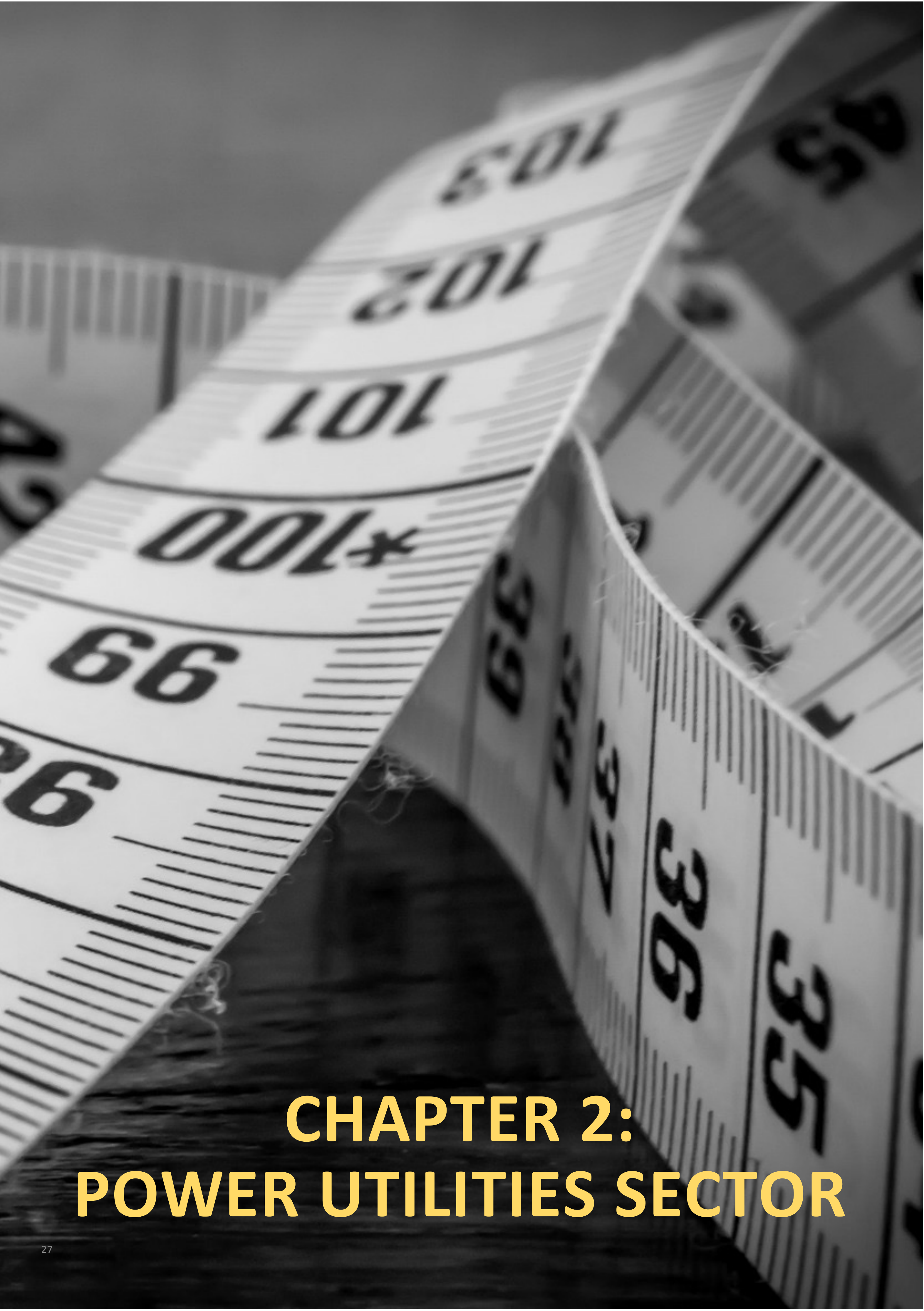


CHAPTER 2:
POWER UTILITIES SECTOR

2 POWER UTILITIES

GENERAL OVERVIEW

In 2013, 42% of global CO_2 emissions originated from the power sector. The sector was responsible for 60% of coal and 40% of gas demand (IEA 2015b). From an energy transition perspective, it is by far the most important sector.

The transition risk story for the electric utilities sector articulates itself through a few trends:

- **Consumption is expected to increase globally**. Demand changes will respond mainly to efficiency measures, and macroeconomic and demographic factors. These factors imply that dynamics in developed and developing economies will be different, with the demand in the latter increasing at a higher pace in some countries.

- **Fuel switch.** The shift from fossil fuels to renewable energy-based power is going to be driven by three main forces: The increase of thermal coal, gas and CO_2 prices, the support from policymakers for the development of new low-carbon technologies and the decreasing marginal costs of renewable power production. Under both the LCT and the ACT scenarios, the total share of fossil fuels will decrease. Under the ACT the share of renewables need to surpass that of fossil fuels to achieve the 2°C target.

- **Policy- and market induced technology change.** Incentives from policymakers will enable the transition from a fossil fuel-based economy to a renewable-based one. Policy instruments such as subsidies, taxes and levies can be put in place to enable this transition. Most of the countries under scope have already started to incentivize renewables and/or disincentivize fossil fuels-based power generation as part of their strategy to achieve their long-term renewables share targets. In addition to policies, changes in the relative economics of renewable technologies versus fossil fuels are similarly expected to drive fuel switching.

The scenario involves the following parameters:

PRODUCTION & TECHNOLOGY	Electricity production (TWh) Electricity capacity (GW)
MARKET PRICING	Levelised costs of electricity (EUR/Mwh)
POLICY MANDATES, INCENTIVES & TAXES	Subsidies (EUR/Mwh) Effective carbon rates (EUR/tCO_2)

5 THINGS BEFORE GETTING STARTED

1. **Latent Forces.** Two major forces are going to shape developments in the power sector: End-users and governments:

   - Changes in preferences, purchasing power and sensitivity to higher electricity prices (which may vary) will all be factors in any reduction in the sector's overall demand and thus the production levels required to meet the demand. Moreover, consumer preferences may also extend to fuel sources of electricity generation, driving a shift to renewables.
   - Governments will be responsible for setting the policy framework associated with decarbonisation pathways and targets (2°C or otherwise).

   Each of these forces will both reinforce and be influenced by technology drivers.

2. **Fossil Fuel Prices vs. Technology Costs.** The link between fossil fuel prices and technology learning rates will determine the economic case of shifting towards renewable sources. In particular, the forecasted increase in the fuel prices during the next 10 years (see Section 1.2) is likely to accelerate the deployment of renewable technologies.

3. **Impact of Consumers Awareness.** In some geographies, consumers' awareness of the use of renewable sources may increase renewables uptake. This development has mostly been observed in developed countries with an active program for the energy transition, such as Germany. Simultaneously, higher consumer awareness has a positive effect on renewable energy electricity producers as it affects their reputational risks.

4. **Effect of Infrastructure and Storage Investments.** The ability for the electricity system to absorb a higher share of variable generation capacity is conditional upon the future infrastructure and storage needs. The IEA estimates in its 450 scenario that total infrastructure investments in the sector will add up to $7.2 trillion. Spending towards the enhancement of distribution and transmission grids represent around 85% of the total investment needed, while only 15% is estimated to be needed for the integration of variable renewable energy sources into the grid. Investments necessary to increase today's storage capacity by 150% will be required by 2050 to meet a 2°C scenario (IEA 2016b). The effect of these costs on the sector's supply and demand is still an open question.

