TRANSITIONS PATHWAYS AND RISK ANALYSIS FOR CLIMATE CHANGE MITIGATION AND ADAPTATION STRATEGIES

D3.2 Context of 15 case studies:

Spain: Renewable Energy

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1 COUNTRY CASE STUDIES OF THE HUMAN INNOVATION SYSTEM (HIS): THE ENABLING ENVIRONMENT FOR SUSTAINABILITY

This case study focuses on Renewable Energy in the European context, where Spain is a leading country in these technologies. Spain is recognised internationally (by the IEA) as a good example of wind promotion and as a bad example on solar PV development (IEA, 2009). First, the case study will analyse Renewable Energy promotion in Spain during the past decades. Second, and considering that recently the European Commission has approved the 2030 energy-climate package with no national binding targets for renewables for Member States, but with a 27% target for the whole EU-27, the case study will analyse the implications of Renewable Energy policy in the transition towards a low carbon future in Spain. Third, and finally, the case study will analyse how renewable promotion could compete, within the context of Spain, for land and could affect (or not) other important land products such as food and biofuels. In order to achieve these goals, a combination of qualitative and quantitative approaches will be used. A selected group of experts on the Spanish Renewable Energy sector will be contacted and their insights will be quantified through mathematical models.

1.1 Research questions for the Spanish case study

RQ1. What are possible future(s) in our case study country/sector context and how might we get there?

RQ2. What changes are required for us to get to our desired future?

1. What happened?

    a. What was the effect of RES deployment in Spain? (socio-economic & environmental, cost-benefit analysis, distributive effects…)

    b. Was the development of RES too fast?

    c. Which are the biggest mistakes Spain made?

    d. Which are the key aspects for the success/failures in renewable promotion that can be useful for other countries?

RQ3. What are the opportunities and risks of RES in the transition to a low carbon economy in Spain?

2. Where are we going?

    a. Will Spain be able to fulfil the European 2050 target of 80%-95% emission reduction?

        i. Which will be the energy mix at the lowest possible cost?

ii. What will be the trade-offs necessary to achieve the target?

iii. What will be the implications of land use for RES?

iv. What will be the co-benefits of an energy mix based on RES? (health, employment,…)

b. What are the risks of underinvestment in new renewable capacity?

i. What will happen when RES facilities -especially wind power- finish their operation time if they are not replaced?

ii. What are the effects (e.g. on electricity prices, solar development, grid costs…) of the “sun tax” (i.e. new national law on self-consumption)?

c. What are the opportunities of fostering RES in Spain?

i. Could Spain become an energy RES exporter for Europe in the future?

RQ4. What policy tools and actions could we take?

3. Where are we now?

a. What is the effect of the last regulatory changes (FIT phase out, retroactive measures, legal uncertainty)?

b. What is the actual role of RES in the deficit of regulated activities (tariff deficit) in Spain?

c. How could Spain solve the problems related to the overcapacity of CCGT?

d. What are the limitations of the current market structure? (e.g. Windfall profits)

1.2 Introduction to the general context

1.2.1 Policy overview

Spain, as a Member State of the European Union (EU), is committed to the EU's climate policy, which is aimed at reducing greenhouse gas emissions to 80-95% below 1990 levels by 2050 (European Commission, 2011). The EU's INDC sets the binding target of an at least 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990 (European Commission, 2015). Additionally, the 2030 Energy Strategy for the EU (European Commission, 2014) also includes a target of at least a 27% share of Renewable Energy (RE) consumption - binding at the EU level - and at least 27% energy savings - non-binding - compared with the business-as-usual scenario[1]. These targets will be fulfilled jointly with all Member States, but there are currently no binding targets for individual Member States for the post-2020 period.

In the shorter run, the EU's climate/energy strategy for the period 2010-2020 (European Commission, 2010) proposes a reduction of greenhouse gas emissions of at least 20%, an increase of the share of Renewable Energy Sources (RES)[2] to at least 20% of consumption, and energy savings of at least 20%. These targets are also aimed at Spain, where the RE target is divided into a 40% share for the electricity sector (RES-E), a 13.6% for the transport sector (RES-T) and an 18.9% for the heating and cooling sector (RES-H&C), according to the National Renewable Energy Action Plan (MITyC, 2010).

RE in the electricity sector during the greatest renewable expansion period in Spain (from 2004 until 2013) has been supported by a combined system of Feed-in Tariffs (FIT) and Feed-in Premiums (FIP), which was established in the Renewable Energy Act and applied to all RES and cogeneration (BOE, 2004).[3] In this period, RES-E grew from a 9% of gross generation in 2004 up to a 26% in 2015 (REE, 2004-2015). However, one of the most important political concerns at that time was the deficit of regulated activities[4] (or tariff deficit), which had increased from 0.25 billion euro in the year 2000 to 26 billion euro in 2013, and was causing an important financial black hole at the country level (CNE/CNMC, 2007-2013). The Spanish tariff deficit was the result of the difference between the income of the electricity system and its regulatory costs. The FIT-FIP incentive scheme to RE accounted for a large part of it (9.3 billion euro in 2013, 46% of total regulatory costs), which led to an energy reform including the suppression of tariffs and the enacted of a

[1] The average GDP growth rate over the period 2015-2030 is 1.6% (European Commission, 2013)
[2] RES include wind, Solar Photovoltaic (PV), solar thermal, small-scale hydropower (< 50 MW) and biomass/wastes. Large-scale hydropower is usually presented as an individual category.
[3] See Section 1.3.1 for more detail.
[4] Including incentives for RES and national coal, distribution costs, transport costs, incentives for investment and availability, non-mainland costs and debt service for funding the tariff deficit.

new remuneration system for RE from 2014 onwards. The new Electricity Sector Law (BOE, 2013d) introduced retroactive measures, removing the FIT and FIP for both new and existing generation units[5]. This increased the risk of not achieving the 2020 targets and reduced the legal certainty of the sector. Furthermore, as a result of the energy reform, dozens of companies and investment funds (national and international) have started a legal battle against the Spanish government over the cuts to renewable subsidies.

The regulatory framework for RE in the transport sector sets a biofuel quota of 4.1% of the total amount sold from 2013 onwards (BOE, 2013b. Article 41). This target represents a reduction from the original 6.5%, which endangers the achievement of the 10% goal by 2020 (risk), but at the same time incurs some additional benefits (e.g. reduces the biofuels competing for food security or those biofuels with lower energy returns and more environmental impact).

Moving to the heating and cooling sector, the European directives have not been properly transposed into the Spanish legal framework to promote the development of RE for heating and cooling, which limits the incentives to low carbon sources for heating and cooling. The only policies aimed at RES-H&C include the building sector, where the Regulation for Thermal Installations in Buildings encourages the use of RES (biomass, geothermal and solar) with energy efficiency purposes, but with no concrete targets (BOE, 2007b; updated in BOE, 2013a). Additionally, the Technical Building Code states that solar thermal contribution to total warm sanitary water should be between 30 and 70%, depending on the demand level, geographic area and main heating source (BOE, 2006 and BOE, 2013c).

Finally, concerning the energy efficiency target, the Spanish government forwarded the National Energy Efficiency Action Plan 2014-2020 to the European Commission. This strategy plan contains a target of primary energy consumption in 2020 of 119.9 Mtep, in accordance with the EU objective of improving energy efficiency by 20% in 2020 (MINETUR, 2014). The policy measures defined in this action plan include the adoption of an energy efficiency scheme, financial and fiscal measures, as well as energy efficiency standards and voluntary agreements.

1.2.2 Natural resources and environmental priorities

Given the major role played by RES in the Spanish energy mix after the passing of the Renewable Energy Act in 2004, this section focuses on the FIT-FIP period (2004-2013) and the post FIT-FIP period (2014-2015).

Table 1 presents the evolution of the primary energy production in Spain from 2004 to 2015 (last available data). According to data provided by the Ministry of Industry, Tourism and Commerce, RE gained relevance after the introduction of the regulatory system based in FIT and FIP in 2004, increasing its participation in the primary energy production from 8.5% in 2004 up to 43.5% in 2015. This increase in RE led to a change in Spanish primary energy production, where coal

[5] See Section 1.3.1 for more detail.

production was displaced from the second position in the energy mix to one of the lowest positions. Nuclear power still remains the leading contributor to primary energy production in Spain, whereas oil and natural gas were in last place during the whole observation period.

Table 1: Primary energy production by technology (%) and total (Mtoe)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
coal	23.6	24.7	19.3	18.0	13.8	12.6	9.6	8.3	7.3	5.2	4.7	3.6
Oil	0.9	0.6	0.5	0.5	0.4	0.4	0.4	0.3	0.4	1.1	0.9	0.7
Natural gas	1.1	0.5	0.2	0.1	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2
hydropower	9.3	6.3	7.1	7.8	6.6	7.5	10.6	8.3	5.3	9.3	9.8	7.2
nuclear	56.6	56.0	50.0	47.4	50.6	45.4	47.1	47.2	47.8	43.3	43.3	44.8
Renewable Energy	8.5	11.8	22.9	26.3	28.4	34.1	32.2	35.8	39.0	41.0	41.3	43.5
TOTAL (Mtoe)	29.27	26.78	31.34	30.30	30.35	30.28	34.33	31.88	33.52	34.14	34.53	33.31

Source: Spanish Ministry of Industry, Tourism and Commerce (MINETUR, 2004-2015).

Spanish dependency on energy imports is one of the most important issues concerning security of supply. As Table 2 reports, more than 70% of the Spanish primary energy relies on imports, particularly for oil and natural gas. The main oil suppliers for Spain in 2015 were Nigeria (17%), Mexico (14%), Russia (12%) and Saudi Arabia (11%), including also other countries with lower shares (Iraq 3%, Algeria 5%, Libya 2%, United Kingdom 3% and Venezuela 5%, among others) (MINETUR, 2004-2015). However, natural gas imports are more concentrated, with more than one third coming from Algeria (33%), followed by Nigeria (12%) and Qatar (9%) (MINETUR, 2004-2015), which threatens the security of Spain's primary energy supply.

coal imports strongly depend on the classification of the mineral. For instance, in 2015 (Foro nuclear (2016), data reported until November), 43% of thermal coal came from Colombia, 33% from Russia and 11% from South Africa; 57% of soft coal had its origin in the United States and 43% in Australia; anthracite was mainly imported from Russia and Ukraine (60%) and for the first time also from Vietnam (18%); and finally, 67% of other types of coal was imported from Indonesia and 30% from Colombia. National coal production in 2015 was divided into 43% of black lignite, 36% of anthracite and 21% of soft coal, most of it concentrated in the Asturias region (north of Spain). The large drop in national production from 2011 onwards (especially seen in 2015) is due to the reduction in public financial support devoted to the mining sector, and the progressive closure of coalfields that has resulted.

