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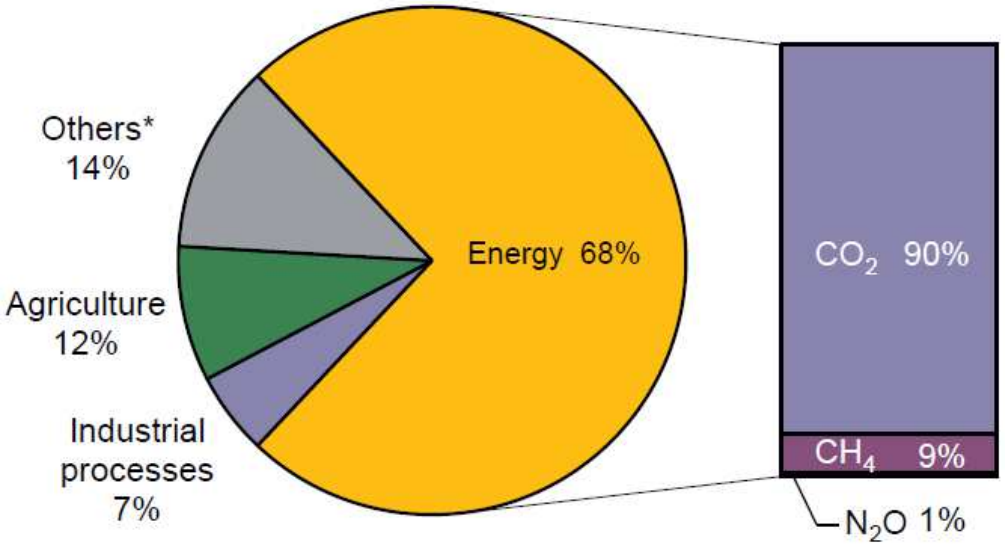
6/7/2018

Energy for a low carbon society

Energy use is the main responsible of climate change

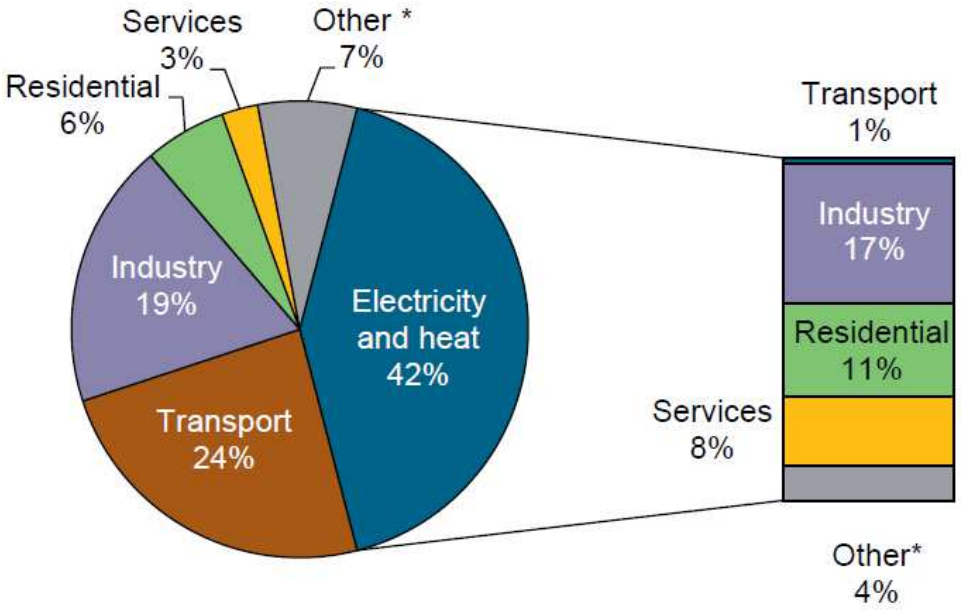
Estimated shares of global Anthropogenic GHG emissions, 2014



* Others include large-scale biomass burning, post-burn decay, peat decay, indirect N_2O emissions from non-agricultural emissions of NO_x and NH_3, Waste, and Solvent Use.

Source: based on IEA estimates for CO_2 from fuel combustion and EDGAR 4.3.0 and 4.3.2 for non-fuel combustion CO_2 and 4.2 FT2010 for all other sources; for 2010; based on 100-year Global Warming Potential (GWP).

World CO_2 emissions from fuel combustion for sector, 2015



Note: Also shows allocation of electricity and heat to end-use sectors.

