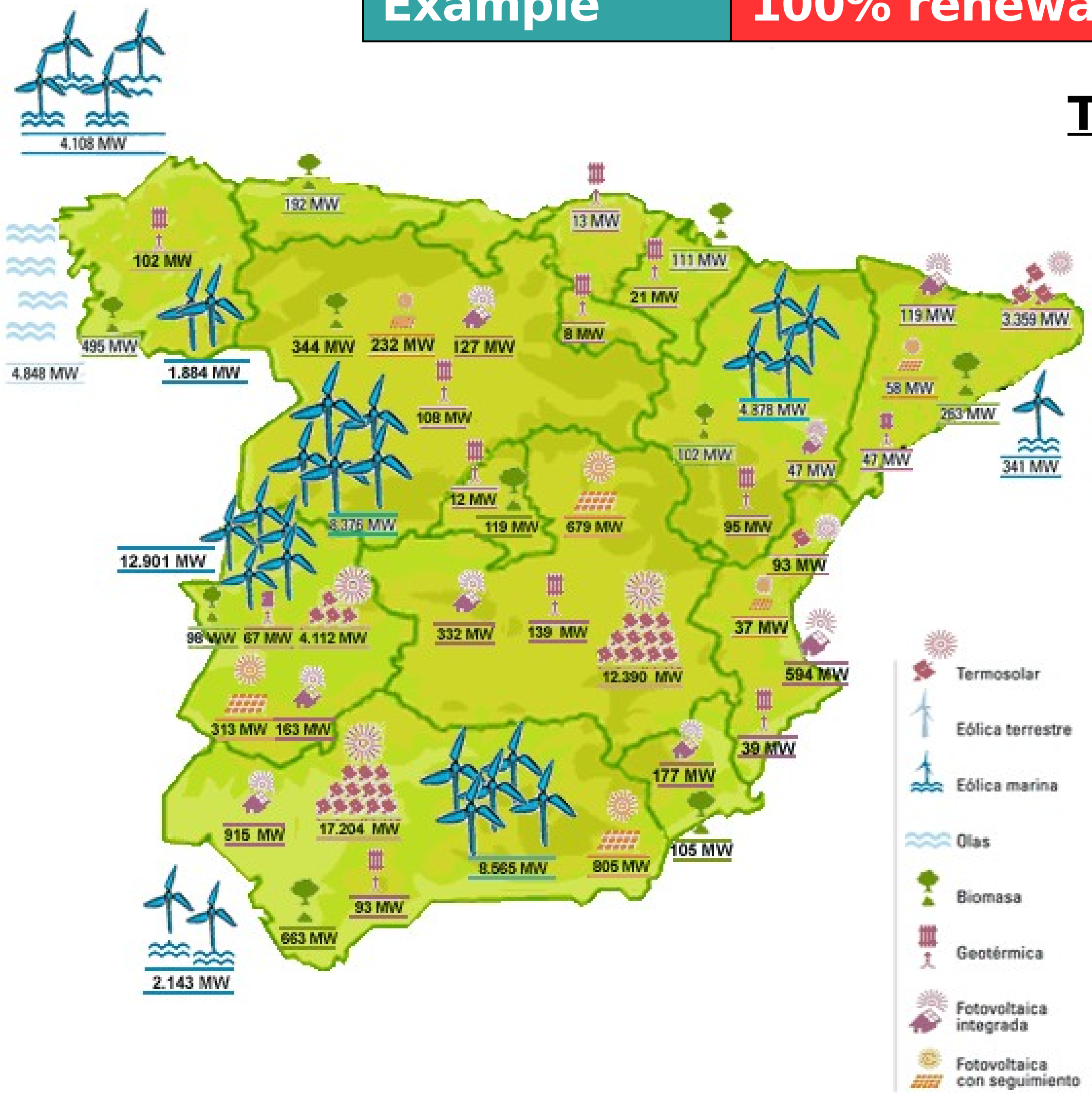


Annual hourly evolution of available power, demand, dissipation and deficit for a mix with SM= 2.5 with storage capacity of 1.5 TWh. SF=100%