5. **Costs Granularity.** Fuel costs and capital costs can be highly variable for individual utilities. They are driven both by specific contract structures around fuel purchases in the case of natural gas for example, as well as different capital costs depending on geography, financing requirements, etc. By extension, the cost figures quoted in the scenarios presented here represent only high-level 'averages' for sector analysts interested in taking a generalized view.

2.1 ELECTRICITY GENERATION

Overview. Electricity generation in the context of the transition to a low carbon economy relates to the power needed to meet demand while aligning with the energy mix required to achieve country targets on emissions reduction. Electricity supply is generally determined by the market structure (e.g. regulated vs competition) and the availability of resources. Under the scenarios in scope, additional factors will come into play. Electricity supply will change:

- In magnitude, driven by energy efficiency gains and purchasing power increase of end-users, set to follow significantly different trajectories in developing and developed markets.
- In its energy mix, driven by the evolution of renewable technology prices and the policy framework supporting market dynamics, as well as the infrastructure necessary to meet demand needs.

Risk pass-through mechanism. The total electricity generated will affect, ceteris paribus, company expected revenues. The degree of exposure to transition risk depends on the relationship between changes in demand and the energy mix. In particular, companies with operations in countries set to experience a decrease in aggregate demand rates may face lower revenues due to overcapacity. This effect could be amplified if the company is dependent on fossil-fuel based generation due to carbon pricing mechanisms and price incentives for renewable production.

Sources. Electricity generation is an indicator that is widely covered in the literature and one of the core pieces of transition scenarios, given the prominence of the electricity sector more generally. Thus, several scenarios at a global, regional and country scale (e.g. ETP, CTI 2017, EIA 2017) exist, associated with different levels of climate ambition. As an example, the Carbon Tracker Initiative (CTI 2017) in partnership with Imperial College developed 12 scenarios, relating to solar PV and electric vehicles, considering different levels of demand, technology and policy ambition, thus reaching different climate targets (2.3°C to 4.1°C). Under its most ambitious scenario, 51% of the total power generated could come from renewable energy sources by 2050, of which 29% is set to come from solar PV.

Method. The IEA Energy Technology Perspective scenario provides the basis for the ambitious and limited climate transition scenario. This scenario is preferred due to its geographic and technology differentiation granularity. To compute country estimates for France, Italy and Germany, the technology weights of the 2016 EU Reference Scenario are taken as base. It is assumed that these weights are equivalent under both, the ACT and LCT scenarios, across all periods. The 2DS and 4DS growth rates of the EU technology mix are applied to these weights for each country and year. This process leads to the inclusion of current and announced country renewable share targets. For the US, Mexico and Brazil scenarios, generation is taken as well from IEA's 2DS and 4DS scenarios. These were compared to current national policy targets in order to ensure consistency.

When considering these models, a number of potential shortcomings can be identified that may influence users preference in using this or another reference scenario. The 2DS assumes that significant deployment of CCS technologies is necessary to stay in the carbon budget associated with the scenario, together with a high share of nuclear energy sources. While, these projections are overall consistent with the results of other scenarios (e.g. Enerdata 2017, ETC 2017), it raises questions around the economic and social viability limitations underlying the scenarios' assumptions.

Results. Table 2.1 on the next page presents the growth in total electricity generation respect to 2013 levels by country and Table 2.2 the global breakdown by type of source (for results by country please refer to Annex 1). In the ACT scenario, the lower supply is explained by a reduction in demand from the industrial sector and households due to efficiency gains in end-user devices and electric motor systems. The ACT and LCT scenarios foresee lower electricity generation compared to BAU scenarios. Generation steadily increases, with developing economies showing a higher annual increase. The share of renewable energy is expected to be higher under a 2°C scenario. Differences in renewables share (excluding nuclear) of developing and developed countries in scope are not that significant, with Brazil having the highest expected share (84%) and Mexico (54%) outpacing that of the US (47%) and France (42%) by 2040.

TABLE 2.1 GROWTH IN TOTAL ELECTRICITY GENERATION (TWh) UNDER THE ACT AND LCT SCENARIO BY COUNTRY (SOURCE: AUTHORS, BASED ON IEA 2016A, EC 2016, WORLD BANK)

Country	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
World	24 421	10%	13%	20%	26%	30%	41%	40%	55%	49%	67%
Brazil	600	12%	13%	22%	29%	36%	45%	54%	67%	67%	82%
France	563	10%	6%	15%	7%	18%	8%	21%	7%	22%	8%
Germany	599	4%	0%	0%	1%	-14%	2%	-27%	2%	-23%	3%
Italy	291	0%	9%	-3%	8%	-3%	11%	-7%	21%	-12%	30%
Mexico	319	17%	18%	36%	43%	55%	64%	75%	91%	96%	116%
USA	4 319	-1%	5%	-2%	7%	-3%	9%	-3%	10%	-3%	12%

TABLE 2.2 GROWTH IN TOTAL GLOBAL ELECTRICITY GENERATION (TWh AND GROWTH RESPECT TO 2015) UNDER ACT AND LCT SCENARIOS BY TECHNOLOGY (SOURCE: AUTHORS, BASED ON IEA 2016A, EC 2016)

Country	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Total	24 421	10%	13%	20%	26%	30%	41%	40%	55%	49%	67%
Oil	971	-22%	-13%	-40%	-25%	-54%	-35%	-64%	-38%	-74%	-47%
Coal	9 853	3%	9%	-10%	14%	-29%	19%	-49%	25%	-62%	27%
% Coal w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*10%*	*1%*	*28%*	*2%*	*64%*	*3%*
Natural gas	5 158	0%	8%	6%	23%	15%	42%	20%	58%	11%	66%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*1%*	*0%*	*5%*	*1%*	*10%*	*1%*	*18%*	*1%*
Nuclear	2 655	17%	16%	48%	34%	82%	48%	108%	57%	132%	72%
Biomass and waste	574	62%	36%	113%	74%	180%	114%	274%	157%	349%	203%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*0%*
Hydro*	3 981	12%	12%	29%	23%	43%	33%	57%	43%	70%	52%
Geothermal	83	36%	35%	180%	111%	314%	195%	469%	293%	664%	415%
Wind onshore	843	79%	74%	188%	141%	309%	218%	408%	296%	484%	371%
Wind offshore	225	-53%	507%	-5%	736%	73%	993%	172%	1242%	268%	1479%
Solar PV	190	181%	-47%	409%	-22%	705%	15%	1045%	65%	1609%	115%
CSP	85	-63%	531%	108%	863%	440%	1307%	1016%	1664%	1610%	2077%

*(excl. pumped storage) **Ocean and Other technologies are not included

2.2 ELECTRICITY CAPACITY

Overview. Under the transition, meeting the capacity requirements needed to guarantee the forecasted (and then actual) demand levels and the policy-related energy source needs will require changes in the installed capacity. Changes in the installed capacity relate to capacity retirements of fossil fuel power plants and additions of renewable-based electricity, as well as the potential evolution of nuclear and hydropower.

Risk pass-through mechanism. Capacity changes can affect both cash flows and revenues, as well as the write-down of assets. Investment in new installed capacity has a negative impact on company free cash flows due to increased capital expenditures. On the other hand, investments leading to an increase in the capacity factor (e.g. storage) could have a positive impact in revenues through an associated increase in the electricity generated and sold.

Sources. Several scenarios model the capacity needs of the power sector either at a country-specific (e.g. CCC 2015, négaWatt 2017), regional (e.g. IEA) and / or global level (e.g. Greenpeace). Disaggregated results by type of energy source are generally provided, allowing analysts to integrate projections around capacity factors in their analysis. Even though most scenarios integrate assumptions around the uptake of CCS technologies, few of them disclose the power capacity associated with the technology, making it more difficult to interpret the concrete deployment of CCS in terms of its scale and effect on infrastructure.