In this sense, the role of RE, which is 100% home generated in the case of solar, wind and geothermal power and more than 95% for biomass and biofuels, is crucial in order to satisfy demand and reduce dependency on imports.

Table 2: Primary energy self-sufficiency (%)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
coal	31.3	33.8	33.8	28.8	31.3	36.0	37.0	20.9	16.0	15.5	14.0	8.3
Oil	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.7	0.6	0.5
Natural gas	0.5	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.1	0.2
hydropower	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
nuclear	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Renewable Energy	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.5*	83.0*	91.3*	97.7*	95.2*
TOTAL	19.0	19.8	21.9	21.0	21.7	23.0	26.0	24.7	25.9	28.2	29.2	26.9

Source: Spanish Ministry of Industry, Tourism and Commerce (MINETUR, 2004-2015).
** Solar, wind and Geothermal account for the 100%, self-sufficiency decreases for biomass and Biofuels.*

The gross electricity generation mix displayed in Table 3 deviates in some sense from the primary production picture from Table 1. The most noticeable change is related to the sharing out of technologies. The different sources for electricity generation are less concentrated than in the case of primary production: most of it (88% in 2015) came from nuclear and RE (recall Table 1). We also observe that RE ranks first in terms of electricity generation, whereas it was second in primary energy production. There has been a continuous increase in RES-E from 2004 until 2013, when the FIT-FIP system was in force, with only a slight drop after the new incentive scheme was introduced.

Coal participation is more relevant for the electricity sector compared to total energy shares. New regulation enacted in late 2010 to promote the use of domestic coal in the electricity market (BOE, 2010a; amended in BOE, 2010b) resulted in the technologies using natural gas being displaced from electricity generation by producers using domestic coal, given that both technologies are price setters in the Spanish electricity market, up to a point that it made it difficult for the combined cycle plants to recover fixed costs (CNE, 2010). In fact, the substitution from gas to coal in the last years could affect the Spanish emission reduction commitment if this trend continues in the future. These capacity payments that favoured coal ceased in 2014, but still we observe an increased share of this technology in electricity generation in 2015, which could be due to the drop in RES-E after the suppression of FIT and FIP.

Table 3: Gross electricity generation by technology (%) and total (TWh)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
coal	30.3	29.0	24.1	25.3	16.4	12.9	8.6	16.2	19.8	15.1	17.0	20.5
Oil-fired	3.1	6.8	5.0	3.7	3.5	3.5	3.2	2.6	2.6	2.5	2.4	2.5
combined cycle	11.5	18.3	23.3	24.4	31.5	28.5	23.2	19.2	14.6	10.2	9.5	11.0
hydro-power	11.8	6.9	8.8	8.9	7.1	8.3	13.1	9.6	6.7	12.1	13.1	9.3
nuclear	25.3	20.6	20.9	18.6	19.4	18.3	20.9	20.1	21.1	20.2	20.9	20.6
Renewable Energy	9.3	10.2	10.8	12.3	14.4	18.9	21.2	21.1	23.8	28.4	27.7	26.2
CHP	8.7	8.1	6.9	6.9	7.7	9.5	9.8	11.2	11.6	11.5	9.4	9.9
TOTAL (TWh)	251.7	278.7	287.1	296.6	303.4	288.2	296.1	287.3	291.8	280.8	274.2	275.9

Source: Spanish electricity system operator, Red Eléctrica de España (REE, 2004-2015).

Electricity generation based on hydropower is highly vulnerable to natural events. According to data provided by the Spanish system operator (REE, 2004-2015), the period from 2004 to 2009 was relatively dry, as was 2015, which contrasts with high precipitation in 2010, 2013 and 2014. This is the main cause of the observed fluctuations in electricity produced by this technology. In a country such as Spain, where droughts are becoming more frequent and long-lasting as a consequence of the climate change, it limits the possibilities of an energy source which is clean and completely independent from energy imports.

Related to this, Figure 1 shows the distribution of the installed capacity compared to gross electricity generation for all the technologies used in Spain in 2015. According to the installed capacity, the potential of RE and hydropower is higher than their actual contribution to the electricity mix. In the case of RE, this is due to the fact that most of it comes from intermittent sources (wind and Solar), which are not always available. We also observe this effect for combined cycle, but in this case this is a result of the overcapacity of this technology and its reduced use because of coal (given the regulation that favoured electricity generation using domestic coal –mentioned above-) and RE.

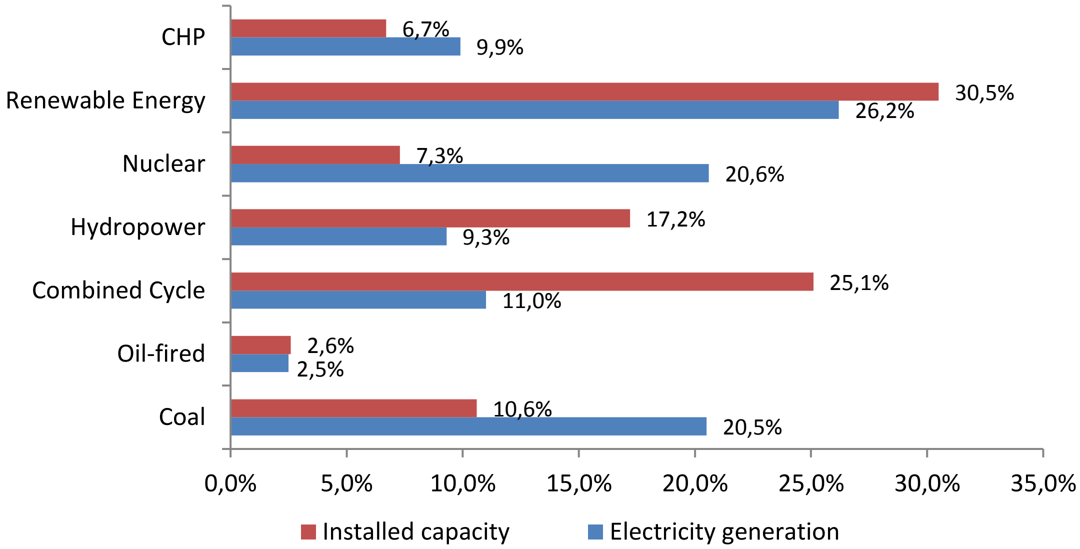

Figure 1: Distribution of installed capacity and gross electricity generation in 2015 (%)

Source: Spanish electricity system operator, Red Eléctrica de España (REE, 2004-2015).

Table 4 shows the final energy use by sector for the period 2004-2014 (2015 not available yet) (IDAE, 2016). The main sectors are transport (40.4% in 2015, 32.4% of total energy use corresponds to road transport), industry (25.1%) and households (18.7%).

Households have increased their energy use by 3 percentage points (pp) from 2004 to 2014, as has the service sector. However, industry has reduced by 7 pp, mainly due to the combination of three effects: the severe economic crisis affecting Spain since 2008, the increase in energy prices and the energy efficiency improvements in their production processes. Finally, on average there have been no changes in the evolution of the transport sector.

As Table 5 shows, Spain reduced its CO_2 emissions from 324 million tons in 2004 to 233 in 2014, but emissions are still 13% above 1990 levels (MAGRAMA, 2016a). The majority of emissions originated in the industry and transport sectors, which accounted for the 66% of total CO_2 emissions. Spain achieved the 15% increase target for the period 2008-2012 of the Kyoto Protocol. However, part of this success is due to the energy demand reduction driven by the economic crisis.

Table 4: Energy use by end-user group (%) and total (Mtoe)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1. INDUSTRY	**32.0**	**31.9**	**26.7**	**28.1**	**27.4**	**24.2**	**24.2**	**24.6**	**25.0**	**25.6**	**25.1**
Extractive	0.3	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.6
Food and stimulant	3.3	3.0	2.3	2.3	2.3	2.4	2.5	2.1	2.5	2.7	2.9
Textile, leader and footwear	1.1	1.0	0.7	0.6	0.5	0.6	0.5	0.5	0.5	0.4	0.4
Wood, paper and printing	2.4	2.5	2.3	2.5	2.3	2.2	1.6	1.9	2.2	2.3	2.3
Chemical	4.7	4.8	4.7	4.4	4.4	3.5	3.6	4.4	4.9	5.0	4.8
Non-metallic minerals	7.3	7.7	6.9	6.9	6.6	5.1	5.1	5.4	4.5	4.1	4.1
Iron and steel	5.4	4.7	4.0	3.9	4.0	3.0	3.5	3.7	3.5	3.7	3.5
Non-ferrous metallurgy	1.6	1.2	1.2	1.3	1.2	1.4	1.4	1.5	1.4	1.2	1.3
Metal processing	1.5	1.4	1.2	1.3	1.3	1.3	1.2	1.3	0.9	1.2	1.1
Freight transportation	1.1	0.9	0.7	0.8	0.8	0.6	0.5	0.6	0.5	0.5	0.6
Construction	0.4	0.5	0.5	0.5	0.5	0.7	0.6	0.6	1.4	1.6	1.6
Others	3.0	3.7	1.9	3.4	3.1	3.0	3.5	2.4	2.2	2.1	2.0
2. TRANSPORT	**40.5**	**40.6**	**42.8**	**43.0**	**42.7**	**43.1**	**41.6**	**41.5**	**40.0**	**39.4**	**40.4**
Road	32.4	32.4	34.2	34.4	34.0	34.8	33.3	32.8	30.4	31.4	32.4
Train	1.0	1.1	0.9	1.0	1.0	1.0	1.0	0.8	0.9	0.4	0.3
Sea	1.7	1.6	1.8	1.5	1.4	1.3	1.2	1.0	1.0	0.6	0.4
Air	5.3	5.5	5.9	6.0	6.1	6.0	6.1	6.7	6.5	6.4	6.7
Oil pipeline	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Others	0.2	0.2	0.2	0.0	0.0	0.1	0.0	0.2	1.2	0.6	0.5
3. DIVERSE USES	**27.4**	**27.5**	**30.4**	**28.9**	**29.9**	**32.7**	**34.2**	**33.9**	**35.0**	**35.1**	**34.5**
Agriculture	3.5	3.2	3.0	3.0	2.9	2.7	2.5	2.8	3.2	3.4	3.4
Fishery	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2
Services	8.2	8.6	9.4	9.0	9.8	10.7	11.0	11.8	12.1	12.0	11.2
Households	15.5	15.5	16.3	15.9	16.4	18.2	19.0	18.1	18.7	18.5	18.7
Others	0.2	0.2	1.8	1.0	0.8	1.1	1.7	1.2	0.9	1.0	1.1
TOTAL (Mtoe)	**94.6**	**97.6**	**95.3**	**98.0**	**94.5**	**87.6**	**89.0**	**86.4**	**83.0**	**80.4**	**78.9**

Source: Institute for Energy Diversification and Saving (IDAE, 2016).