“Renewables **100%**” report

Example | **100% renewable mix**

Technology diversity

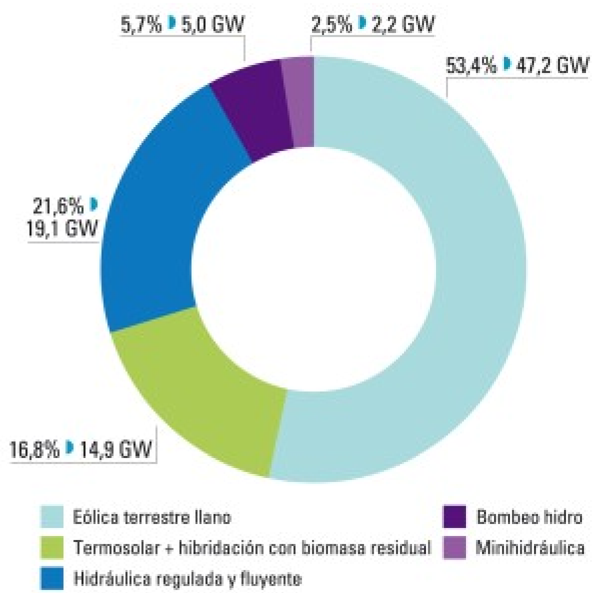


“Renewables **100%**” report

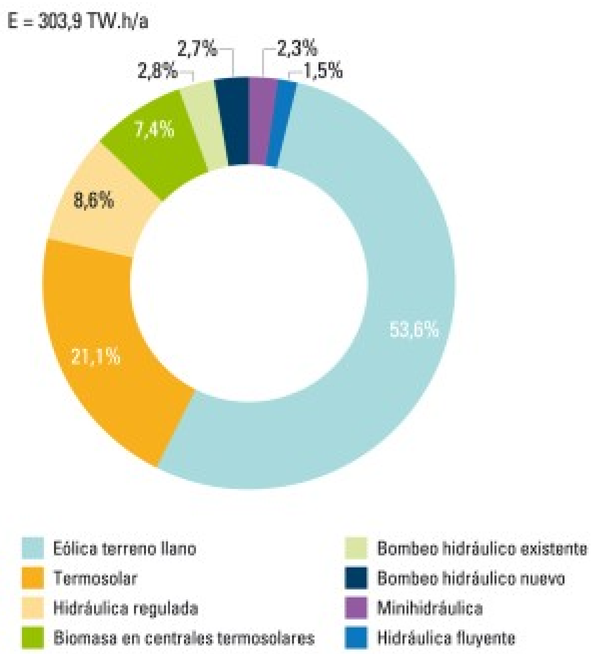
Another example

Economic optimization

Demand-side management



Installed capacity by technology

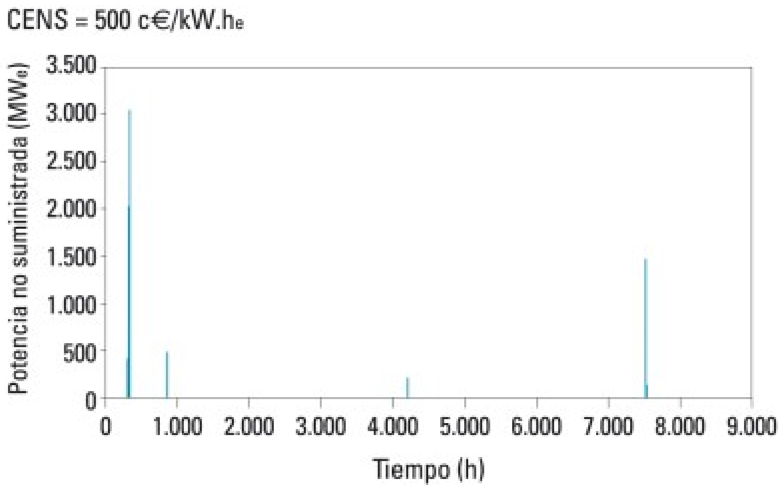


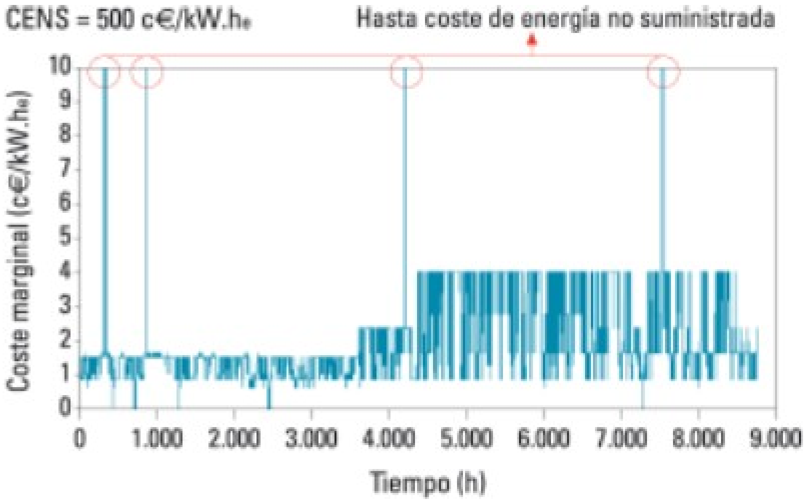
Configuration and electricity generation, mix optimized for NSEC = 500c€/kWh, SM=2.29, SF=99.993%, LEC= 2.42 c€/kWh

“Renewables **100%**” report

Another example | **Economic optimization**

Demand-side management





Annual hourly evolution of marginal cost 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 electric
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 to business as usual
- **There are enough tools to guarantee demand coverage**