

# Renewables 2050

A report on the potential of renewable energies in peninsular Spain

RENOVABLES 2050



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**Greenpeace demands**

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# 1 Objective of the study

## **Solution to climate change:**

substitution of renewables and efficiency for fossil fuels.

BUT...

- ● → Are renewables enough to meet the demand?
- ● → Do we need other energy sources?

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# Description of the study

## Greenpeace commissioned IIT:

- 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: Capacity and generation ceilings

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## 2 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
- Maximum contribution from each of them:  
capacity and generation ceilings

## 2 Hypothesis

→ Spanish mainland population in 2050: 38.31 M.inhab., spatially spread like in 2003

→ Power demand in 2050:

- **20 kWh/inhab-day = 280 TWh/year.** Obtained after discounting from business as usual:

- 80% hot water, through solar thermal and biomass
- 80% space heating, through bioclimatic architecture, solar thermal, biomass and insulation
- 60% space refrigeration, through solar thermal and bioclimatic architecture
- Demand-side management not considered

- **Per capita demand spread by regions = 2003**

- **Same per capita demand in every province in the same region**

- **Hour modulation = 2003**

→ Final energy demand:  
109 kWh/inhab-day = 1,525 TWh/year.

2

# Methodology

## Land uses

••→ Land availability (Geographic Information System)

••→ Environmental restrictions:

- **Exclude 28% peninsular territory**

- **Areas excluded in general:**

- **Natura 2000 Network: SPA + SCI**

- **Protected natural areas**

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# Methodology

## Environmental restriction (28 % territory)



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Total excluded areas for the capacity and generation ceilings for environmental reasons (SCI+SPA+protected natural areas). Source Ministry of Environment



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## Outcomes by technology

Geothermal

Hydro

Biomass

Waves

Off-shore wind

On-shore wind

Solar chimney

Solar PV in buildings

Solar PV with tracking

Concentrated solar thermal

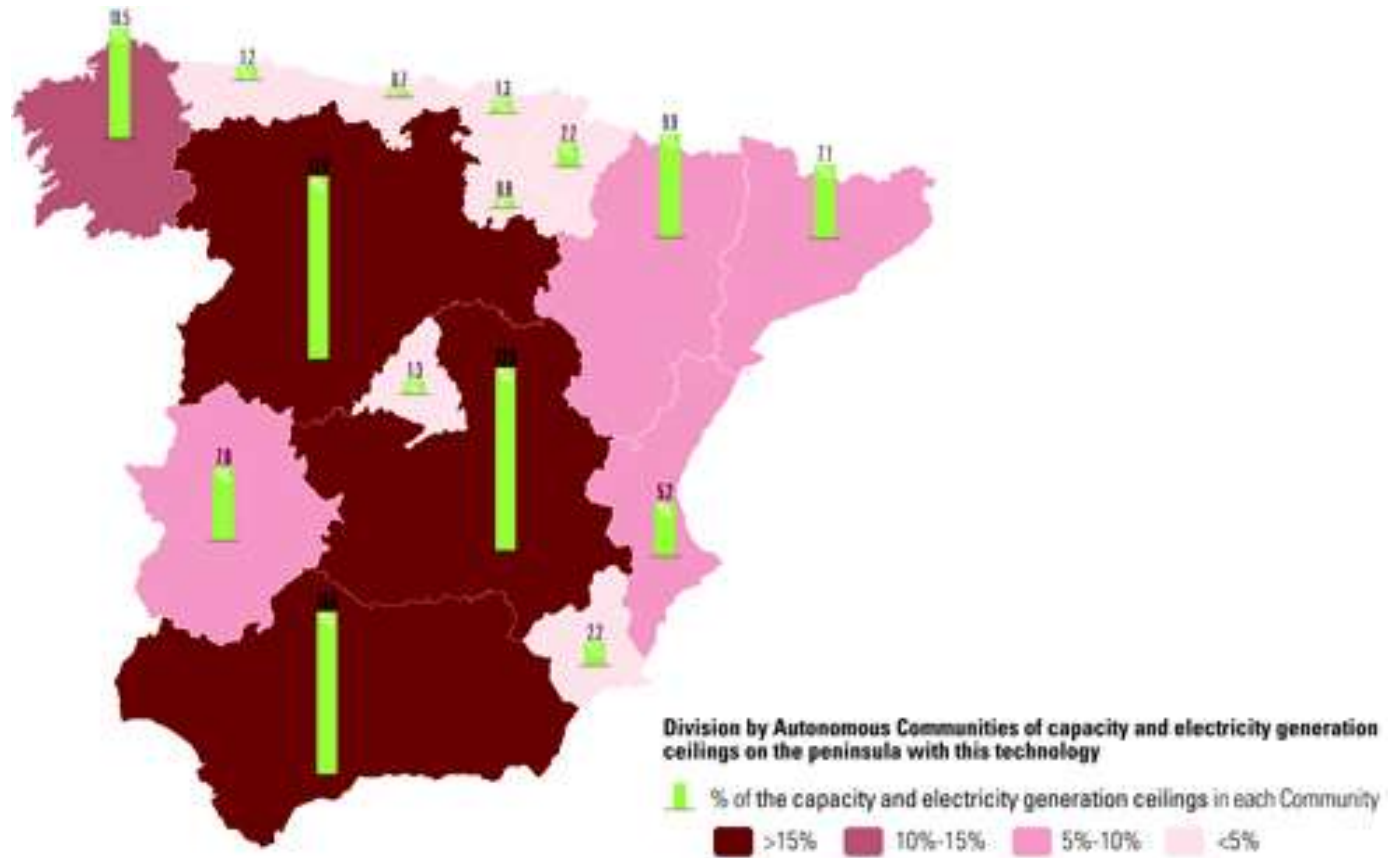
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### 3 Outcomes by technology