Table 5: CO_2 emissions by energy sector (%), total emissions (million ton) and emissions per capita (ton per capita)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Energy industries (%)	35	37	36	37	35	33	28	33	35	31	32
Manufacturing industries and construction (%)	21	20	18	18	19	17	19	18	18	18	17
Transport (%)	31	30	32	32	33	34	35	33	31	34	34
Commercial/institutional sector (%)	3	3	3	3	3	4	5	5	5	4	4
Residential sector (%)	6	6	6	6	6	7	8	6	6	7	7
Agriculture/forestry/ fishing (%)	3	3	3	3	3	4	4	4	4	5	5
Fugitive emissions from fuels (%)	1	1	1	1	1	1	1	1	1	2	2
Total (million ton)	324	338	329	336	309	275	261	263	261	235	233
Total per capita (ton per capita)	7.48	7.68	7.35	7.37	6.69	5.91	5.59	5.62	5.58	5.04	5.03

Source: Emissions from the Ministry of Agriculture, Food and Environment (MAGRAMA, 2016a). Population from the National Institute for Statistics (INE, 2016a).

Concerning vulnerability to natural events, the increasing exposure of Spain to droughts was mentioned earlier. Another important risk – and closely related to the previous one - affecting land use in Spain are fires. More than 103,000 hectares were burned in 2015, a number below the average of the period 2005-2014 (rounding 108,500 hectares). The most affected region was the Northwest part of the country, accounting for 52% of total fires, followed by the interior regions (31.44%) and to a lesser extent the Mediterranean area and the Canary Islands (MAGRAMA, 2016b).

The environmental priorities in Spain follow the EU directives and are directly related to the energy policy discussed in Section 1.2.1. They focus on a low carbon economy, with high participation of RE and a reduction of emissions. In this sense, there are concrete targets for RE by technology: 63,761 MW of installed renewable capacity by 2020, of which 22% should be hydropower, 11% Photovoltaic, 7.5% Solar thermal, 56% wind and 3% biomass and wastes (IDAE, 2011). In 2015, actual installed capacity from RES was 40,328 GWh, of which 6% was small-scale hydropower, 14% Photovoltaic, 7% Solar thermal, 67% wind and 6% biomass and wastes (CNMC, 2015). Other priorities included in the Spanish energy planning by the Ministry of Industry, Energy and Tourism approved by the Council of Ministers in 2015 (MINETUR, 2015) are the following: (i) security of supply (including back-up capacity and fuel import issues), (ii) a limited environmental impact of the Spanish electricity grid (with the participation of the Ministry of Agriculture, Food and Environment) and (iii) an increase of international interconnections (Spain could serve as an energy exporter, due to the overcapacity of the country). Finally, another important challenge is the regulation of distributed electricity, which is currently under debate because of the charges that the last regulatory measures (see Section 1.2.1) impose on self-consumption.

1.2.3 Economic priorities

In the short term, the General State Budget for 2016 seeks to drive economic growth and employment in Spain (MINHAP, 2016). In 2015, 38% of the Spanish budget was devoted to the retirement fund, 14% to other public administrations and 10% to public debt, whereas Industry and Energy received only a 2% (MINHAP, 2015a) as direct budget. Another economic priority in the medium term is maintaining the stability targets: deficit and debt, mainly. Spain had a headline deficit of 5.1% of GDP in 2015 and the target for 2019 is to keep it below 1.6% of GDP. Spanish debt stabilised in 2015 to 99.2% of GDP and the government plans to reduce debt to 96% in 2019 (European Commission, 2016).

According to the National Institute for Statistics after the recession of 2011-2013 (the worse years of the economic crisis), in 2014 the GDP in Spain began to recover. In 2015 it was about 1,081 billion euros (nominal GDP), 3.2% higher than in the previous year and more than 25% higher than in 2005 (INE, 2016b). Forecasts (Bank of Spain, 2016) suggested that it will continue growing during 2016 and 2017 but at a slower pace of 2.7% in 2016 and 2.3% in 2017, compared to the 3.2% of 2015. Both internal and external factors have favoured the economic growth observed in 2015, such as the good behaviour of the labour market, the recovery of exports, the expansive trend of monetary policy and low oil prices. Nevertheless, despite this economic growth, Spain is still a country below the EU average, ranking 13 in terms of GDP per capita in 2014 (Eurostat, 2015).

Table 6 presents the contribution of RE to GDP. The Spanish Association for Renewable Energies (APPA, 2015) estimates that RE contributes to less than 1% of total GDP, but this number increased in recent years (from 0.48% in 2005 to 0.71% in 2014, peaking in 2012 with a 1.01%). However, despite the increasing trend until 2012, when RE contribution reached its maximum, there has been a decrease in 2013 and 2014. This backward effect is due to the new regulatory framework, which reduced the public support devoted to RES and introduced retroactive measures affecting the legal certainty of the sector.

Table 6: Renewable Energy contribution to Spanish GDP (million euros) and share over total GDP (%)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Direct Contribution	2,865	3,237	3,476	4,932	6,280	6,844	6,794	7,389	7,173	6,123
Induced Contribution	1,644	1,863	2,086	3,204	3,307	3,291	3,531	3,146	2,323	1,265
Total Contribution	4,509	5,100	5,561	8,136	9,588	10,135	10,325	10,535	9,497	7,387
Share of total GDP (%)	0.48	0.51	0.51	0.73	0.89	0.94	0.96	1.01	0.92	0.71

Source: Contribution of RE from the Spanish Association of Renewable Energies (APPA, 2015). GDP from the National Institute for Statistics (INE, 2016b).
Note: Direct contribution results from expenditure associated with RE. Induced contribution results from the employees of the renewable sector purchasing goods and services in other sectors.

Energy demand in Spain followed a growing trend until 2008, when the economic crisis started, and seemed to begin to grow again in 2015. As Table 7 shows, all conventional technologies have reduced their contribution in this recession context; however, RE grew during almost the whole period (except in 2014).

Table 7: Energy demand (ktoe)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
coal	21,049	20,513	17,908	19,970	13,267	9,316	6,800	12,691	15,331	11,348	11,639	14,426
Oil	70,838	71,241	70,937	71,430	68,506	63,473	61,160	58,372	53,978	51,318	50,447	52,434
Natural gas	25,167	29,838	31,227	31,778	34,903	31,219	31,123	28,930	28,569	26,158	23,662	24,590
hydropower	2,673	1,582	2,232	2,349	2,009	2,271	3,638	2,631	1,767	3,170	3,369	2,397
nuclear	16,576	14,995	15,669	14,360	15,369	13,750	16,155	15,042	16,019	14,783	14,934	14,927
Renewable Energy	6,264	7,005	7,183	7,968	8,871	10,645	11,611	12,424	14,570	14,801	14,632	15,107
TOTAL	142,567	145,174	145,156	147,855	142,925	130,674	130,487	130,090	130,234	121,578	118,683	123,881

Source: Spanish Ministry of Industry, Tourism and Commerce (MINETUR, 2004-2015).

1.2.4 Societal priorities perspective on climate change

Spain is the fifth largest European country in terms of population, with 9% of the total EU-28 population, after Germany, France, United Kingdom and Italy (Eurostat, 2016). The country had 46.6 million inhabitants in 2015, 18.3% of them above 65 years-old (INE, 2016a). Forecasts suggest that by 2030 this share will increase up to 30-35%. Therefore, population aging is one of the major societal concerns, since the social security system will need a reform to be sustainable in the near future.

In line with the EU 2020 Strategy Plan, other societal priorities in Spain translate into the following targets by the year 2020 (MINHAP, 2015b): (i) 74% of the population aged 20-64 should be employed (the EU target is 75% while the current status in Spain is 62% in 2015), (ii) 3% of the Spain's GDP should be invested in R&D (1.23% in 2014), (iii) the share of early school leavers should be under 15% (the EU target is 10% the current status in Spain is 20% in 2015) and at least 44% (the EU target is 40%) of the generation aged 30-34 should have a tertiary degree (40.9% in 2015) and (iv) poverty and social exclusion should be reduced (28.6% of people at risk of poverty or social exclusion in Spain in 2015; 23.7% in the EU).

In this sense, the Spanish energy policy also contributes to the enhancement of some of those socio-economic priorities. Indeed, the RE sector created 561,025 direct employments and 492,937 indirect jobs from 2005 to 2014 (APPA, 2015) and the Social Bonus mechanism (BOE, 2009), which consists of a 25% discount on the total electricity bill for eligible households, seeks to protect vulnerable consumers with low incomes. In fact, energy poverty in Spain increased from 3.6% before the economic crisis in 2007 to 9.88% in 2013 (nominal values), after the average electricity bill grew by 76% and natural gas bills by 35% (Economics for Energy, 2015). Hence, social measures devoted to the energy sector are also needed.