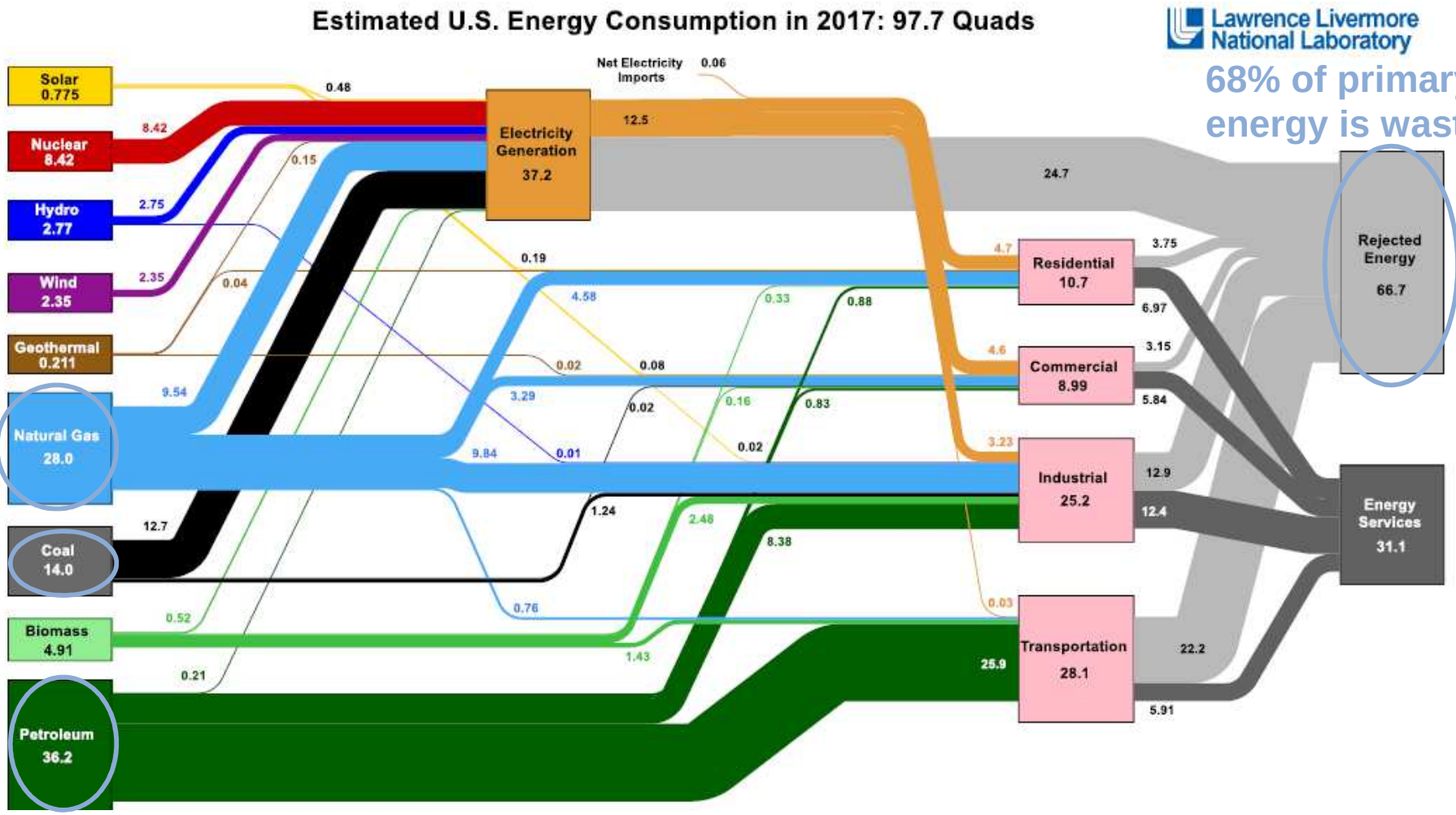
* Other includes agriculture/forestry, fishing, energy industries other than electricity and heat generation, and other emissions not specified elsewhere.

The use of energy represents by far the largest source of human-related GHG emissions. Electricity, heat an transport produce two thirds of total energy CO_2 emissions

Fuel combustion creates besides air quality problems

Source: IEA, CO_2 emissions from fuel combustion – Highlights, 2017

US - An example of how we produce and consume energy



68% of primary energy is wasted…

…almost all of it (80%) from fossil fuels

Emissions of Electricity Supply Technologies and Transportation modes

The way to produce or consume energy affects heavily GHG emissions

TECHNOLOGY (1)	VARIABLE grCO2/kWh	LIFE-CYCLE grCO2/kWh
COAL	760	820
CCGT	370	490
PV	0	44
GEOTHERMAL	0	38
CSP	0	27
HYDRO	0	24
NUCLEAR	0	12
WIND	0	11