Method. The ambitious and limited climate transition scenarios take as a basis the IEA 2DS and 4DS scenarios. Data points for France, Italy and Germany are computed using the electricity generation estimates (see previous section) and converted to capacity units, using the capacity-to-generation conversion factors from the EU region projections of IEA Energy Technology Perspective. A more intuitive approach would be to use electricity demand estimates as a starting point, however, estimates by type of source are not provided in the ETP scenarios.

Results. Table 2.3 presents the growth in total electricity generation respect to 2013 levels by country and Table 2.4 presents the capacity growth at a global scale by type of source (refer to annex 2 for country-specific data). Electricity capacity is expected to increase in both the ACT and LCT scenarios (98% and 86%, respectively) by 2040 due to a higher demand and renewables share. However, to achieve the emissions reduction needed to reach each scenario, different dynamics in regional capacity retirements, additions and shifts are required over time. Mature economies will have a high change of stock requiring the retirement of more plants (both from coal and renewables sources) compared to emerging economies in scope as installed is more recent. Overall, installation of new generation capacity is expected to be higher in emerging economies responding mainly to consumption growth assumptions in the context of higher economic growth and a different stage in renewable plants development.

TABLE 2.3 GROWTH IN ELECTRICITY CAPACITY (GW) UNDER THE ACT AND LCT SCENARIOS BY COUNTRY (SOURCE: AUTHORS, BASED ON IEA 2016A, EC 2016)

Country	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
World	6 293	20%	20%	33%	30%	50%	44%	62%	57%	82%	72%
Brazil	144	32%	33%	44%	45%	56%	58%	70%	76%	82%	98%
France	120	1%	1%	1%	1%	2%	2%	3%	3%	4%	4%
Germany	193	21%	9%	24%	10%	17%	15%	4%	7%	9%	11%
Italy	126	2%	9%	-4%	2%	-5%	1%	-11%	-4%	-8%	11%
Mexico	75	37%	28%	71%	52%	104%	92%	145%	112%	163%	112%
USA	1 139	3%	4%	8%	2%	13%	5%	10%	7%	17%	11%

TABLE 2.4 GROWTH IN GLOBAL ELECTRICITY CAPACITY (GW) UNDER THE ACT AND LCT SCENARIOS BY TECHNOLOGY* (SOURCE: AUTHORS, BASED ON IEA 2016A, EC 2016)

Country	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Total	6 293	20%	20%	33%	30%	50%	44%	62%	57%	82%	72%
Oil	459	6%	10%	-12%	-8%	-29%	-25%	-45%	-40%	-60%	-47%
Coal	1 929	7%	11%	-1%	11%	-7%	13%	-31%	14%	-43%	14%
% Coal w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*6%*	*1%*	*16%*	*2%*	*33%*	*2%*
Natural gas	1 630	17%	17%	19%	26%	17%	39%	18%	53%	22%	67%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*1%*	*0%*	*2%*	*0%*	*5%*	*1%*	*8%*	*1%*
Nuclear	416	11%	10%	33%	21%	60%	32%	82%	39%	102%	50%
Biomass and waste	134	55%	38%	87%	62%	129%	80%	193%	99%	260%	128%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*2%*	*0%*
Hydro**	1 074	16%	16%	28%	22%	43%	32%	58%	41%	71%	51%
Geothermal	14	39%	35%	144%	89%	253%	156%	387%	237%	562%	334%
Wind onshore	398	72%	56%	168%	109%	275%	167%	361%	223%	428%	275%
Wind offshore	14	127%	119%	326%	203%	633%	323%	1023%	479%	1370%	619%
Solar PV	219	94%	94%	231%	184%	408%	302%	598%	385%	921%	489%
CSP	6	91%	64%	963%	305%	2327%	682%	4337%	1449%	6576%	2144%

*(excl. pumped storage)
** Values in GW
***Ocean and Other technologies are not shown

2.3 LEVELISED COSTS OF ELECTRICITY

Overview. Levelised Cost Of Electricity (LCOE) is the key economic indicator for determining the economic viability or competitiveness of different technologies. It allows comparison of the opportunity costs associated with investments in one technology or another. Differences between LCOE of renewables and fossil fuel-based technologies will depend mainly on three factors: i.) declining capital costs (e.g. capital expenditures), ii.) changes in the relative economics of fuel costs; and iii.) increasing/decreasing capacity factors.

Risk pass-through mechanisms. The relevance of integrating country/region estimates of LCOEs for risk analysis highly depends on the type of model used. Top-down models can integrate the parameter as part of their macro analysis, while bottom-up models may use it as a benchmark to map the competitive environment in which the analysed companies operate. Whether bottom up or top down, LCOE estimates ultimately determine the margins at which electricity can be sold.

Sources. LCOE is considered in all scenarios modelling the energy mix of a country or region, however, only until recently more visibility around assumptions and results have been provided (e.g. Lazard 2016, CTI 2016). In general, the granularity provided is quite poor, disclosing data at a global level; thus, preventing the analysis of country-level differences.

Method. The ACT and LCT scenarios take the scenarios developed by the National Renewable Energy Laboratory (NREL) in its Annual Technology Baseline as their basis. NREL has developed scenarios in the US for the most relevant technologies through 2050. The steps to compute the LCOE were the following:

- Estimation of country factors: 2014 LCOE of the US were taken as baseline. These were compared against those of other countries to define the starting point. Current values were taken from IEA Projected Costs of Electricity for each technology. In those cases where technology estimates were not available, estimates of countries with similar characteristics were used.
- Estimation of the starting point: The starting point is computed by multiplying the country factor and the estimated LCOE by technology from NREL scenarios.
- Estimation of LCOE trajectory: The trajectory follows the US learning curve.
- Selection of technology scenarios: All scenarios selected consider the capacity factors estimates of ETP 2DS and 4DS scenarios. For gas and coal plants an average capacity factor was selected and it is assumed to be constant through 2040. For renewable sources, the capacity factor is assumed to increase with time. These assumptions could apply to companies that have a relative equal share of old and new power plants but could be contestable for those that do not.

Results. Table 2.5 shows the estimated LCOE in the US (for other countries see Annex 3). Under both decarbonisation scenarios, the LCOE of renewable sources is, in general, projected to be lower than that of fossil fuel power plants. These estimates do not include the effect of a carbon tax. Lower costs in the ACT scenario are driven by a higher reduction of capital costs, the main cost driver for renewable technologies.

TABLE 2.5 LCOE (EUR/MWh) IN THE USA UNDER THE ACT AND LCT SCENARIO (SOURCE: AUTHORS, BASED ON NREL AND IEA 2015)

Technology	2014	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Coal SC	86	85	88	85	88	84	90	83	91	82	94
Coal with CCS	115	110	112	107	110	104	109	101	109	99	110
Gas CT	71	70	83	64	92	76	94	76	99	77	102
Gas with CCS	55	55	65	57	72	59	73	59	77	59	79
Nuclear	79	79	79	79	79	78	78	77	77	76	76
Wind onshore 26% CF	76	61	74	53	74	51	74	50	74	49	74
Wind onshore 30% CF	59	47	57	41	57	39	57	38	57	38	57
Solar PV 14% CF	127	70	122	54	122	46	122	42	122	37	122
Solar PV 20% CF	89	49	85	38	85	32	85	29	85	26	85

2.4 SUBSIDIES

Overview. In the transition to a low-carbon economy, policy options on subsidies will operate in two ways: i.) governments will phase out consumer- and producer-related fossil fuels subsidies; and ii.) governments will gradually decrease renewable power subsidies per unit, although some regions and countries that have lagged to date on climate policies may see a phasing in of subsidies in the short-term, following a phase out as technologies become competitive.