Spain is especially vulnerable to climate change, since it affects the coastal areas and reduces agriculture productivity (after the worsening of the weather conditions). However, according to the last survey provided by the Spanish Sociological Research Centre in June 2016 (CIS, 2016), environmental issues are considered the third mayor issue only for 0.1% of the Spanish population and none of the interviewees reported it in the first place nor in the second. Given the current economic situation of the country, 52% of the Spanish citizens claim that unemployment is the first main problem and 19% consider it as the second main problem.

1.2.5 Politics of energy development priorities

In line with the EU, the three pillars of Spain's energy policy are efficiency, sustainability and security of supply. In the electricity sector, this trilemma ensures (or at the very least addresses) environmental quality, security of supply and economic sustainability simultaneously. In this sense, RE plays a major role, since the use of non-depletable energy resources not only provides eco-friendly and sustainable electricity production but also mitigates the security of supply issue, since it reduces dependency on imports of fuel to generate electricity and provides a less concentrated energy mix. These national political priorities have been translated into a regulatory framework for RE based on public support (FIT and FIP until 2013 and a new retributive Spain from 2014 onwards). [6]

National and local governments work hand in hand in the process of launching RE projects, which include different steps: incentive schemes, grid access, electricity market and other administrative procedures such as permits. Since the creation of the Special Regime in Spain, which includes RE and cogeneration (because of its efficiency potential), many small RE developers have entered the market.[7] However, past experience in Spain shows that the complexity of the administrative procedures and the difficulties to find funding (mainly during the economic crisis) are an entry barrier for smaller firms and barely affect the big utilities.

Apart from RE development, regional governments work on other measures against climate change by promoting the use of public transport, driving local industry and managing waste treatment, among others. Finally, long-term targets for 2030 and 2050 have not yet been established at the national level.

1.2.6 Conflicts and synergies of priorities

As mentioned before, the political framework for RE in Spain during the last decade has been characterized by an initial strong promotion for RE and a subsequent setback, driven by the economic problems of the country. The financial crisis affecting the country since 2008 has been an important milestone in RE development and has even affected the social perception of environmental issues. In this sense, the participation of stakeholders coming from both the public and the private sector (including big and small firms) is crucial to understand the past and achieve a future with high RE penetration.

1.3 The Human Innovation System Narrative

1.3.1 Overview of the development of the case study focus

Most of RE development in Spain comes from the electricity sector, which is the main focus of this case study. RE has been regulated since 1980, when Law 82/1980 (BOE, 1980) on energy conservation was enacted, which claimed an increase in energy efficiency and a reduction in energy dependence. It happened as a consequence of the second international oil crisis and represented the start of the development of RES in the country. Since then, RE promotion has

[6] See Section 1.3.1 for more detail.
[7] See Section 1.3.3 for more detail.

been a national policy priority and legislation has been in constant change. In 1985 the government firmly pledged its commitment to RE with the Royal Decree 916/1985 (BOE, 1985) supporting the small-hydraulic energy, the only RES existing at that time.

After entry into the European Union, Law 54/1997 (BOE, 1997) liberalized the electricity sector in Spain and established a plan for the promotion of RES for achieving the goal of 12% of gross inland consumption of energy from renewable sources by 2010 (IDAE, 2005). After this law, the Special Regime (SR) and the corresponding Feed-in Tariffs (FIT) were first established. The SR included renewable (wind, solar photovoltaic (PV), solar thermal, small-scale hydropower and biomass/wastes) and cogeneration generators, with a maximum of 50 MW power.

Later, The Royal Decree 436/2004 (BOE, 2004), known as the Spanish Renewable Energy Act, was set up to fit into the existing general framework supporting the electricity from RES (RES-E). Generators could decide to sell their electricity to a distributor and receive a fixed tariff (FIT) or sell it on the free market and receive a premium (FIP) on top of the market price. The main difference between FIT and FIP is that the incentive level under the FIT system is fixed, whereas under the FIP scheme renewable generators get a guaranteed premium, which is lower than the FIT, plus the price of the pool. This decree provided incentives for new RES installed capacity and was subsequently renewed in the Royal Decree 661/2007 (BOE, 2007a), where new tariffs and premiums for RES-E generators were established, as well as a cap and a floor for renewable remuneration.

The combined system of FIT and FIP led to a strong increase of investment in renewable production, so that most technologies highly exceeded government targets for the period 2005-2010 (IDAE, 2005). In an attempt to reduce regulatory costs, incentives were adjusted in 2010 (BOE, 2010c) including cuts to the FIT of solar thermal electricity and wind generation, and a cap on the number of hours eligible for support for PV installations.[8]

In a context of overcapacity and weak demand, the regulatory changes introduced in 2010 were not deemed sufficient to reduce regulatory costs and, therefore, in 2012 (BOE, 2012) new regulation was passed for the temporary suppression of FIT and FIP for new installations. These measures left new RES-E without public support, but existing obligations remained.

The last cutbacks to the FIT-FIP system were passed in 2013 (BOE, 2013e and BOE, 2013f) and affected all renewable production units, including those who were already functioning. The FIT and FIP were reduced for both new and existing generation plants. This reform aimed at the financial stability of the system, which had accumulated a 26 billion euro tariff deficit by 2013 (~2% of the Spanish GDP). From 2014 onwards (BOE, 2014a and BOE, 2014b), renewable producers receive the market price and, if needed, a subsidy to guarantee a fixed rate of return on investment (the yield of the ten-year Spanish Treasury bond plus 300 basis points). The new

[8] For a detailed explanation on the effect of cost-containment measures on solar PV in Spain see Mir-Artigues et al. (2015).

scheme consists of the regular electricity market price supplemented by a capacity payment and a generation-based premium which are calculated on the basis of technology - and project - specific parameters.

Another relevant issue affecting the future of RE in Spain is related to the role of RE in the distributed generation. In this sense, Royal Decree 900/2015 (BOE, 2015a) legislates electricity generation for self-consumption. It applies to any RES generating electricity for self-consumption and being connected to the national grid, which will be subjected to distribution and transport grid access fees charges. The Spanish government claims that this regulation has been designed in order to ensure the technical and economic sustainability of the national grid. However, public opinion labelled the initiative as a 'sun tax'[9], since consumers with their own photovoltaic (PV) systems will be taxed for the electricity they generate and consume without using the grid.

Finally, the first RE capacity auction under the new regulatory scheme was launched in January 2016 (BOE, 2015a and BOE, 2015b). 500 MW of onshore wind and 200 MW of bioenergy generation capacity were auctioned and all opened capacity was awarded. This auction was opened with the aim of fulfilling Spain's 2020 RE target and considers the possibility of wind energy repowering, which is an attractive alternative in the current scenario without FIT.

The Spanish legal framework had direct implications on the evolution of renewable installed capacity and electricity generation, as Figure 2 shows. As a result of national regulation, when the FIT-FIP system was in force SR capacity grew from 17 GW in 2004 to almost 40 GW in 2013, and electricity generation increased from 47 TWh in 2004 to 111 TWh in 2013. However, the last energy reform (including the subsequent cutbacks in the incentive scheme from 2012 onwards) led to no new renewable capacity in 2014 and 2015 and a drop in the electricity generated by the SR. At the technology level, wind and solar accounted for 74% of total SR capacity in 2015 (57% wind, 12% solar PV and 6% solar thermal) and 62% of electricity generation (49% wind, 8% solar PV and 5% solar thermal).

Concerning the cost of the Spanish incentive scheme, Figure 3 shows the evolution of the public retribution to RES and cogeneration in Spain from 2004 onwards. These costs rose steeply from 2008 to 2013, coinciding with the period of maximum investment in renewable capacity, and dropped after the suppression of the FIT-FIP scheme. Again, 74% of the burden in 2015 was due to wind and solar power (almost 5,000 million euros), but roles changed with respect to their installed capacity shares, and on this occasion solar technologies imposed the greatest cost share: 37% for solar PV and 19% for solar thermal, whereas the share for wind power was 19%.

All in all, the Spanish RE system characterizes by a strong wind power participation and a great financial burden due to solar PV. Figure 2 and Figure 3 are thus key elements to understand how the renewable sector developed along with the corresponding policies (we will analyse this further

[9] This consists of a fixed term for residential consumers owning panels and a fixed and variable term for industrial consumers which generate and consume their own electricity.

in D3.3). Furthermore, the relationship between capacity, generation and incentive levels by technology helps explain an important characteristic of the Spanish case study: “Spain is recognized internationally (by the IEA) as a good example of wind promotion and as a bad example on solar PV development” (as defined in the TIS matrix in D3.1). This difference between technologies reflects both the lights and shadows of renewable deployment in Spain and lays the foundations for this case study, which devotes particular attention to wind and solar power.

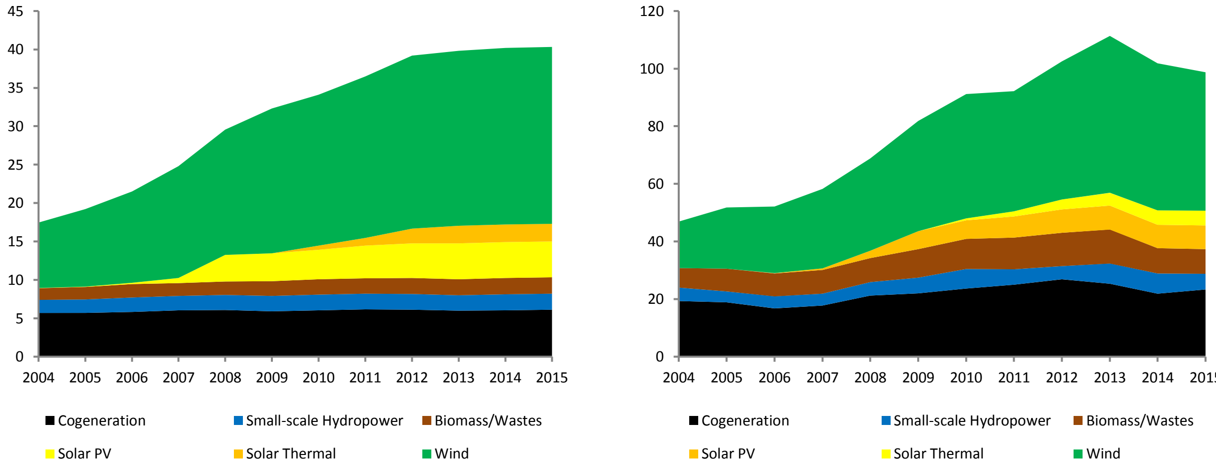

Figure 2: Evolution of Installed Capacity (GW) and Electricity Generation for RES and cogeneration

a) Installed Capacity (GW) **b) Electricity Generation (TWh)**

Source: National Commission of Markets and Competence (CNMC, 2015).
Note: cogeneration is not a RES, but it was included in the Spanish FIT-FIP system, due to its efficiency potential.