## HDR Geothermal

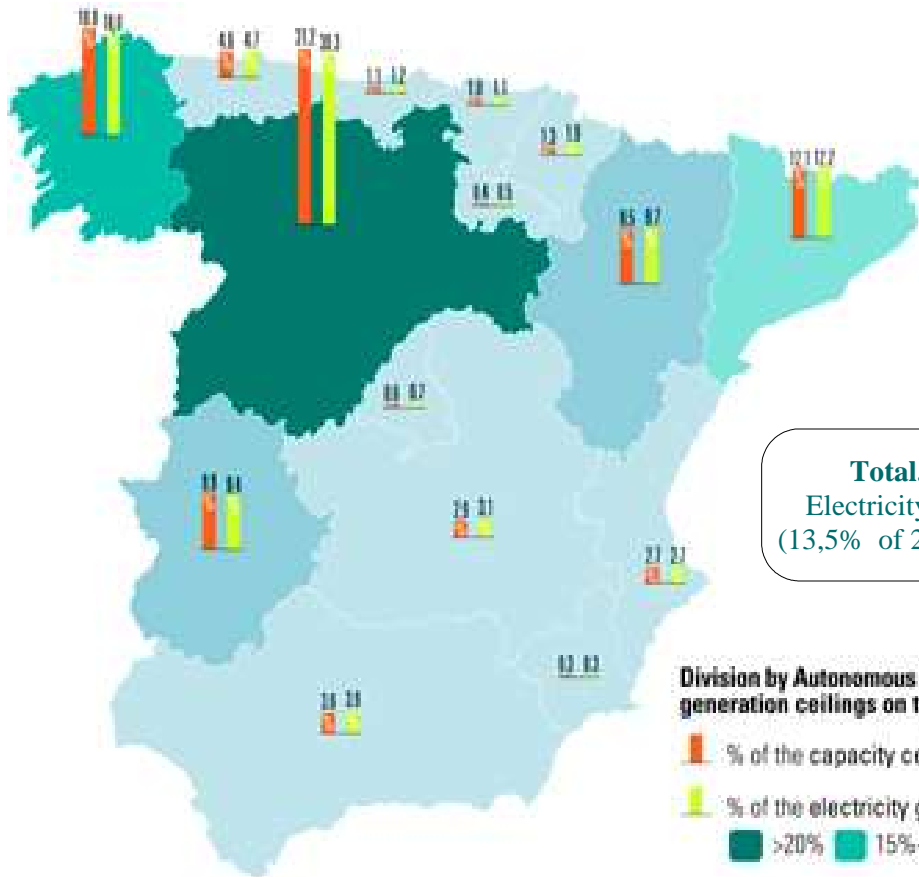


**Total:** Capacity ceiling = 248GW Electricity generation ceiling = 19.53 TWh/a  
(7% of 2050 peninsular electricity demand)



# 3 Outcomes by technology

## Hydro



**Total.** Capacity ceiling= 18,80 GW  
Electricity generation ceiling=37,61TWh/y  
(13,5% of 2050 peninsular electricity demand )

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

- Red bar: % of the capacity ceiling in each Community
- Yellow bar: % of the electricity generation ceiling in each Community

Legend for map color-coding:

- >20% (Dark Green)
- 15%-20% (Medium Green)
- 10%-15% (Light Green)
- 5%-10% (Light Blue)
- <5% (Very Light Blue)



# 3 Outcomes by technology

## Biomass

We look to exploit its possibilities to the limit because of its regulation ability