Risk pass-through mechanisms. A reduction of consumer-related fuel subsidies will result in an increase in end user electricity prices which may change consumer behaviour and the application of energy efficient measures. This, in turn, may affect companies through a decrease in revenues. On the other hand, a decrease in the subsidies given to renewable energy power plants may affect the economic viability of both planned and current renewable power capacity and production.

Sources. Few scenarios integrate in their model assumptions around changes in the subsidy structure. Those that do so, generally disclose results with a single indicator preventing the analysis of the consequences at sector, technology and company level. The subsidy assumptions provided here were thus modelled by the authors (see description below)

Method. The subsidy estimates presented here build on the previous estimates of LCOE. It is assumed that under both scenarios LCOEs of fossil fuel and renewable-based technologies reach parity. To do so, the spread between LCOEs is covered through a policy subsidy. Thus, subsides of renewable technologies are computed using the difference between the technology's LCOE and the lowest priced fossil fuel LCOE for each country in each year. While these are presented here as subsidies, this 'gap' can also be filled through a 'tax'. An alternative approach is to use 'announced' or planned policies for developing the subsidy forecasts. However, given the limited time horizon around many of these policies and the fact that in particular the ACT scenario will likely have to rely on 'unknown' policies, this approach seems more appropriate for the LCT scenario. Crucially, this approach treats carbon taxes independent of this calculation. Given the lack of visibility as to whether the policy intervention will take place in the form of a cost or subsidy, carbon taxes / prices could be used as the basis for the overall policy subsidy, assuming these taxes are higher than the required limits defined here.

Results. Table 2.6 presents the estimated subsidies by country for selected technologies (see Annex 4 for geography breakdown). Subsidies in the ACT scenario tend to diminish due to a higher learning rates for renewable technologies compared to thermal generation. In the LCT, subsidies are more constant across time.

TABLE 2.6 ACT AND LCT SCENARIOS SUBSIDIES IN THE UNITED STATES (EUR/MWh) (SOURCE: AUTHORS, BASED ON NREL)

Technology	2014	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Nuclear	24	24	14	22	7	19	5	18	0	17	0
Wind onshore - 30% CF	21	6	9	0	2	0	1	0	0	0	0
Wind onshore - 26% CF	4	0	0	0	0	0	0	0	0	0	0
Solar PV - Utility - 14% CF	72	15	57	0	50	0	49	0	45	0	28
Solar PV - Utility - 20% CF	34	0	20	0	13	0	12	0	8	0	0

2.5 EFFECTIVE CARBON RATES

Overview. Effective carbon rates in the power sector generally encompass three main policy instruments: taxes on electricity, carbon taxes, and permit prices from exchange trade systems. The application of these instruments has different effects in the sector depending on the existing regulatory framework and the market structure. In countries where the regulation allows electricity producers to pass on the increase in production costs to consumers, a tax on energy use and a carbon or fuel tax may have the same overall effect in the economy, a decrease in consumption and window to shift to low-carbon technologies (e.g. Meng, et al. 2013).

Risk pass-through mechanisms. Effective carbon rates can only be considered as a risk driver when these are absorbed by the company and thus cannot be totally transferred to the consumer. Given current effective carbon rates levels and policy goals under both scenarios, it is highly likely that companies will have to internalize the associated costs as lower production costs from renewable technologies could push down market electricity prices.

Sources. There are no public forecasts on effective carbon rates nor on the rates needed to achieve either an ACT or LCT equivalent scenario. The only instrument currently being forecasted is the carbon price, disclosed in several scenarios (see Indicator 1.5).

Method. Since the effective carbon rates encompass several instruments, including carbon taxes, it is assumed that the rates under each scenario will at least equal the country's expected carbon price in cases where the current effective carbon rates are lower. This approach thus defines a threshold rather than establish the optimal rate that companies should account for. The values identified with an asterisk where interpolated using a linear regression**.**

Results. Table 2.7 shows the rates for the ACT and LCT scenarios. 2020, 2025 and 2035 estimates were interpolated. The current rates in the countries in scope are very low (from EUR 3 to 30 per ton CO_2), with all of them having specific taxes on electricity evenly applied through the power sector and some of them pricing emissions through emission trading schemes at a very low price.

TABLE 2.7 EFECTIVE CARBON RATES UNDER THE ACT AND LCT (EUR/tCO_2) (SOURCE: AUTHORS, BASED ON IEA 2016b, OECD 2016)

Year	Brazil		France		Germany		Italy		Mexico		USA	
	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
2012	11		20		34		23		3		4	
2020	39	11	56	28*	63	35*	57	29*	18	7	47	16*
2025	57	11	78	32*	82	36*	79	33*	53*	13*	73	23*
2030	75	11	100	37	100	37	100	37	88	18	100	30
2035	100*	11	120*	44*	120*	44*	120*	44*	105*	23*	120*	35*
2040	125	11	140	50	140	50	140	50	123	28	140	40

*Interpolated figures

ANNEX 1 – ELECTRICTY GENERATION

TABLE 1. GROWTH IN ELECTRICITY GENERATION (TWh) (SOURCE: AUTHORS, BASED ON ETP 2016, EC 2016)