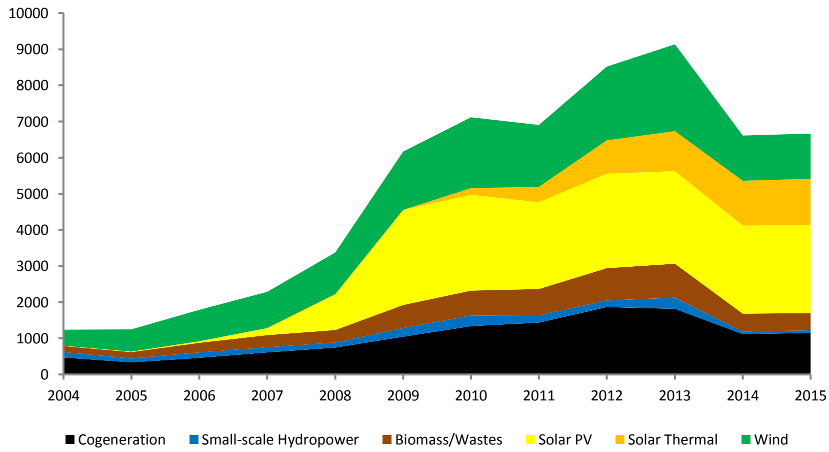

Figure 3: Cost of the incentive scheme for RES and cogeneration (million euros)

Source: National Commission of Markets and Competence (CNMC, 2015).
Note: cogeneration is not a RES, but it was included in the Spanish FIT-FIP system, due to its efficiency potential.

1.3.2 TIS life cycle value chain: a cradle to grave analysis

The technological innovation system analysed in this case study is the RE power sector in Spain, with a special focus on wind and solar PV, given the evolution of these technologies as a result of the regulatory framework discussed in Section 1.3.1.

The value chain of the RE sector in Spain is presented in Figure 4, where blue boxes represent the elements of the supply chain and white boxes the main facilitating services affecting all links in the supply chain.

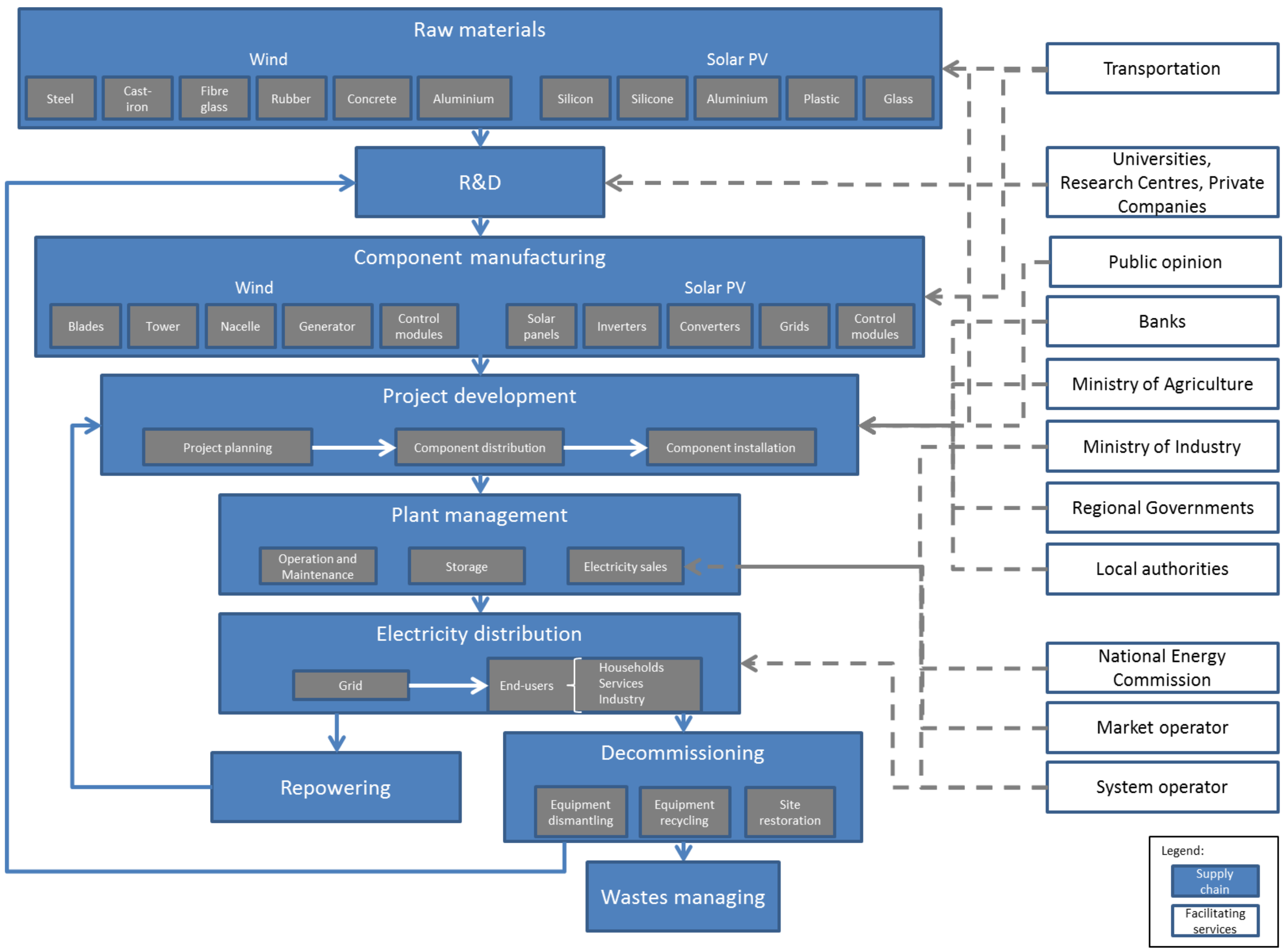

Figure 4: Value chain of the RE sector in Spain (wind and solar PV)

Source: Own elaboration.

Concerning the **energy resource extraction**, wind power and solar PV technologies do not require any fuel extraction for electricity generation. However, they require raw materials for their construction, such as steel for wind power or silicon for solar PV (among others, see Figure 4). The use of these elements in the supply chain has some implications (positive and negative) for both the energy sector and the whole economy. For instance, wind turbines manufacturing, where the 80% of the tower is made from steel, contributes to the development of the steel sector in Spain (generating jobs). Furthermore, more than 90% of the steel can be recycled, which makes this material more eco-friendly than plastic or fibre glass. However, the steel industry is one of the most energy intensive industries, which impacts on the return on energy and the avoided emissions by wind power along its entire life cycle.

Research and development (R&D) is a key element in the supply chain of RE, including investmentof 216 million euros in 2014, which represent a 3.52% of their direct contribution to the GDP (APPA, 2015). Public and private investment in R&D (universities, research centres and private companies) may have positive effects on component manufacturing, since it helps to improve energy generators' economic profitability, technological efficiency and environmental sustainability. In this sense, the substitution of fibre glass by steel - with higher recycling percentages (Martínez et al. (2009) - in wind turbines facilitates recycling, and the use of black silicon instead of crystalline silicon in solar cells improves their efficiency (Savin et al. 2015). Additionally, energy **storage**-related R&D (i.e. batteries) contributes to reducing the intermittency problems of these technologies.

After the component manufacturing, which is undertaken by specific firms (electronic manufacturers, blade manufacturers, solar panel manufacturers …), **power plant generators** are responsible for the next steps of the supply chain: from the project development until the decommissioning of the plant. In the case of small-scale hydropower, wind and solar PV technologies, energy resources are only converted into electricity. Nevertheless, other RE technologies, such as biomass and wastes, are also used for heating and transport (biofuels).

Concerning RES project development, there are several determinants framing project planning: macroeconomic, energy market and technological. For macroeconomic issues, both economic and political stability are fundamental to ensure the appropriate environment, including access to finance and existence and reliability of support schemes (e.g. legal certainty, remuneration level, revenue risk…). The energy market aspects combine the prioritization of RES (e.g. special framework, existence of non-discriminatory markets or inclusion of RES in national planning) and accessibility, including grid regulation and infrastructure. Finally, the technology-specific factors refer to the project attractiveness and may include elements related to the nature of the renewable source (e.g. strength of natural resource, availability of suitable sites, access to land), technological maturity, forecasted growth, cost of the project and complexity of the spatial planning and the administrative procedures (e.g. transparency, duration or cost). Table 8 presents a summary of the existing drivers and barriers for the development of each renewable technology. Therefore, actors such as banks and governments (national, regional and local) are fundamental to facilitate this step of the value chain.

One very important aspect of the project planning in Spain is related to the spatial planning and land use. In addition to the favourable legal framework for RE discussed in Section 1.3.1, Spain counts on high availability for suitable sites for wind and solar promotion, with plenty and widely distributed wind resources (mountains and seaside areas) and large potential for solar energy (more than 2,600 sunshine hours on average – note that Germany is the European leader in solar energy with only 1,700 sunshine hours on average). In the case of wind power there is normally no competition for land use (wind turbines are usually located in mountain areas and could coexist with crops or livestock). However, PV panels are generally installed in potential crop and pasture areas, but are not compatible with these other land uses. The planning system is complex, including many different agents and a long approval process in which both national and regional authorities take part. Indeed, energy targets are defined at the national level, but zoning schemes are subnational political decisions, and the interaction between the two agents is not always straightforward.[10] Social perception of the impact of these technologies has generally been supportive. However, criticism against wind turbines (both onshore and offshore) is growing in the areas of proliferation, because of the visual impact of the turbines and the effects on ecosystems (wood cutting and bird mortality).