- Waste
- Energy crops
- Fast turnover forest crops
- Scrub



Tecnology: Biomass gasification

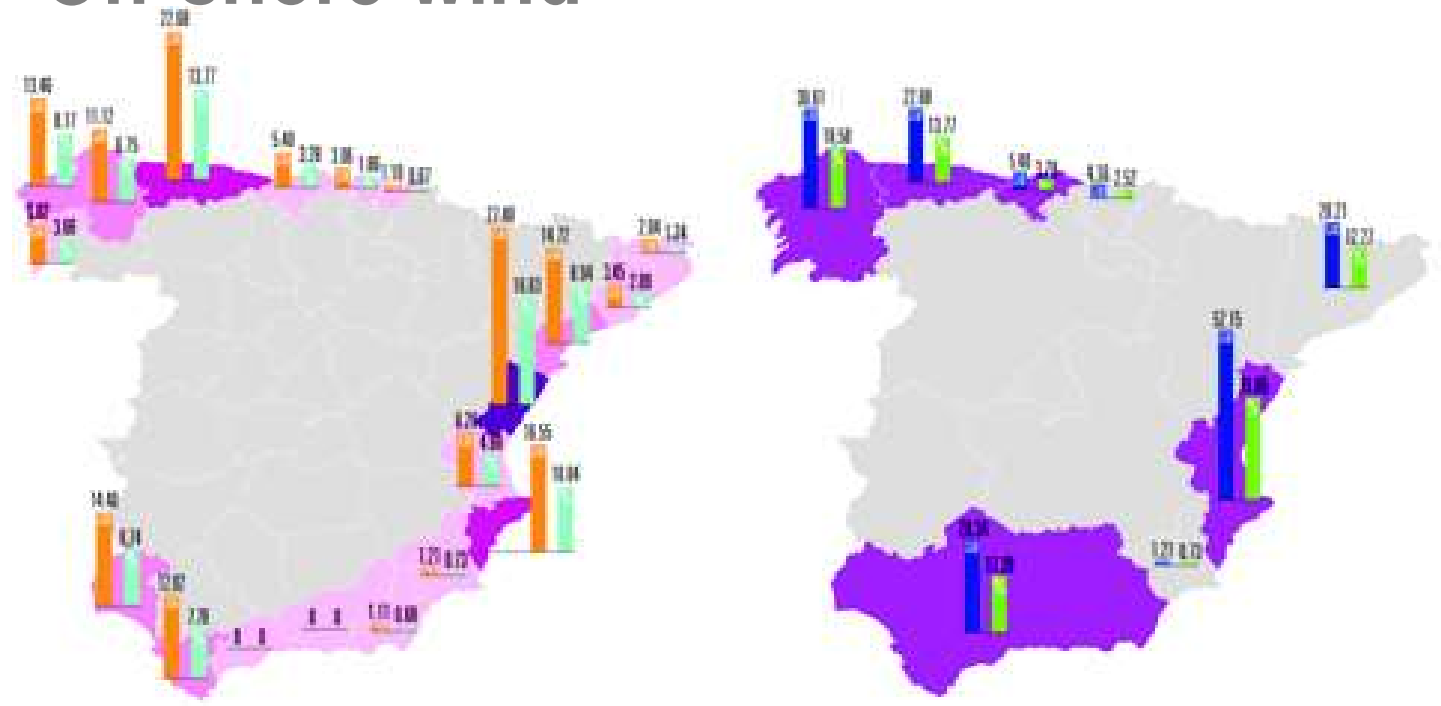






# 3 Outcomes by technology

## Off-shore wind



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

- █ Capacity ceiling in each province (GW)
- █ % of the electricity generation ceiling in each province
- █ >15%
- █ 10%-15%
- █ 5%-10%
- █ <5%

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

- █ Capacity ceiling in each Community (GW)
- █ % of the electricity generation capacity ceiling in each Community
- █ Communities self-sufficient with this technology for their 2050 electricity demand

**Total.** Capacity ceiling = 164,76 GW – Electricity generation ceiling = 334 TWh/y  
(119,3% of 2050 peninsular electricity demand)