Technology	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Brazil											
Total	600.4	670.9	680.4	733.4	772.4	814.0	868.1	925.6	1 002.7	1 004.0	1 090.8
Oil	21.8	9.9	9.9	7.4	7.4	3.0	6.9	3.0	7.0	2.9	6.7
Coal	20.7	17.9	17.9	12.7	25.7	7.7	16.3	0.5	26.6	0.0	32.5
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Natural gas	61.5	38.1	47.7	7.9	34.5	12.4	46.3	25.9	81.3	26.6	87.7
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*10%*	*0%*	*29%*	*0%*	*54%*	*0%*
Nuclear	17.5	24.6	24.6	24.6	24.6	33.6	29.6	39.9	30.0	40.0	30.1
Biomass and waste	43.2	50.1	50.1	54.4	51.5	66.9	63.1	86.9	81.3	90.6	89.2
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Hydro*	411.1	461.5	461.5	530.6	536.9	575.0	592.2	619.4	632.2	670.3	674.3
Geothermal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind	23.0	64.0	64.0	85.5	81.5	99.1	97.7	126.3	121.6	140.2	136.1
% Wind onshore	*100%*	*100%*	*100%*	*94%*	*100%*	*90%*	*100%*	*89%*	*99%*	*88%*	*98%*
Solar	1.4	4.7	4.7	10.4	10.3	16.3	16.0	23.8	22.5	33.4	34.2
% Solar PV	*100%*	*100%*	*100%*	*100%*	*100%*	*95%*	*95%*	*90%*	*89%*	*83%*	*89%*
France											
Total	562.8	621.0	596.1	646.0	599.5	663.3	608.4	683.4	603.9	687.9	609.2
Oil	1.9	0.5	0.0	0.3	0.3	0.2	0.3	0.1	0.2	0.0	0.1
Coal	18.9	7.9	9.1	0.3	0.4	0.0	0.1	0.0	0.0	0.0	0.0
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Natural gas	20.4	20.2	22.3	18.1	23.7	9.2	12.0	4.8	10.0	10.6	54.0
% Natural Gas w/ CCS	*0%*	*1%*	*0%*	*5%*	*0%*	*14%*	*1%*	*33%*	*1%*	*69%*	*1%*
Nuclear	406.8	431.3	396.2	423.5	385.2	412.0	385.1	411.8	378.9	362.6	299.3
Biomass and waste	9.8	14.7	14.1	19.6	20.1	19.5	20.3	18.9	20.5	22.7	26.3
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*2%*
Hydro*	68.1	65.1	66.9	66.6	64.1	69.0	64.1	71.7	65.5	76.9	69.5
Geothermal	0.5	0.6	0.8	2.2	1.2	4.5	2.0	8.2	3.3	14.4	5.2
Wind	27.0	54.2	55.1	81.2	65.4	114.1	83.4	129.2	83.6	153.1	103.7
% Wind onshore	*86%*	*83%*	*82%*	*85%*	*83%*	*85%*	*81%*	*82%*	*78%*	*81%*	*77%*
Solar	9.3	26.4	31.6	34.1	39.2	34.6	41.0	38.7	41.9	47.6	51.3
% Solar PV	*95%*	*96%*	*96%*	*91%*	*93%*	*88%*	*91%*	*83%*	*87%*	*79%*	*84%*
Germany											
Total	598.5	621.0	599.2	601.2	603.8	517.0	610.8	436.4	611.6	460.7	617.7
Oil	6.7	1.1	0.9	1.8	2.0	2.0	3.1	1.9	3.4	0.6	3.6
Coal	269.2	240.4	273.8	204.0	267.2	98.6	231.9	21.8	182.9	22.9	160.4
% Coal w/ CCS	*0%*	*1%*	*0%*	*5%*	*0%*	*20%*	*2%*	*90%*	*6%*	*100%*	*12%*
Natural gas	69.6	67.8	74.7	78.0	102.2	83.5	108.8	71.7	150.1	30.4	154.6
% Natural Gas w/ CCS	*0%*	*1%*	*0%*	*5%*	*0%*	*14%*	*1%*	*33%*	*1%*	*69%*	*1%*
Nuclear	76.0	37.5	34.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass and waste	41.3	35.2	33.9	42.5	43.4	51.4	53.4	53.1	57.5	58.8	67.8
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*2%*
Hydro*	23.2	30.7	22.5	31.1	23.0	29.6	23.8	28.2	25.7	34.1	27.4
Geothermal	0.4	1.1	1.0	2.3	1.0	2.4	1.0	2.4	1.0	3.9	1.0
Wind	75.7	150.6	109.5	183.0	113.2	192.1	128.3	201.1	130.1	240.5	139.0
% Wind onshore	*87%*	*83%*	*82%*	*85%*	*83%*	*85%*	*81%*	*82%*	*78%*	*81%*	*77%*
Solar	36.4	56.7	48.5	58.4	51.8	57.4	60.5	56.3	61.0	69.6	63.9
% Solar PV	*95%*	*96%*	*96%*	*91%*	*93%*	*88%*	*91%*	*83%*	*87%*	*79%*	*84%*
Total	598.5	621.0	599.2	601.2	603.8	517.0	610.8	436.4	611.6	460.7	617.7

*(excl. pumped storage) ** Values in TWh ***Ocean and Other technologies are not included

TABLE 1 (Cont.). GROWTH IN ELECTRICITY GENERATION (TWh) (SOURCE: AUTHORS, BASED ON ETP 2016, EC 2016)

Technology	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Italy											
Total	291.0	291.8	316.5	281.8	313.8	283.7	323.1	270.3	351.6	256.8	378.8
Oil	15.3	9.2	7.8	7.4	8.0	5.2	7.8	2.8	5.1	0.7	4.5
Coal	46.6	59.0	67.2	34.4	45.1	19.0	44.7	4.6	38.8	1.4	9.9
% Coal w/ CCS	*0%*	*1%*	*0%*	*5%*	*0%*	*20%*	*2%*	*90%*	*6%*	*100%*	*12%*
Natural gas	119.4	114.4	126.2	94.8	124.2	93.9	122.4	65.1	136.4	32.9	167.6
% Natural Gas w/ CCS	*0%*	*1%*	*0%*	*5%*	*0%*	*14%*	*1%*	*33%*	*1%*	*69%*	*1%*
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biomass and waste	16.2	22.3	21.4	23.7	24.2	24.6	25.6	40.1	43.4	50.5	58.3
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*2%*
Hydro*	49.8	46.3	47.5	50.9	49.0	53.5	49.7	56.2	51.3	58.2	52.6
Geothermal	6.4	5.0	6.2	11.5	6.2	14.0	6.2	15.4	6.2	17.3	6.2
Wind	14.9	14.4	14.6	31.8	25.6	44.8	32.7	52.2	33.8	58.7	39.8
% Wind onshore	*89%*	*83%*	*82%*	*85%*	*83%*	*85%*	*81%*	*82%*	*78%*	*81%*	*77%*
Solar	22.4	21.3	25.6	27.3	31.5	28.7	34.0	33.9	36.7	37.1	39.9
% Solar PV	*95%*	*96%*	*96%*	*91%*	*93%*	*88%*	*91%*	*83%*	*87%*	*79%*	*84%*
Mexico											
Total	319.0	372.1	375.3	434.0	455.1	493.4	524.2	556.8	609.1	626.0	690.5
Oil	41.5	24.9	26.1	16.2	12.8	7.5	8.1	5.8	7.3	1.6	1.6
Coal	34.6	27.8	54.9	22.7	54.9	3.0	54.9	3.0	51.8	3.0	48.7
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*100%*	*0%*	*100%*	*0%*	*100%*	*0%*
Natural gas	177.4	208.1	204.7	227.4	256.9	236.7	279.1	211.0	338.8	200.4	395.8
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*1%*	*0%*	*4%*	*0%*	*8%*	*0%*	*13%*	*0%*
Nuclear	11.8	11.9	11.9	14.9	11.9	26.8	18.9	34.7	18.9	46.0	26.8
Biomass and waste	5.7	24.7	8.6	25.9	13.8	27.1	21.4	30.1	19.5	39.9	19.3
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Hydro*	30.9	38.0	38.0	45.4	43.9	46.2	45.4	47.3	46.7	48.5	47.9
Geothermal	6.6	8.0	8.0	12.9	11.7	16.5	14.4	20.8	17.1	26.2	20.4
Wind	9.7	26.4	20.9	45.3	34.5	72.2	49.5	102.2	64.2	114.6	74.3
% Wind onshore	*100%*	*100%*	*100%*	*99%*	*100%*	*98%*	*100%*	*98%*	*100%*	*95%*	*98%*
Solar	0.7	2.2	2.2	23.1	14.6	57.4	32.5	101.8	44.8	145.9	55.8
% Solar PV	*97%*	*96%*	*97%*	*45%*	*50%*	*54%*	*56%*	*52%*	*46%*	*49%*	*41%*
United States											
Total	4 319.4	4 286.4	4 515.1	4 224.5	4 615.5	4 179.8	4 708.1	4 189.5	4 762.7	4 178.6	4 839.2
Oil	34.7	17.6	41.3	18.3	41.3	48.6	41.2	28.1	43.9	5.8	5.5
Coal	1 647.4	1 458.8	1 510.7	885.6	1 149.5	179.4	875.9	151.1	804.4	219.2	794.5
% Coal w/ CCS	*0%*	*0%*	*0%*	*4%*	*0%*	*58%*	*3%*	*100%*	*5%*	*100%*	*10%*
Natural gas	1 198.8	1 214.5	1 384.5	1 350.6	1 657.7	1 507.6	1 782.4	1 333.4	1 820.6	870.8	1 755.2
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*5%*	*2%*	*13%*	*4%*	*45%*	*4%*
Nuclear	821.2	819.2	819.2	839.6	839.6	888.1	868.4	828.9	804.2	916.0	884.9
Biomass and waste	81.9	92.2	89.9	114.0	102.4	148.2	115.2	185.4	128.1	222.4	139.9
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Hydro*	277.0	291.0	294.0	302.0	301.6	322.1	309.3	329.5	316.1	337.2	323.1
Geothermal	19.5	22.1	22.1	45.5	37.8	63.4	48.1	84.6	57.4	113.1	68.7
Wind	200.9	288.0	270.3	447.9	365.2	630.2	480.4	749.1	535.4	822.4	566.8
% Wind onshore	*100%*	*99%*	*99%*	*96%*	*99%*	*95%*	*98%*	*92%*	*97%*	*89%*	*95%*
Solar	34.9	83.1	83.1	220.4	119.6	390.3	185.0	493.2	249.1	653.7	295.7
% Solar PV	*91%*	*90%*	*90%*	*83%*	*89%*	*74%*	*85%*	*62%*	*78%*	*57%*	*78%*