Table 8: Barriers and drivers for RES development

	small-scale hydropower	wind*	Solar	biomass/ wastes
Drivers:				
Low O&M costs		x	x	
High site availability		x	x	
No intermittency	x			x
Land use compatibility		x		
Resource availability		x	x	
Barriers:				
High investment costs		x	x**	
Low site availability	x			
Intermittency		x	x	
Land use conflicts			x	x
Food conflicts				x
Emissions				x
Noise		x		
Visual impact	x	x	x	

*Source: Own elaboration.*wind onshore. **Only for high scale projects.*

Other project development tasks after the project planning include component distribution (transport) and installation. **Transport** has been identified as a facilitating service in Spanish RE value chain, rather than another element in the supply chain (though it is required for the component distribution). This classification comes from the fact that transport is a demanded service in any step of the supply chain: (i) raw materials to component manufacturers, (ii) manufactured equipment to the plant site (both for construction and maintenance) and (iii) decommissioned equipment to recycling plants. In the Spanish RE value chain, this process is mainly road transport.

[10] A detailed description of these policies is presented in Section 1.3.3.

Once electricity is generated by the plant, RE generators are responsible for selling it in the market before it is delivered into the grid. The market environment in Spain consists of a pool, as well as a floor for bilateral contracts and a forward market, and it is managed jointly with the Portuguese market by the Iberian electricity market operator (Operador del Mercado Ibérico de Electricidad, OMIE). Big utilities count on their own electricity trading departments, but small RE generators generally outsource this service to authorized providers. The National Commission for Markets and Competitiveness supervises the well-functioning and good practices in the electricity market. Another important agent in the value chain is the Spanish system operator (Red Eléctrica de España, REE), which owns the transmission grids and manages electricity transmission in real-time, constantly ensuring that scheduled generation in power stations matches consumer demands. Electricity is delivered to end-users (residential, small business and industries) through the distribution network, which is owned by the distribution companies. Finally, end consumers are charged by retailing companies. Big utilities are usually vertically integrated and comprise the generation (including both renewable and non-renewable technologies), distribution and retailing businesses. However, much of the renewable capacity in Spain comes from small firms that only work in electricity generation.

When renewable plants reach their end of life (~20-25 years for wind power and ~25-30 years for solar PV), there are two possible options: i) decommissioning or ii) repowering. **Decommissioning** includes equipment dismantling, recycling (with the corresponding waste handling) and site restoration.[11] **Repowering** consists of replacing old equipment with newer and more efficient models, given the innovation and cost reduction driven by the learning-by-doing effect of the sector. This could consist of holding the same capacity levels with less equipment, which reduces the land use and the visual impact of the power station, or increasing the capacity of the plant, which is usually better than installing capacity in new sites (e.g. current power stations are located in the places with the better conditions for energy generation). Repowering in Spain will be especially important for wind power, which accounts for most of the current renewable installed capacity and 85% of it will have surpassed the average lifetime by 2030 (risking the fulfilment of RE and emissions future targets).[12]

1.3.3 Enabling environment: policy mixes in the socio-economic system

Table 9 and Table 10 present the current policy mix in Spain and the interrelationships with the elements of the TIS matrix to be discussed with stakeholders.

[11] See Section 1.3.3 for more information on the Spanish legal framework for recycling and waste handling.
[12] This will be discussed in detail in the second part of the case study (Deliverable 3.3).

Table 9: EU Environmental priorities and corresponding EU and national policies in the Spanish Renewable Energy sector[13]

EU energy and environmental priorities	Spain National Policies	EU Directive Reference
1. "Preventing climate change"	P1: National Renewable Energy Plan 2015-2020 (NREP)[14] P2: Electricity and Gas Sector Plan 2008-2016 P3: Electricity Transmission Grid Plan 2015-2020 (ETGP) P4: Sustainable Economy Law (SEL) – Articles 105 and 106 and sixth additional provision. P5: Incentive scheme for Renewable Energy (Royal Decree 413/2014 and Order 1045/2014)	- Renewable Energy Directive 2009/28/EC (RED) - Energy Union Package COM(2014) 80 final - Clean Vehicles Directive 2009/33/EC (CVD) - EU Emissions Trading System
2. "Maintain and restore biodiversity"	P6: Law of Natural Heritage and Biodiversity (Law 33/2015)	- RED - Green Infrastructure Strategy (GIS)
3. "Substantially reduce natural resource use"	P1: NREP P7: Energy Savings and Efficiency Plan 2011-2020 P8: Integrated National waste Plan[15] (Royal Decree 110/2015) P9: Carbon Footprint Register (RD 163/2014)	- Energy Efficiency Directive - Landfill waste Directive - Accounting Rules for Greenhouse Gases Emitted or Absorbed by Forests and Agriculture (ARGGEAFA) - Land use, land use change and forestry (LULUCF) - Directive on waste Electrical and Electronic Equipment (2012/19/EU)
4. "Make the EU a healthy place to live"	P10: Air Quality and Protection of the Atmosphere Act (Law 34/2007, Royal Decree 102/2011 and Royal Decree 678/2014) P4: SEL	- Air Quality Directive - ARGGEAFA - CVD - GIS
5. "Make the internal energy market work"	P3: ETGP	- Internal Market in Electricity Directive 2009/72/EC

Source: Own elaboration.

[13] To be completed by stakeholders.
[14] To be discussed with stakeholders: How does the suppression of the FIT-FIP scheme affects to the fulfilment of the 2020 targets?
[15] To be discussed with stakeholders: This regulation establishes the legal framework for the management of electrical and electronic wastes, including PV structures. However, at present no directive exists regulating the recycling of wind turbine equipment. These materials contain chemical substances that are potential pollutants for the environment, so there is a need for regulating their recycling.

Table 10: Spanish policy instruments that directly or indirectly impact the Renewable Energy sector[16]

Policy themes	Spain National Policy Instruments			
Energy	P1: National Renewable Energy Plan 2015-2020 (NREP)	P2: Electricity and Gas Sector Plan 2008-2016	P3: Electricity Transmission Grid Plan 2015-2020	P5: Incentive scheme for Renewable Energy (Royal Decree 413/2014 and Order 1045/2014)
Climate				
Agriculture	P1: NREP (biomass)	P6: Law of Natural Heritage and Biodiversity (Law 33/2015)	Common Agricultural Policy 2014-2020	
Buildings	P7: Energy Savings and Efficiency Plan 2011-2020	Decree on Self-Consumption (Royal Decree 900/2015)	Urban rehabilitation, regeneration and renewal Act (Law 8/2013)	
Transportation	P1: NREP (biofuel promotion)	Royal Decree on Biofuel Promotion (RD 1085/2015)	Incentives to electric vehicles	
Service (Health)	P10: Air Quality and Protection of the Atmosphere Act (Law 34/2007, Royal Decree 102/2011 and Royal Decree 678/2014)			
Materials and Minerals	Low-voltage electro technical regulation (Royal Decree 842/2002)	Domestic coal Promotion (RD 134/2010 and RD 1221/2010)		
waste/ resource use	P1: NREP (wastes)	P8: Integrated National waste Plan (at the national level)	Spanish waste Act (Law 22/2011) (at the national level)	Landfill tax on industrial waste, construction waste and municipal solid waste (at the regional level) Municipal waste management programs (at the local level)
Land	P1: NREP (spatial planning)	Rehabilitation, regeneration and renewal Act (Law 8/2013)	P6: Law of Natural Heritage and Biodiversity (Law 33/2015)	Law on Land and Urban rehabilitation (Royal Decree-law 7/2015)
Forest	P1: NREP (forest)	P6: Law of Natural Heritage and Biodiversity (Law 33/2015)	Spanish National Forestry Plan	

Source: Own elaboration.

Among all the policies mentioned in

[16] To be completed by stakeholders.

Table 10, the most relevant instruments concerning RE in Spain are those framed in the Energy and Climate category. The next paragraphs provide a brief explanation of the main policies that will be further analysed in the second part of the case study (D3.3).

The National Renewable Energy Plan (NREP) 2015-2020 is the main policy instrument framing RE in Spain and cuts across the majority of the policy themes identified in Table 10. It includes concrete measures to achieve the 2020 targets for RE, containing individual targets and measures for each technology: wind, solar, small-scale hydropower, biomass, wastes, wastes treatment and others (e.g. geothermal).

The Electricity and Gas Sector Plan 2008-2016 sets the development plan for the electricity and gas sectors in Spain. It includes:

- demand forecasts
- interconnections
- infrastructures
- investments
- costs

The Electricity Transmission Grid Plan 2015-2020 sets the development plan for the transmission grid in Spain (expansion and upgrades).

Concerning the regulation on the incentive schemes for renewable energy, Spain had an incentive system based on feed-in tariffs and premiums from 2004 to 2013.17 Due to the financial burden, after 2014 a new support scheme based on a fixed returned to investment was established. Under this new system, the unitary support that RE receives is lower than with the tariffs and premiums. This is a key aspect to be discussed with stakeholders.

The Integrated National waste Plan regulates the recycling and waste treatment for solar PV components. It is important to mention that at the moment there is no regulation on waste treatment for wind components, which affects the decommissioning process in the value chain.

The Spanish waste Act is the main Act regulating waste generation and processing in Spain. It covers the electricity generation from wastes. Concerning waste management at the local level, the Municipal waste management programs regulate waste management by municipality and the Landfill Tax is aimed at reducing local waste generation.

The Energy Savings and Efficiency Plan 2011-2020 translates the European Efficiency Directive into concrete targets for Spain. It is especially important for solar PV in buildings.

The Regulation on Self-Consumption addresses the issues of grid access for small-scale renewable installations that produce electricity for own use. It has a high impact on solar PV.

The Urban Rehabilitation, Regeneration and Renewal Act sets targets for building rehabilitation, including the promotion of renewable sources for heating.

The Regulation on Biofuel Promotion, in line with the European Directive on RE in the transport sector, translates targets for biofuels. Specifically, it sets a biofuel quota of 4.1% of the total amount sold from 2013 onwards.

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[17] Already detailed in Sections 1.2.1 and 1.3.1.

Incentives for electric vehicles include several programs (PIVE and MOVELE) with subsidies for electric vehicle promotion.