# 3 Outcomes by technology

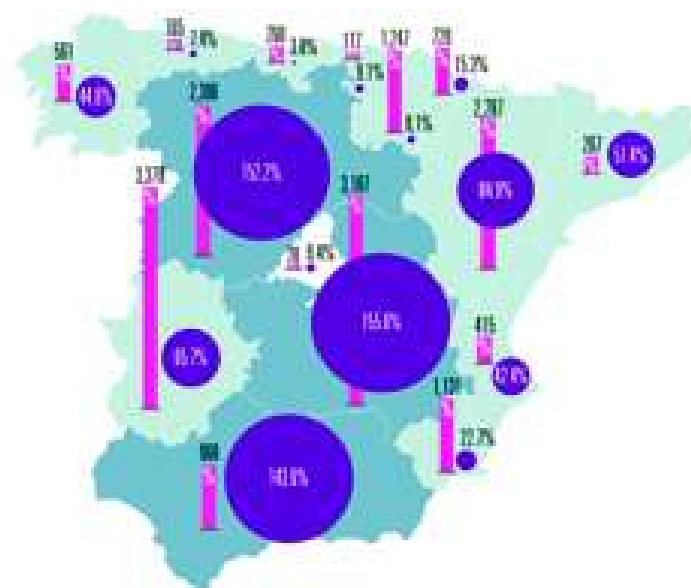
## On-shore wind



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

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

**Total.** Capacity ceiling= 915 GW  
 Electricity generation ceiling=2285 TWh/y  
 (816,1% of 2050 peninsular electricity demand)



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

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

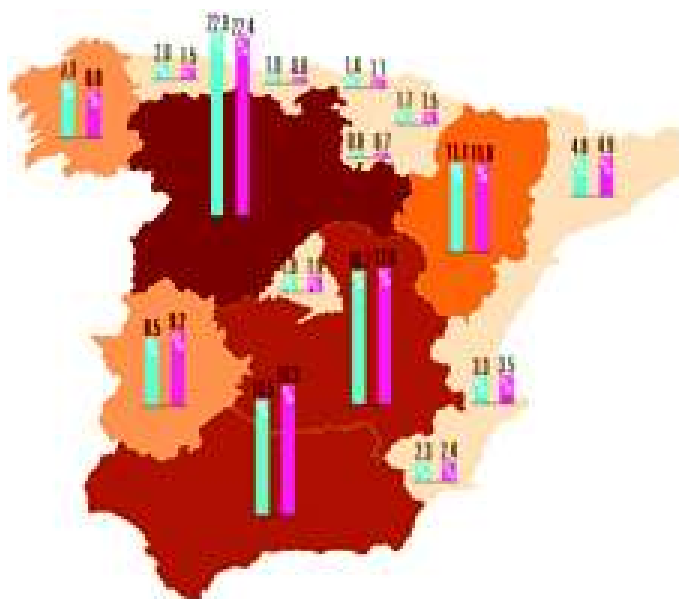
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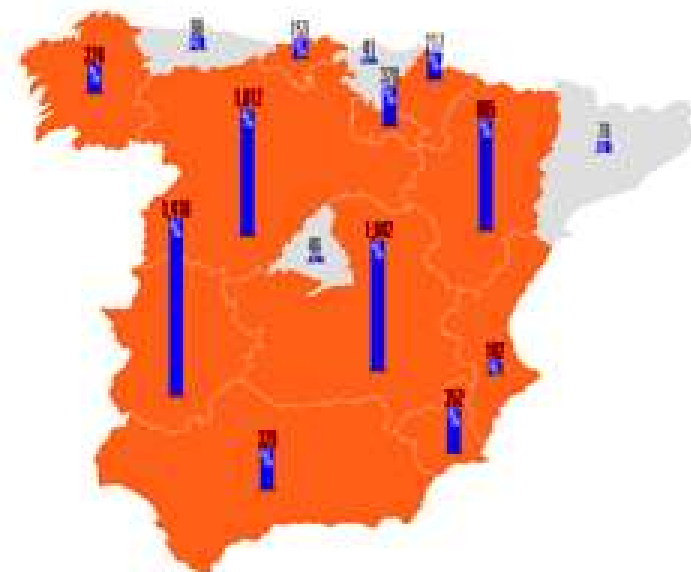
# 3 Outcomes by technology