*(excl. pumped storage) ** Values in TWh ***Ocean and Other technologies are not included

ANNEX 2 – ELECTRICTY CAPACITY

TABLE 1. GROWTH IN ELECTRICITY CAPACITY (GW) (SOURCE: AUTHORS, BASED ON ETP 2016, EC 2016)

Technology	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Brazil											
Total	144	32%	33%	44%	45%	56%	58%	70%	76%	82%	98%
Oil	9	14%	17%	-1%	7%	-23%	-15%	-38%	-30%	-86%	-57%
Coal	5	25%	29%	19%	25%	17%	32%	11%	36%	-18%	43%
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Natural gas	13	26%	34%	25%	35%	22%	30%	13%	86%	54%	188%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*8%*	*0%*	*11%*	*0%*
Nuclear	2	41%	41%	41%	41%	92%	69%	127%	72%	127%	72%
Biomass and waste	11	39%	33%	46%	33%	55%	32%	53%	35%	46%	38%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0.00%*
Hydro*	93	19%	19%	25%	26%	35%	38%	44%	47%	56%	57%
Geothermal	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wind	10	160%	160%	245%	236%	291%	287%	370%	362%	391%	395%
% Wind onshore	*100%*	*100%*	*100%*	*96%*	*100%*	*93%*	*100%*	*92%*	*99%*	*91%*	*99%*
Solar	1	239%	239%	627%	621%	1020%	997%	1493%	1416%	2111%	2237%
% Solar PV	*100%*	*100%*	*100%*	*100%*	*100%*	*98%*	*98%*	*97%*	*96%*	*91%*	*96%*
France											
Total	119	24%	25%	34%	28%	40%	29%	43%	24%	58%	40%
Oil	1.7	-39%	-100%	-66%	-62%	-75%	-58%	-83%	-78%	-96%	-92%
Coal	4	-51%	-49%	-98%	-98%	-100%	-100%	-100%	-100%	-100%	-100%
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Natural gas	9	-3%	11%	-16%	-7%	-59%	-59%	-76%	-68%	11%	112%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*5%*	*1%*	*11%*	*1%*	*11%*	*1%*
Nuclear	60	7%	-2%	4%	-5%	0%	-6%	0%	-8%	-14%	-29%
Biomass and waste	3	53%	49%	99%	103%	85%	87%	60%	78%	97%	135%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*1%*
Hydro*	21	-2%	0%	-5%	-6%	-1%	-8%	3%	-7%	11%	-1%
Geothermal	0.1	43%	62%	305%	124%	712%	269%	1404%	518%	2529%	849%
Wind	12	93%	100%	182%	128%	291%	182%	331%	174%	402%	232%
% Wind onshore	*91%*	*88%*	*88%*	*90%*	*88%*	*90%*	*87%*	*88%*	*86%*	*88%*	*85%*
Solar	8.4	180%	235%	237%	296%	224%	294%	229%	265%	303%	339%
% Solar PV	*98%*	*98%*	*98%*	*97%*	*97%*	*95%*	*97%*	*94%*	*94%*	*92%*	*93%*
Germany											
Total	193	21%	9%	24%	10%	17%	15%	4%	7%	9%	11%
Oil	6.0	-62%	-68%	-44%	-37%	-37%	4%	-34%	-14%	-56%	-19%
Coal	59	3%	6%	-5%	5%	-30%	3%	-66%	-31%	-87%	-48%
% Coal w/ CCS	*0%*	*1%*	*0%*	*3%*	*0%*	*7%*	*1%*	*14%*	*5%*	*43%*	*10%*
Natural gas	30	-5%	9%	6%	17%	8%	9%	6%	38%	-7%	78%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*5%*	*1%*	*11%*	*1%*	*11%*	*1%*
Nuclear	11	-50%	-54%	-100%	-100%	-100%	-100%	-100%	-100%	-100%	-100%
Biomass and waste	11	-12%	-14%	4%	5%	17%	19%	8%	20%	22%	46%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*1%*
Hydro*	7	35%	-1%	31%	-1%	25%	0%	19%	8%	44%	15%
Geothermal	0.1	229%	167%	465%	140%	465%	136%	486%	141%	840%	136%
Wind	35	90%	41%	126%	41%	134%	54%	138%	52%	180%	58%
% Wind onshore	*91%*	*88%*	*88%*	*90%*	*88%*	*90%*	*87%*	*88%*	*86%*	*88%*	*85%*
Solar	34	49%	27%	43%	29%	33%	44%	19%	32%	46%	35%
% Solar PV	*97%*	*98%*	*98%*	*97%*	*97%*	*95%*	*97%*	*94%*	*94%*	*92%*	*93%*

*(excl. pumped storage) ** Values in GW ***Ocean and Other technologies are not included

TABLE 1 (Cont.). GROWTH IN ELECTRICITY CAPACITY (GW) (SOURCE: AUTHORS. BASED ON ETP 2016. EC 2016)