The Common Agricultural Policy 2014-2020 regulates the land use for agriculture in Spain, which affects the electricity generation based on biomass and biofuel production.

The Law of Natural Heritage and Biodiversity regulates the protected areas in Spain, which affects the installation of new plants for solar and wind and the use of biomass for electricity production.

Finally, the Air Quality and Protection of the Atmosphere Act, which is in line with the European targets, sets targets for limiting emissions and improving air quality.

1.3.4 Enabling environment: government institutions

Figure 5 shows the key government institutions taking part in the TIS value chain for RE in Spain. Spain is a Parliamentary Monarchy, where the powers are separated into three branches: legislative (Parliament), executive (Government) and judicial (Courts). The Parliament consists of two chambers (Senate and Congress of Deputies) and controls over the actions of the Government, in addition to approving the national budget.

The Spanish Council of Ministers, which consists of the government president, vice-presidents, ministers and some state secretaries, is the institution responsible for approving the energy planning[18] in Spain. The Ministry of Industry, Energy and Tourism and the Ministry of Agriculture, Food and Environment take part in energy planning, working with the Secretary of State for Energy and the Secretary of State for the Environment respectively. The Ministry of Agriculture handles regulation on waste treatment.

The government is responsible for determining the retributive regime of RE for the whole country (i.e. the FIT-FIP system until 2013) and regulating the electricity market and electricity generation, transport, distribution and commercialization. Additionally, the Institute for Energy and Diversification Saving, which is a public body attached to the Ministry of Industry, Energy and Tourism via the Secretary of State for Energy, contributes to the fulfilment of the national targets on efficiency, RE and other low carbon technologies. At the regional level, each of the 17 Spanish Autonomous Communities includes a regional energy agency with its own energy strategy to help in the planning and development of RE projects, including special planning, project authorisation and licensing, environmental protection and public support. Finally, local institutions regulate minor environmental policies in the area (e.g. metropolitan transport, waste collection, etc…) and grants building permits for RE plants. The interrelationship between local, regional and national institutions is a complex mechanism (sometimes even a barrier for RE projects) that should be further explored with stakeholders.

[18] As mentioned in Section 1.2.2, the main priorities of the Spanish energy planning are: (i) security of supply, (ii) environmental impacts of the electricity system and (iii) international interconnections.

The main regulatory institution for the energy sector in Spain is the National Commission for Markets and Competitiveness (the former National Energy Commission), who handles the payments of the electricity sector and reports on the deficit of regulated activities. Additionally, it monitors the well-functioning of the electricity market and the transmission grid, operated by the Iberian Electricity Market Operator (OMIE in Spanish) and the Spanish Transmission Operator (REE in Spanish).

Other public institutions related to research are universities (which depend on the Ministry of Education) and public research centres such as the Centre for Energy, Environment and Technology research and the Superior Council of Scientific Research (focused not only in energy). Finally, other civil organizations in the enabling environment are environmental NGOs and renewable associations, such as the Renewables Foundation, the Spanish Association for Renewable Producers (APPA in Spanish), the Spanish Photovoltaic Association (UNEF in Spanish) and the wind Association (AEE in Spanish).

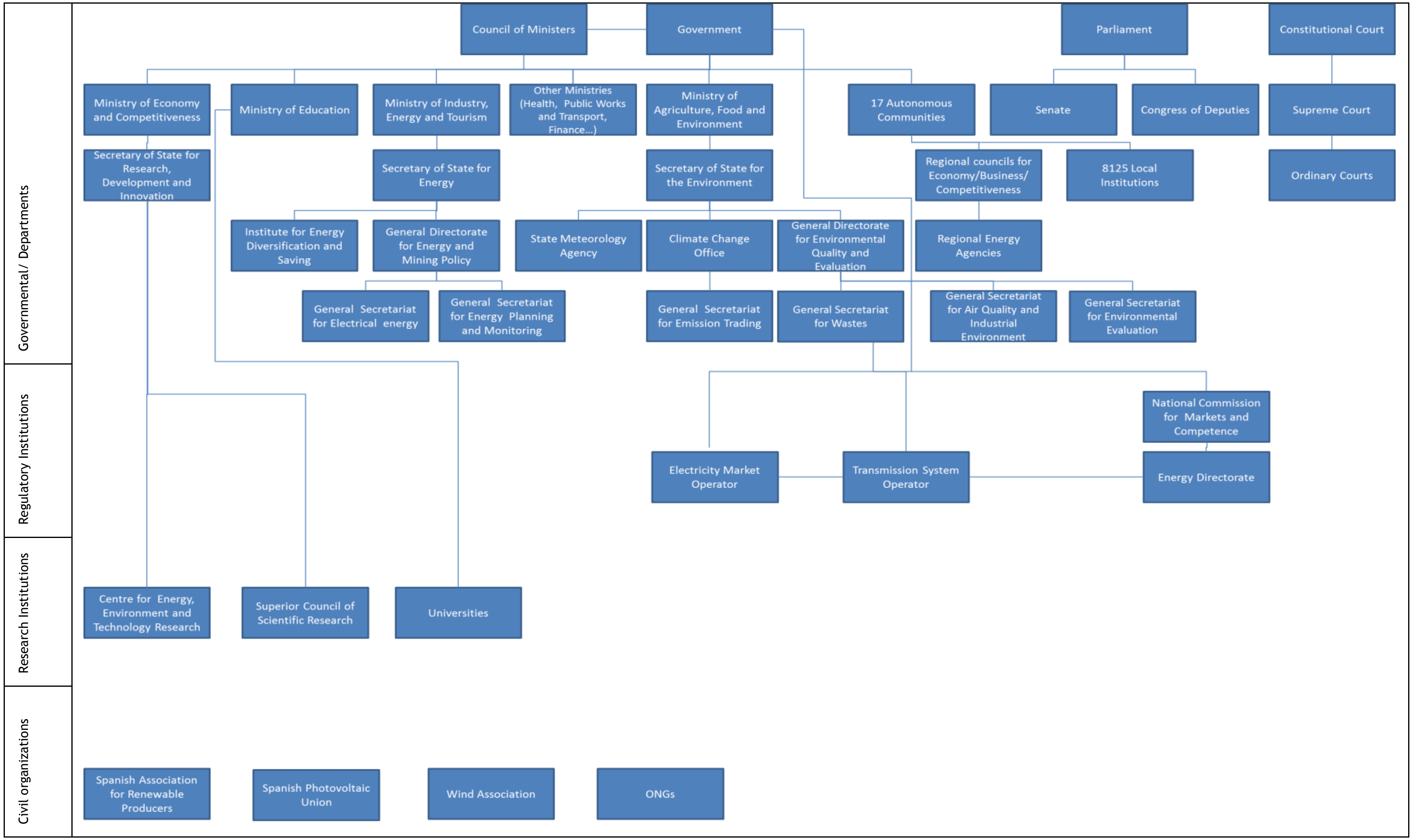

Figure 5: Major institutions in the Renewable Energy framework in Spain

Source: Own elaboration.

1.4 The Innovation System map

Figure 6 shows the Spanish system map, which is divided into four main categories: enabling environment, policies, TIS life cycle and facilitating services and infrastructure. This system map is intended to represent, in a single picture, the existing interrelationships between all the elements that were analysed in detail in Section 1.3. Some of these connections have already been identified (green lines and dotted lines). However, this system map is only a starting point for a more complex analysis to be conducted in D3.3, which will include inputs from stakeholders to draw the complete picture representing the Spanish RE sector.

The enabling environment is composed of the key government (national, regional and local) and regulatory (National Commission of Markets and Competence or National Energy Commission) institutions described in Section 1.3.4, whose role is to ensure institutional coordination, transparency, coherence and legal certainty. These three fundamental pillars are closely related to the main policies framing the RE sector in Spain that were discussed in Section 1.3.3: grid access, spatial planning and RES promotion. Furthermore, these elements are also enablers (or disablers) in RE project development, which is the main component of the TIS life cycle, as it was described in the value chain in Section 1.3.2. Finally, the facilitating services for the well-functioning of the sector in Spain include stakeholders, such as the electricity market operator, the electricity system operator, universities and research centres, associations and NGOs; as well as national services, such as access to finance, administrative procedures, grids and roads. All of these elements (and some others that will appear along the case study elaboration process) will be discussed with the stakeholders in order to identify the risks and uncertainties for a low carbon future in Spain based on RE.