## Solar chimney



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

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



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

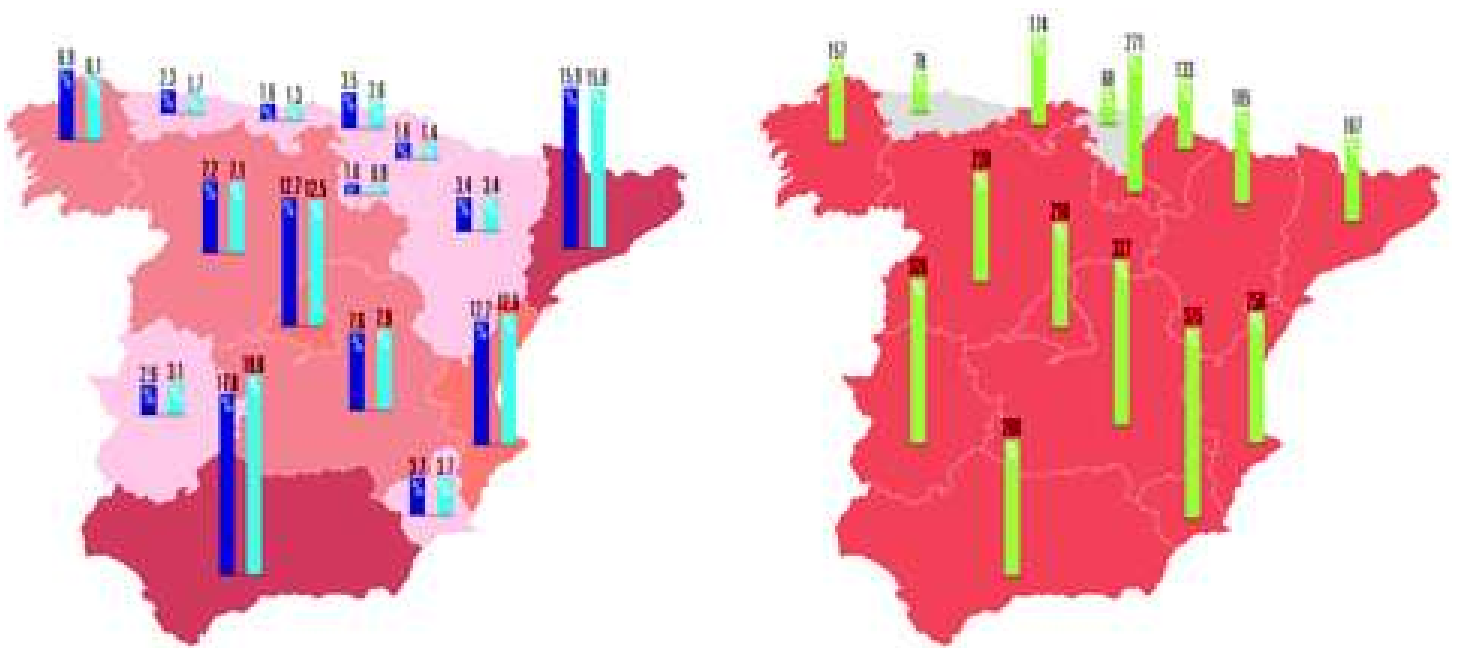
- % of demand in each Community
- Communities self-sufficient with this technology for their 2050 electricity demand

**Total.** Capacity ceiling = 324,3GW – Electricity generation ceiling = 836,2 TWh/y (298,6% of 2050 peninsular electricity demand)



# 3 Outcomes by technology

## Building-integrated PV



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

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

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

- % of the demand of each Community
- Communities self-sufficient with this technology for their 2050 electricity demand

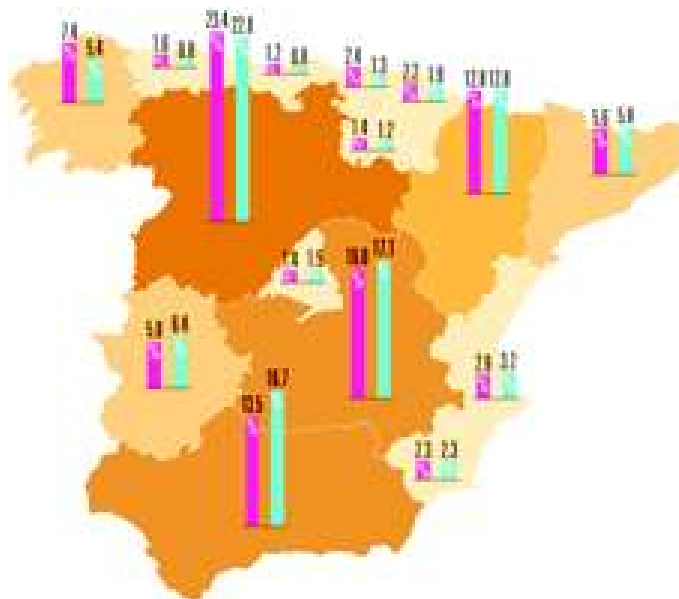
**Total.** Capacity ceiling=494,5 Gwp – Electricity generation ceiling=569,3 Twh/y  
(203% of 2050 peninsular electricity demand)