Technology	2015	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Italy											
Total	126	2%	9%	-4%	2%	-5%	1%	-11%	-4%	-8%	11%
Oil	16	19%	1%	-14%	-4%	-39%	1%	-62%	-51%	-79%	-62%
Coal	10	44%	48%	-8%	1%	-23%	13%	-59%	-16%	-95%	-82%
% Coal w/ CCS	*0%*	*1%*	*0%*	*3%*	*0%*	*7%*	*1%*	*14%*	*5%*	*43%*	*10%*
Natural gas	52	-7%	7%	-25%	-17%	-29%	-29%	-44%	-27%	-41%	13%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*2%*	*0%*	*5%*	*1%*	*11%*	*1%*	*11%*	*1%*
Nuclear	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Biomass and waste	4	41%	37%	46%	48%	41%	43%	105%	129%	165%	216%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*1%*	*0%*	*1%*	*0%*	*2%*	*1%*
Hydro*	15.3	-5%	-3%	0%	-2%	5%	-3%	10%	0%	15%	3%
Geothermal	1	-1%	13%	84%	1%	120%	0%	148%	2%	177%	0%
Wind	7	-9%	-5%	97%	60%	174%	97%	211%	98%	244%	127%
% Wind onshore	*93%*	*88%*	*88%*	*90%*	*88%*	*90%*	*87%*	*88%*	*86%*	*88%*	*85%*
Solar	21.1	-10%	8%	8%	27%	7%	30%	15%	28%	25%	36%
% Solar PV	*97%*	*98%*	*98%*	*97%*	*97%*	*95%*	*97%*	*94%*	*94%*	*92%*	*93%*
Mexico											
Total	75	37%	28%	71%	52%	104%	92%	145%	112%	163%	112%
Oil	16	4%	0%	-1%	-6%	-30%	-35%	-47%	-51%	-62%	-67%
Coal	6	-8%	43%	-24%	43%	-85%	43%	-93%	34%	-94%	24%
% Coal w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*44%*	*0%*	*95%*	*0%*	*100%*	*0%*
Natural gas	31	36%	20%	66%	41%	76%	96%	73%	123%	34%	104%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*2%*	*0%*	*4%*	*0%*	*9%*	*0%*
Nuclear	2	0%	0%	28%	0%	133%	63%	203%	63%	303%	133%
Biomass and waste	1.3	184%	17%	197%	71%	213%	154%	248%	153%	360%	158%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Hydro*	14	46%	46%	46%	46%	46%	46%	45%	45%	45%	45%
Geothermal	1.0	34%	35%	102%	86%	152%	122%	208%	157%	277%	194%
Wind	3.8	171%	117%	364%	259%	634%	415%	936%	566%	1053%	663%
% Wind onshore	*100%*	*100%*	*100%*	*99%*	*100%*	*99%*	*100%*	*98%*	*100%*	*97%*	*99%*
Solar	0.5	193%	192%	2086%	1399%	5780%	3299%	10127%	4044%	14249%	4831%
% Solar PV	*99%*	*99%*	*99%*	*65%*	*66%*	*73%*	*73%*	*74%*	*67%*	*72%*	*63%*
United States											
Total	1 139	3%	4%	8%	2%	13%	5%	10%	7%	17%	11%
Oil	61	-8%	-3%	-38%	-37%	-61%	-63%	-78%	-81%	-84%	-67%
Coal	310	-11%	-8%	-37%	-31%	-61%	-48%	-82%	-58%	-82%	-61%
% Coal w/ CCS	*0%*	*0%*	*0%*	*3%*	*0%*	*13%*	*2%*	*41%*	*5%*	*57%*	*10%*
Natural gas	458	0%	2%	1%	4%	-3%	5%	-11%	9%	-21%	9%
% Natural Gas w/ CCS	*0%*	*0%*	*0%*	*1%*	*0%*	*3%*	*1%*	*6%*	*2%*	*15%*	*2%*
Nuclear	108	0%	0%	2%	2%	8%	6%	2%	-1%	14%	11%
Biomass and waste	18	12%	13%	22%	14%	43%	14%	67%	13%	110%	17%
% Biomass w/ CCS	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
Hydro*	82	5%	6%	10%	10%	18%	13%	21%	16%	24%	19%
Geothermal	4	24%	20%	89%	63%	150%	97%	223%	123%	335%	154%
Wind	72	47%	37%	132%	88%	228%	149%	290%	180%	329%	199%
% Wind onshore	*100%*	*100%*	*100%*	*97%*	*99%*	*96%*	*99%*	*95%*	*98%*	*93%*	*97%*
Solar	25	112%	112%	426%	197%	756%	345%	877%	458%	1132%	556%
% Solar PV	*93%*	*95%*	*95%*	*91%*	*94%*	*86%*	*91%*	*79%*	*88%*	*76%*	*88%*

*(excl. pumped storage) ** Values in GW ***Ocean and Other technologies are not included

ANNEX 3 – LEVELISED COST OF ELECTRICITY

TABLE 1. LEVELISED COST OF ELECTRICITY (LCOE) UNDER THE AMBITIOUS AND LIMITED CLIMATE TRANSITION SCENARIOS BY COUNTRY (SOURCE: AUTHORS, BASED ON NREL DATA)

Technology	2014	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Brazil											
Coal	76	73	77	71	77	70	77	68	77	67	77
Coal with CCS	102	95	95	92	91	89	87	86	85	83	82
Gas	95	76	103	75	97	77	96	73	96	68	95
Gas with CCS	74	60	80	59	75	60	74	56	75	52	74
Nuclear	82	81	81	81	81	80	80	79	79	79	79
Wind onshore 26% CF	79	63	76	55	76	53	76	51	76	50	76
Wind onshore 30% CF	61	49	59	43	59	40	59	39	59	39	59
Solar PV - 14% CF	127	70	122	54	122	46	122	42	122	37	122
Solar PV - 20% CF	89	49	85	38	85	32	85	29	85	26	85
France											
Coal	69	66	69	65	69	63	69	62	69	61	69
Coal with CCS	92	86	86	83	82	80	79	78	77	75	74
Gas	102	81	110	80	104	82	102	78	103	73	102
Gas with CCS	79	64	85	63	80	64	79	60	80	55	79
Nuclear	90	89	89	89	89	88	88	87	87	86	86
Wind onshore 26% CF	102	81	98	71	98	68	98	66	98	65	98
Wind onshore 30% CF	78	63	76	55	76	52	76	51	76	50	76
Solar PV - 14% CF	213	118	205	91	205	78	205	70	205	63	205
Solar PV - 20% CF	149	83	144	64	144	54	144	49	144	44	144
Germany											
Coal	69	66	69	65	69	63	69	62	69	61	69
Coal with CCS	92	86	91	83	92	80	92	78	92	75	92
Gas	107	85	115	84	109	87	107	82	108	76	107
Gas with CCS	83	67	89	66	84	67	83	63	84	58	83
Nuclear	90	89	89	89	89	88	88	87	87	86	86
Wind onshore 26% CF	137	109	132	95	132	91	132	89	132	87	132
Wind onshore 30% CF	105	84	102	74	102	70	102	68	102	67	102
Solar PV - 14% CF	202	112	194	86	194	73	194	66	194	59	194
Solar PV - 20% CF	141	78	136	60	136	51	136	46	136	42	136
Italy											
Coal	69	66	69	65	69	63	69	62	69	61	69
Coal with CCS	92	86	86	83	82	80	79	78	77	75	74
Gas	98	78	105	77	100	79	98	75	99	70	98
Gas with CCS	76	61	82	61	77	62	76	58	77	53	76
Nuclear	90	89	89	89	89	88	88	87	87	86	86
Wind onshore 26% CF	86	69	84	60	84	58	84	56	84	55	84
Wind onshore 30% CF	67	53	64	47	64	44	64	43	64	43	64
Solar PV - 14% CF	228	126	219	97	219	83	219	75	219	67	219
Solar PV - 20% CF	159	88	154	68	154	58	154	52	154	47	154
Mexico											
Coal	76	73	77	71	77	70	77	68	77	67	77
Coal with CCS	102	95	95	92	91	89	87	86	85	83	82
Gas	92	73	99	73	94	75	93	71	93	66	92
Gas with CCS	72	58	77	57	73	58	72	54	72	50	72
Nuclear	82	81	81	81	81	80	80	79	79	79	79
Wind onshore 26% CF	79	63	76	55	76	53	76	51	76	50	76
Wind onshore 30% CF	61	49	59	43	59	40	59	39	59	39	59
Solar PV - 14% CF	127	70	122	54	122	46	122	42	122	37	122
Solar PV - 20% CF	89	49	85	37	85	32	85	29	85	26	85

ANNEX 4 – SUBSIDIES IN POWER GENERATION

TABLE 1. SUBSIDIES IN POWER GENERATION UNDER THE AMBITIOUS AND LIMITED CLIMATE TRANSITION SCENARIOS BY COUNTRY (SOURCE: AUTHORS, BASED ON NREL DATA)