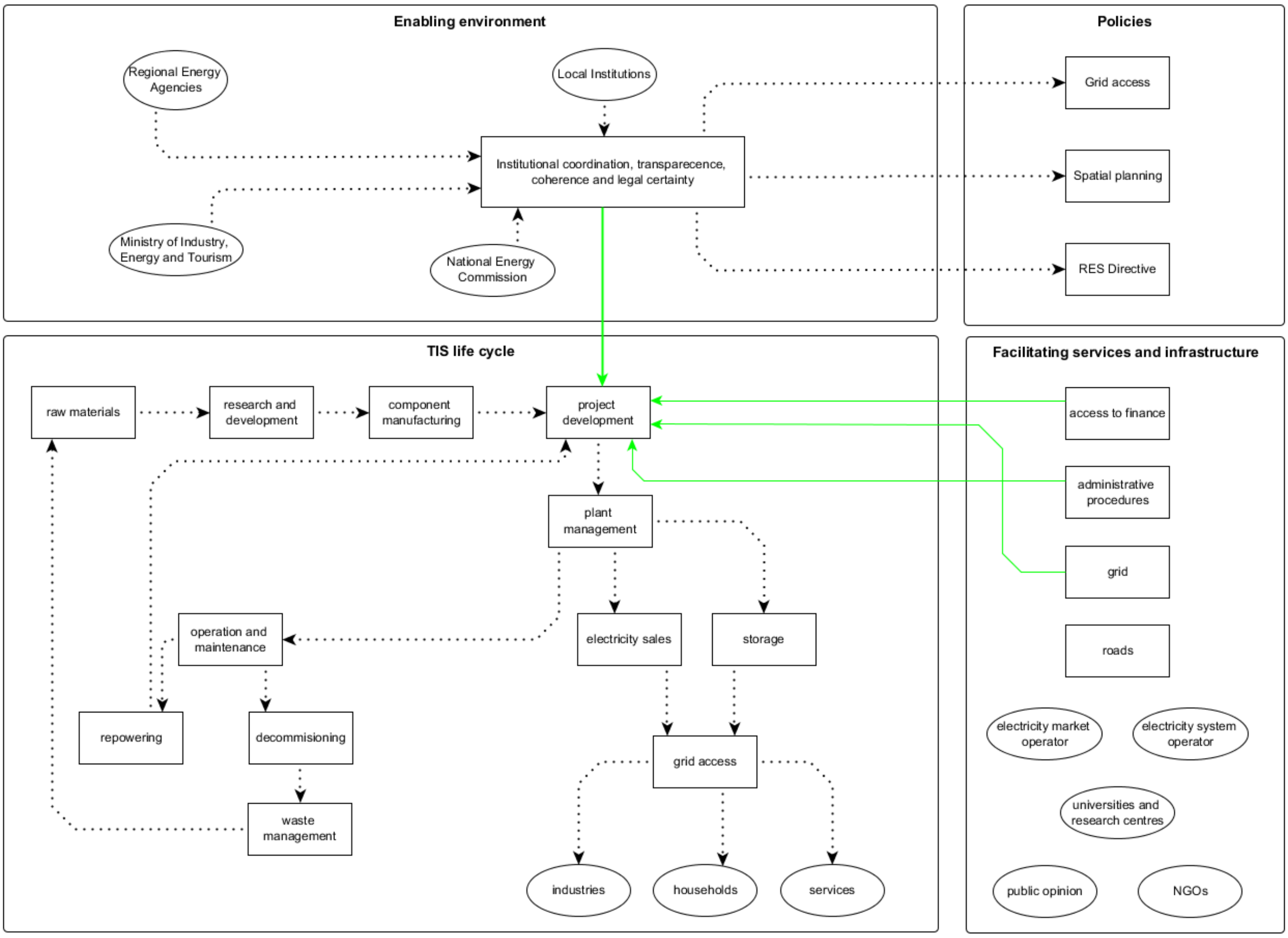

Figure 6: The Spanish system map

Source: Own elaboration.

1.5 Stakeholder engagement

The Spanish case study is a full case study requiring a minimum of 15 interviews and a workshop. Two different groups of stakeholders have been selected according to their type of engagement: full or partial. Full engagement encourages voluntary participation in several surveys throughout the project, one full interview and active presence in one workshop (as a speaker or a member of a round table). Partial engagement implies less commitment than full engagement, since the interview will not be required for them, but it will be useful to have additional inputs via survey. Additionally, stakeholders with partial engagement will be invited to attend the workshop.

In October 2016 we have contacted 22 stakeholders for full engagement, of which 15 have already agreed to take part in the process, two have declined due to time constraints and, after a kind remainder, five more are yet to respond (see Table 11). From the 15 engaged stakeholders, seven are academics, five belong to the private sector (generators and energy firms), one belongs to an international NGO, one is part of the government and one is an industrial consumer. Thus, we have stakeholders covering a big part of the system map.

We still have not carried out any full interviews, due to the tight agenda of our stakeholders, but we have already had some informal discussions with five of our engaged stakeholders (one generator coming from a big utility in Spain and four generalist academics). They have been informed about the case study context and agreed with the issues raised in this deliverable.

Finally, 61 additional stakeholders with partial engagement have already been selected for future rounds (see Table 12 in Appendix A), but they have not yet been contacted. Partial engagement implies less commitment than full engagement, since the interview will not be required for them, but it will be useful to have their additional inputs via survey and they will be invited to attend the workshop. According to the groups identified through the system mapping process, stakeholders for this second round of contacts will belong to the following sectors: generators, distributors, retailers, firms providing energy services, consumers, NGOs, associations, trade unions, regulators, governments (national and regional), market operators, system operators, banks, universities and research centres.

Table 11: Stakeholder Engagement - Full engagement

Type of stakeholder	Position in the organization* **(keep this generic so it doesn't risk stakeholder anonymity)**	Economic sector**	Type of engagement***	Month and year contacted	Already engaged
1. Generator	business: cooperative, national (generation and retail businesses)	Energy	Full engagement	Oct 16	Yes
2. Generator	business: big firm, international (generation, distribution and retail businesses)	Energy	Full engagement	Oct 16	Yes
3. Generator	business: big firm, international (generation, distribution and retail businesses)	Energy	Full engagement	Oct 16	Waiting for response
4. Generator	business: big firm, international (generation, distribution and retail businesses)	Energy	Full engagement	Oct 16	Yes (informal discussion)
5. Generator + Generalist + Association	business: small firm, national (generation and retail businesses)	Energy	Full engagement	Oct 16	Yes
6. Energy services firm	business: small firm, national (generation and retail businesses, energy services and consulting)	Energy	Full engagement	Oct 16	Yes
7. Government	subnational	Energy	Full engagement	Oct 16	Yes
8. Government	national	Energy	Full engagement	Oct 16	Waiting for response
9. Regulator	international	Energy	Full engagement	Oct 16	Waiting for response
10. Association	national	Environment/Energy	Full engagement	Oct 16	Waiting for response
11. Association	national	Energy	Full engagement	Oct 16	Waiting for response
12. NGO	national	Environment	Full engagement	Oct 16	No
13. NGO	international	Environment	Full engagement	Oct 16	Yes
14. Academic	national	Energy	Full engagement	Oct 16	Yes (informal discussion)
15. Academic	national		Full engagement	Oct 16	Yes (informal discussion)
16. Academic	national	Energy	Full engagement	Oct 16	Yes (informal discussion)
17. Academic	national	Energy	Full engagement	Oct 16	Yes (informal discussion)
18. Academic	national	Environment/Energy	Full engagement	Oct 16	Yes
19. Academic	national	Energy	Full engagement	Oct 16	No
20. Academic	national	Energy	Full engagement	Oct 16	Yes
21. Academic	national	Energy	Full engagement	Oct 16	Yes
22. Industrial Consumer	national	Energy	Full engagement	Oct 16	Yes

* Government (national / subnational), research / consultancy, business, other (specify)
** Energy, Industry, transport, environment, agriculture / forest, financial / trader, other (specify)
*** Full engagement includes Interview, Workshop and Surveys. During October-December 2016, the stakeholders will be approached via survey and/or interview.

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Appendix A

Table 12: Stakeholder Engagement - Partial engagement

No.	Type				Economic sector (working in sector or work relevant for sector e.g. Ministry of Economic Affairs -> Energy)								POTENTIAL CONTRIBUTION TO TRANSRISK (BOTH QUALITATIVE AND QUANTITATIVE)				
	Government (national / subnational)	Research / consultnancy	Business	Other (write)	Energy	Industry	Transport	Environment	Agric. / Forest	Financial / trader		Other (write)	Understanding policies and their impacts	Assistance in implementing policies	Knowledge on costs of policies from scenarios	Knowledge on technologies' specificities and market potential	Other (please specify)
1			x		x								x		x	x	
2			x		x								x		x	x	
3			x		x											x	
4			x		x			x					x		x	x	
5			x		x					x						x	
6			x					x					x			x	
7				Association	x											x	
8				Association	x			x					x		x	x	
9				Association	x			x					x		x	x	
10				Association				x					x			x	
11				Association				x					x		x	x	
12				Trade Union				x					x			x	
13				ONG				x					x			x	
14				ONG				x					x			x	
15	x							x					x			x	
16	x				x	x	x						x		x	x	
17	x							x	x				x		x	x	
18	x							x	x				x		x	x	
19	x									x			x			x	
20	x				x								x		x	x	
21		x						x					x		x	x	
22		x						x					x		x	x	
23		x						x					x		x	x	
24				Freelance				x					x		x	x	
25			x		x					x			x			x	
26		x			x								x			x	

No.	Type				Economic sector (working in sector or work relevant for sector e.g. Ministry of Economic Affairs -> Energy)								POTENTIAL CONTRIBUTION TO TRANSRISK (BOTH QUALITATIVE AND QUANTITATIVE)				
	Government (national / subnational)	Research / consultnancy	Business	Other (write)	Energy	Industry	Transport	Environment	Agric. / Forest	Financial / trader		Other (write)	Understanding policies and their impacts	Assistance in implementing policies	Knowledge on costs of policies from scenarios	Knowledge on technologies' specificities and market potential	Other (please specify)
27		x			x			x					x			x	
28		x			x			x					x			x	
29		x			x								x			x	
30		x			x								x			x	
31		x						x	x				x		x	x	
32	x				x	x	x	x	x				x			x	
33		x			x			x					x			x	
34		x			x			x					x			x	
35		x			x			x					x			x	
36				Freelance	x			x	x				x			x	
37		x			x			x	x				x			x	
38	x												x			x	
39		x						x	x				x			x	
40				ONG	x			x	x				x			x	
41			x		x					x			x			x	
42				ONG	x			x	x				x			x	
43				Spanish TSO	x												Knowledge on the transmission network
44	x				x	x	x						x				
45			x		x											x	
46			x		x											x	
47				Spanish TSO	x												Knowledge on the transmission network
48		x			x			x					x				
49		x			x			x					x				
50				Spanish TSO	x												Knowledge on the transmission network

No.	Type				Economic sector (working in sector or work relevant for sector e.g. Ministry of Economic Affairs -> Energy)								POTENTIAL CONTRIBUTION TO TRANSRISK (BOTH QUALITATIVE AND QUANTITATIVE)				
	Government (national / subnational)	Research / consultnancy	Business	Other (write)	Energy	Industry	Transport	Environment	Agric. / Forest	Financial / trader		Other (write)	Understanding policies and their impacts	Assistance in implementing policies	Knowledge on costs of policies from scenarios	Knowledge on technologies' specificities and market potential	Other (please specify)
51	x				x	x	x						x				
52	x									x			x				
53			x		x								x			x	
54	x				x	x	x						x			x	
55			x							x						x	
56			x							x						x	
57			x		x			x		x						x	
58	x							x	x				x				
59	x	x						x	x				x				
60				Spanish market operator	x												Knowledge on the functioning of the electricity market
61				Spanish TSO	x												Knowledge on the transmission network