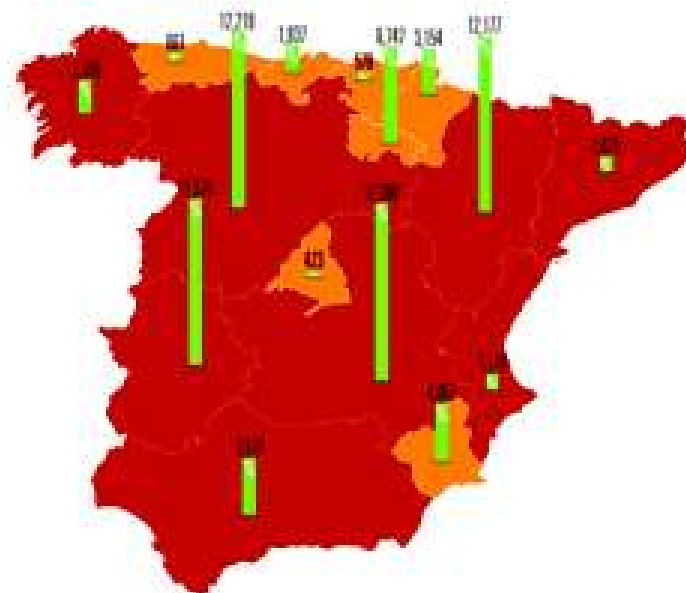
# 3 Outcomes by technology

## Concentrated solar thermal (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%



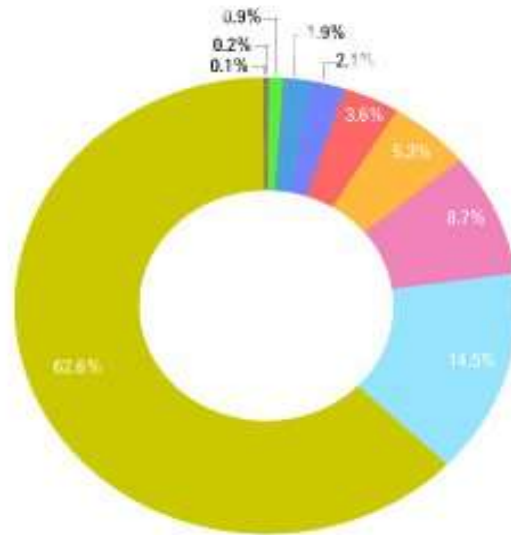
% of electricity demand that would be covered by this technology in 2050

- % 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)

# 4 Synthesis of outcomes

## Generation ceiling spread by technologies



Generation ceiling= 15,798 TW/yr

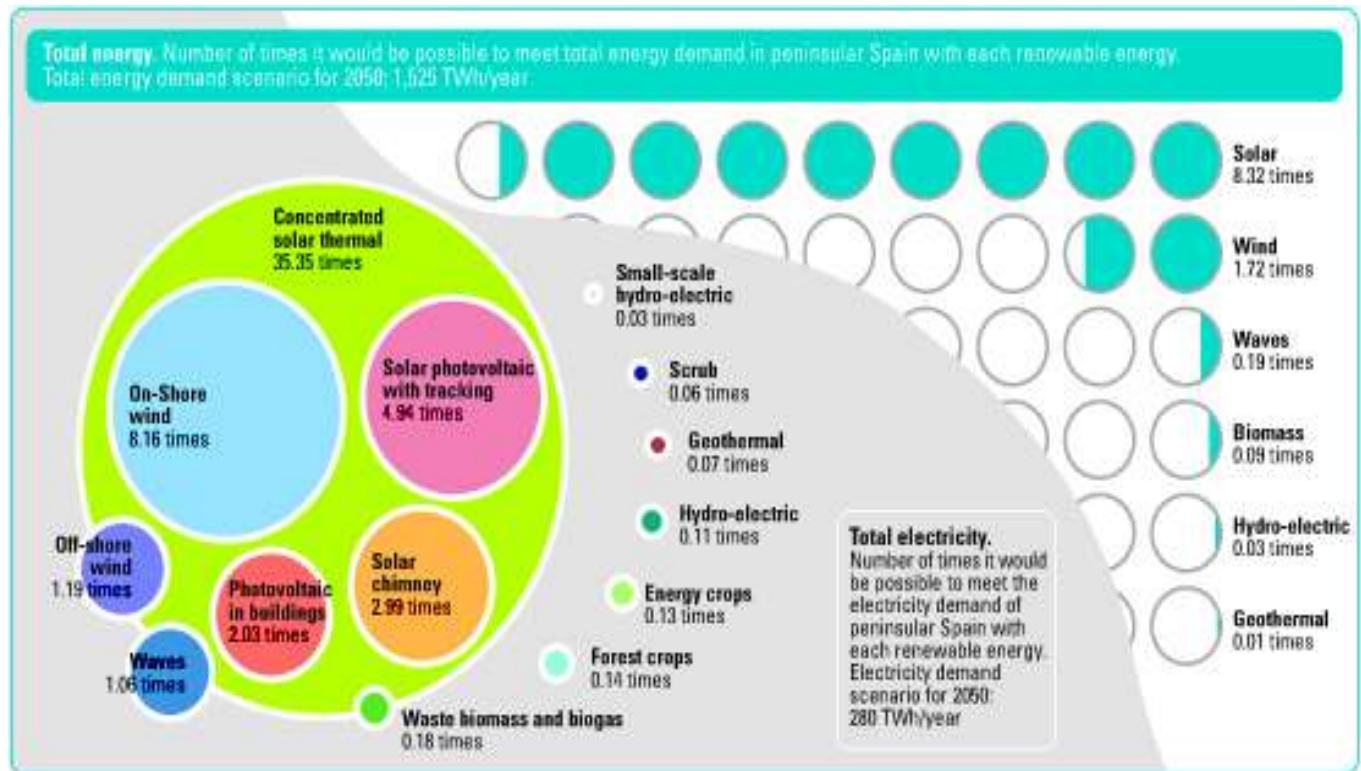
- Concentrated solar thermal
- On-shore wind
- Photovoltaic with tracking
- Solar chimney
- Integrated photovoltaic
- Off-shore wind
- Waves
- Total biomass
- Hydroelectric
- HDR geothermal