Technology	2014	2020		2025		2030		2035		2040	
		ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT	ACT	LCT
Brazil											
Nuclear	8	21	4	22	6	20	6	23	4	27	5
Wind onshore 26% CF	5	3	0	0	1	0	2	0	1	0	2
Wind onshore 30% CF	0	0	0	0	0	0	0	0	0	0	0
Solar PV - 14% CF	53	10	45	0	47	0	48	0	47	0	48
Solar PV - 20% CF	15	0	8	0	10	0	11	0	10	0	11
France											
Nuclear	21	25	20	26	20	25	19	27	18	31	17
Wind onshore 26% CF	33	17	29	8	29	5	29	6	29	10	29
Wind onshore 30% CF	9	0	7	0	7	0	7	0	7	0	7
Solar PV - 14% CF	144	54	136	28	136	15	136	10	136	8	136
Solar PV - 20% CF	80	19	75	1	75	0	75	0	75	0	75
Germany											
Nuclear	21	23	20	24	20	25	19	25	18	28	17
Wind onshore 26% CF	68	43	63	30	63	28	63	27	63	29	63
Wind onshore 30% CF	36	18	33	9	33	7	33	6	33	9	33
Solar PV - 14% CF	133	46	125	21	125	10	125	4	125	1	125
Solar PV - 20% CF	72	12	67	0	67	0	67	0	67	0	67
Italy											
Nuclear	21	28	20	28	20	26	19	29	18	33	17
Wind onshore 26% CF	17	8	15	0	15	0	15	0	15	2	15
Wind onshore 30% CF	0	0	0	0	0	0	0	0	0	0	0
Solar PV - 14% CF	159	65	150	36	150	21	150	17	150	14	150
Solar PV - 20% CF	90	27	85	7	85	0	85	0	85	0	85
Mexico											
Nuclear	10	23	4	24	8	22	8	25	7	29	7
Wind onshore 26% CF	7	5	0	0	3	0	4	0	4	0	4
Wind onshore 30% CF	0	0	0	0	0	0	0	0	0	0	0
Solar PV - 14% CF	55	12	45	0	49	0	50	0	50	0	50
Solar PV - 20% CF	17	0	8	0	12	0	13	0	13	0	13

MEET THE BUILDERS - ET RISK CONSORTIUM

The ET Risk consortium, funded by the European Commission, is working to develop the key analytical building blocks (Fig. 0.1) needed for Energy Transition risk assessment and bring them to market over the coming two years.

ENERGY TRANSITION
RISKS & OPPORTUNITIES

1. TRANSITION SCENARIOS

The consortium will develop and publicly release two transition risk scenarios, the first representing a 'soft' transition extending current and planned policies and technological trends (e.g. an IEA NPS trajectory), and the second representing an ambitious scenario that expands on the data from the IEA 450S /2DS, the project's asset level data work (see Number 2), and relevant third-party literature. The project will also explore more accelerated decarbonization scenarios.

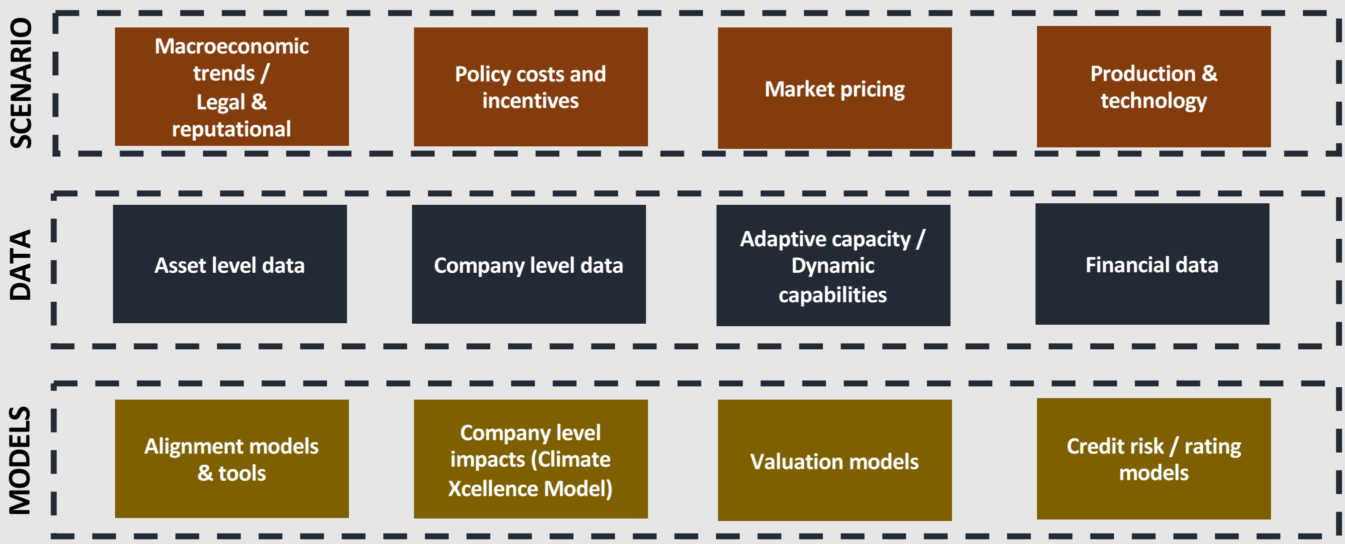
2. COMPANY & FINANCIAL DATA

Oxford Smith School and 2° Investing Initiative will jointly consolidate and analyze asset level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, shipping), including an assessment of committed emissions and the ability to potentially 'unlock' such emissions (e.g. reducing load factors).

3. VALUATION AND RISK MODELS

a) **2°C portfolio assessment – 2° Investing Initiative.** 2° Investing Initiative will seek to integrate the project results into their 2°C alignment model and portfolio tool and analytics developed as part of the SEI metrics project.
b) **ClimateXcellence Model – The CO-Firm**. This company risk model comprises detailed modeling steps to assess how risk factors impact margins and capital expenditure viability at the company level.
c) **Valuation models – Kepler Cheuvreux.** The above impact on climate- and energy-related changes to company margins and cash flows can be used to feed discounted cash flow and other valuation models of financial analysts. Kepler Cheuvreux will pilot this application as part of their equity research.
d) **Credit risk rating models – S&P Global.** The results of the project will be used by S&P Global to determine if there is a material impact on a company's creditworthiness. S&P Dow Jones Indices, a S&P Global Division, will explore the potential for developing indices integrating transition risk.

FIG. 0.0: ASSESSING TRANSITION RISK ACROSS THE INVESTMENT CHAIN (SOURCE: AUTHORS)



ABOUT 2° INVESTING INITIATIVE

The 2° Investing Initiative [2° ii] is a multi-stakeholder think tank working to align the financial sector with 2° C climate goals. Our research work seeks to align investment processes of financial institutions with climate goals; develop the metrics and tools to measure the climate friendliness of financial institutions; and mobilize regulatory and policy incentives to shift capital to energy transition financing. The association was founded in 2012 and has offices in Paris, London, Berlin, and New York City.

ABOUT THE CO-FIRM

The CO-Firm GmbH is a boutique consultancy specialized in developing climate and energy strategies for financial services providers, industry, and utilities. Based on financial risk modelling under a range of climate and energy scenarios, the proprietary ClimateXcellence Toolset, and a dataset of more than 200.000 assets and more than 15.000 different technical mitigation measures, The CO-Firm supports its clients in identifying, evaluating and realizing their specific economic opportunities in the national and global climate transition. Specifically, the CO-Firm serves its clients in adjusting their strategies, setting Science Based Targets, creating new business models, and identifying cost savings in their operations and their supply chain. Additionally, the consultancy provides regulatory monitoring services.

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