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# 4 Synthesis of outcomes

## Total energy and electricity



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## 4

# Synthesis of outcomes

## Comparison with Renewable Energy Plan

**Table 2** Comparison between the capacity ceiling calculated for 2050 and the target for capacity in the Renewable Energies Plan for Spain 2005-2010

	Target capacity (MW) for 2010 in the REP	capacity Ceiling (MW) 2050 Scenario
Concentrated solar thermal	500	2,738,800
Solar Photovoltaic	400	1,202,900
Wind	20,155	1,079,900
Solar chimney	0	324,300
Waves	0	84,400
Total biomass (including biogas)	2,274	19,400
Water	18,977	18,800
Hot dry rock geothermal	0	2,500
Solid Urban Waste	189	0*
<b>Total</b>	<b>42,495</b>	<b>5,471,000</b>

\*Greenpeace does not consider the incineration of solid urban waste as renewable energy.

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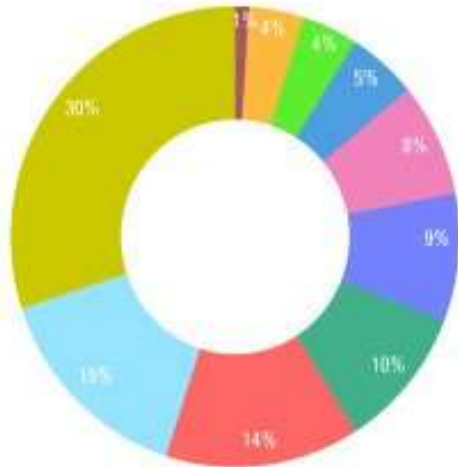
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# 4

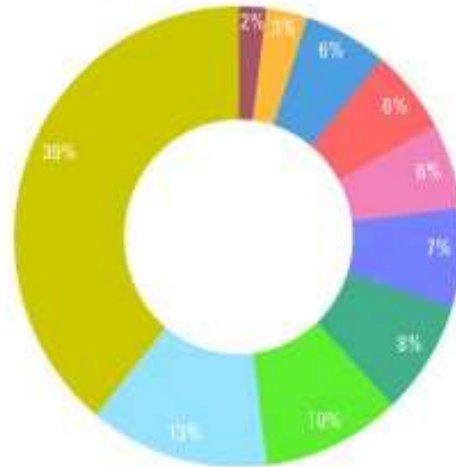
## Synthesis of outcomes

### Possible 100% renewable electricity mix

Capacity= 180 GW



Generation potential= 500 TW,h/y



- Concentrated solar thermal
- On-shore wind
- Integrated photovoltaic
- Hydroelectric
- Off-shore wind
- Photovoltaic with tracking
- Waves
- Total biomass
- Solar chimney
- HDR geothermal

## 4

# Synthesis of outcomes

## Possible 100% renewable electricity mix

Preliminary proposal for a mix of technologies to meet 100% of peninsular electricity demand (assuming a regulation and transport system with 56% efficiency). Percentage share of the capacity and generation potential of the different technologies

	capacity GWp	Generation TW.h/year	Potential developed (%)	Occupation of territory (%)
<b>Solar</b>	<b>100</b>	<b>271</b>	<b>2</b>	<b>0.7</b>
Concentrated solar thermal	55	198	2	0.3
Solar Photovoltaic with tracking	14	28	2	0.2
Solar Chimney	7	17	2	0.3
Integrated photovoltaic	25	29	5	
<b>Wind</b>	<b>44</b>	<b>102</b>	<b>4</b>	<b>1.7</b>
On-shore wind*	28	69	3	1.7
Off-shore wind	17	33	10	
<b>Waves</b>	<b>8</b>	<b>30</b>	<b>10</b>	
<b>Biomass</b>	<b>7</b>	<b>53</b>	<b>37</b>	<b>2.8</b>
Waste biomass and biogas	6	41	80	
Energy crops	1	7	20	1.3
Fast turnover forest crops*	0.4	3	20	0.5
Scrub*	0.3	2	20	1.1
<b>Hydro</b>	<b>19</b>	<b>38</b>	<b>100</b>	
Hydroelectric (P> 10MW)	17	31	100	
Mini-hydroelectric (P< 10MW)	2	7	100	
Hot dry rock geothermal	1	8	40	
<b>Total renewables</b>	<b>180</b>	<b>500</b>	<b>3</b>	<b>5.3</b>

\* Minimum ceilings are shown

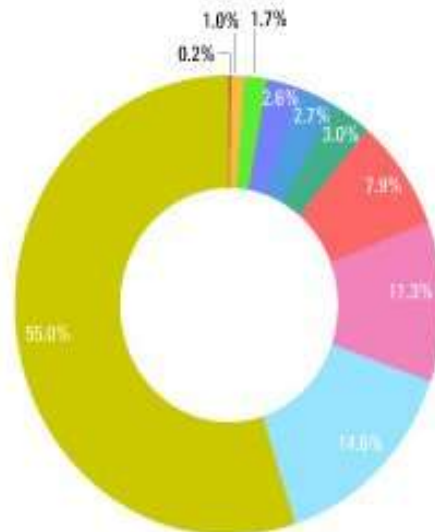
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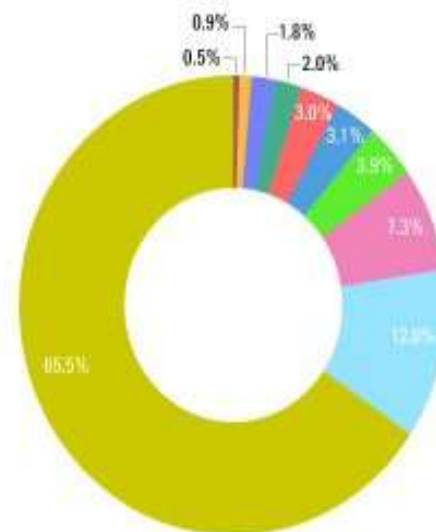
# 4

## Synthesis of outcomes

Possible 100% renewable mix for total energy demand



Installed capacity = 627 GW



Generation potential = 1,900 TW.h/y

- Concentrated solar thermal
- On-shore wind
- Photovoltaic with tracking
- Integrated photovoltaic
- Hydroelectric
- Waves
- Off-shore wind
- Total biomass
- Solar chimney
- HDR geothermal

## 4

# Synthesis of outcomes

## Possible 100% renewable mix for total energy demand

Preliminary proposal for a mix of technologies to meet 100% of total peninsular energy demand (assuming a regulation and transport system with 80% efficiency). Percentage share of installed capacity and generation potential for the different technologies.

	capacity GWp	Generation TW.h/year	Potential developed (%)	Occupation of territory (%)
<b>Solar</b>	<b>471</b>	<b>1,457</b>	<b>11</b>	<b>2.8</b>
Concentrated solar thermal	345	1,245	13	1.7
Solar Photovoltaic with tracking	71	138	10	0.9
Solar Chimney	7	17	2	0.3
Integrated photovoltaic	50	57	10	
<b>Wind</b>	<b>108</b>	<b>262</b>	<b>10</b>	<b>5.7</b>
On-shore wind	92	229	10	5.7
Off-shore wind	17	33	10	
<b>Waves</b>	<b>17</b>	<b>59</b>	<b>20</b>	
<b>Biomass</b>	<b>11</b>	<b>75</b>	<b>53</b>	<b>5.6</b>
Waste biomass and biogas	7	51	100	
Energy crops	2	14	40	2.5
Fast turnover forest crops	0.8	6	40	0.9
Scrub	0.5	4	40	2.2
<b>Hydro</b>	<b>19</b>	<b>38</b>	<b>100</b>	
Hydroelectric (P> 10MW)	17	31	100	
Mini-hydroelectric (P< 10MW)	2	7	100	
Hot dry rock geothermal	1	10	50	0.0
<b>Total renewables</b>	<b>627</b>	<b>1,900</b>	<b>12</b>	<b>14.1</b>

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## 6 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
- Resources are widely distributed throughout the peninsular territory

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# Renewables 2050

## A report on the potential of renewable energies in peninsular Spain

For more information:

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

<http://energia.greenpeace.es/>

- Full report (only in Spanish)
- Summary document
- How to help

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