Mode (2)	# PASSENGERS	grCO2/ PASSENGER - KM
WALK	1	0
BICYCLE	1	0
ELECTRIC TRAIN	156	14
BUS	12,7	68
MOTORBIKE	1,2	72
CAR	1,5	104
VAN	1,5	158
PLANE	88	285

(1) Source: Schlömer S., T. Bruckner, L. Fulton, E. Hertwich, A. McKinnon, D. Perczyk, J. Roy, R. Schaeffer, R. Sims, P. Smith, and R. Wiser, 2014: Annex III: Technology-specific cost and performance parameters. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

(2) EEA

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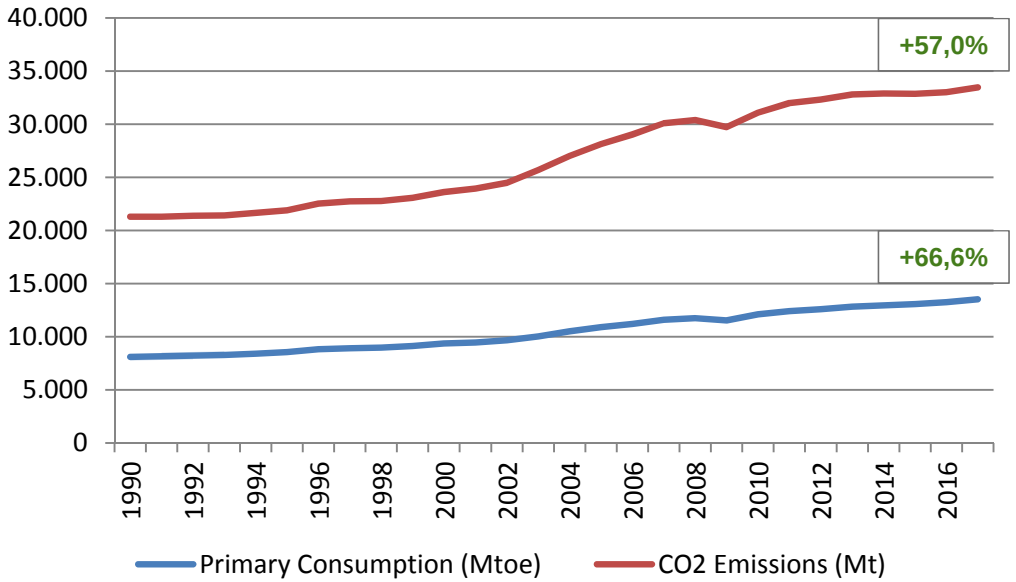
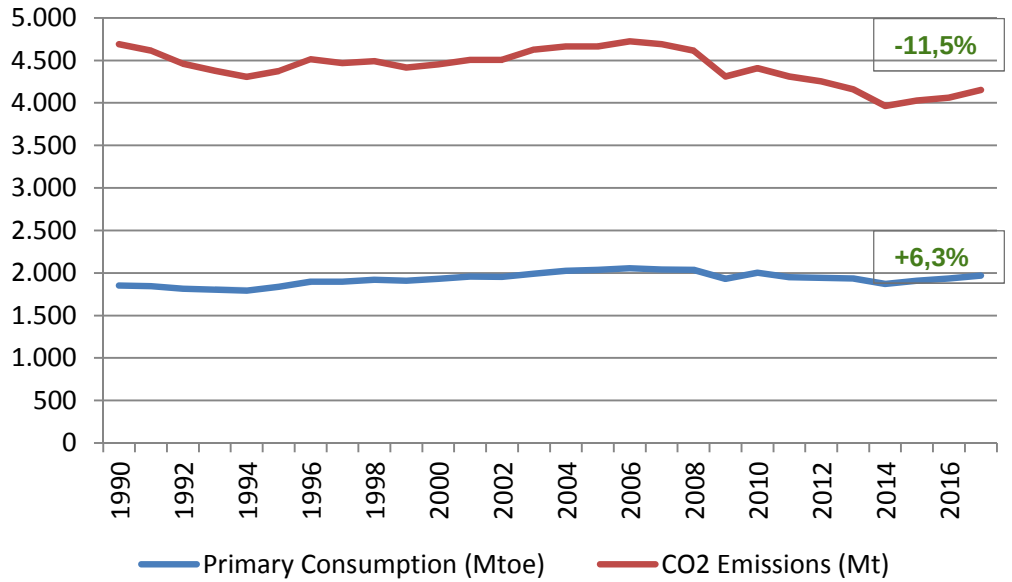
Current Primary Energy Consumption and Emissions

WORLD*



EUROPE*



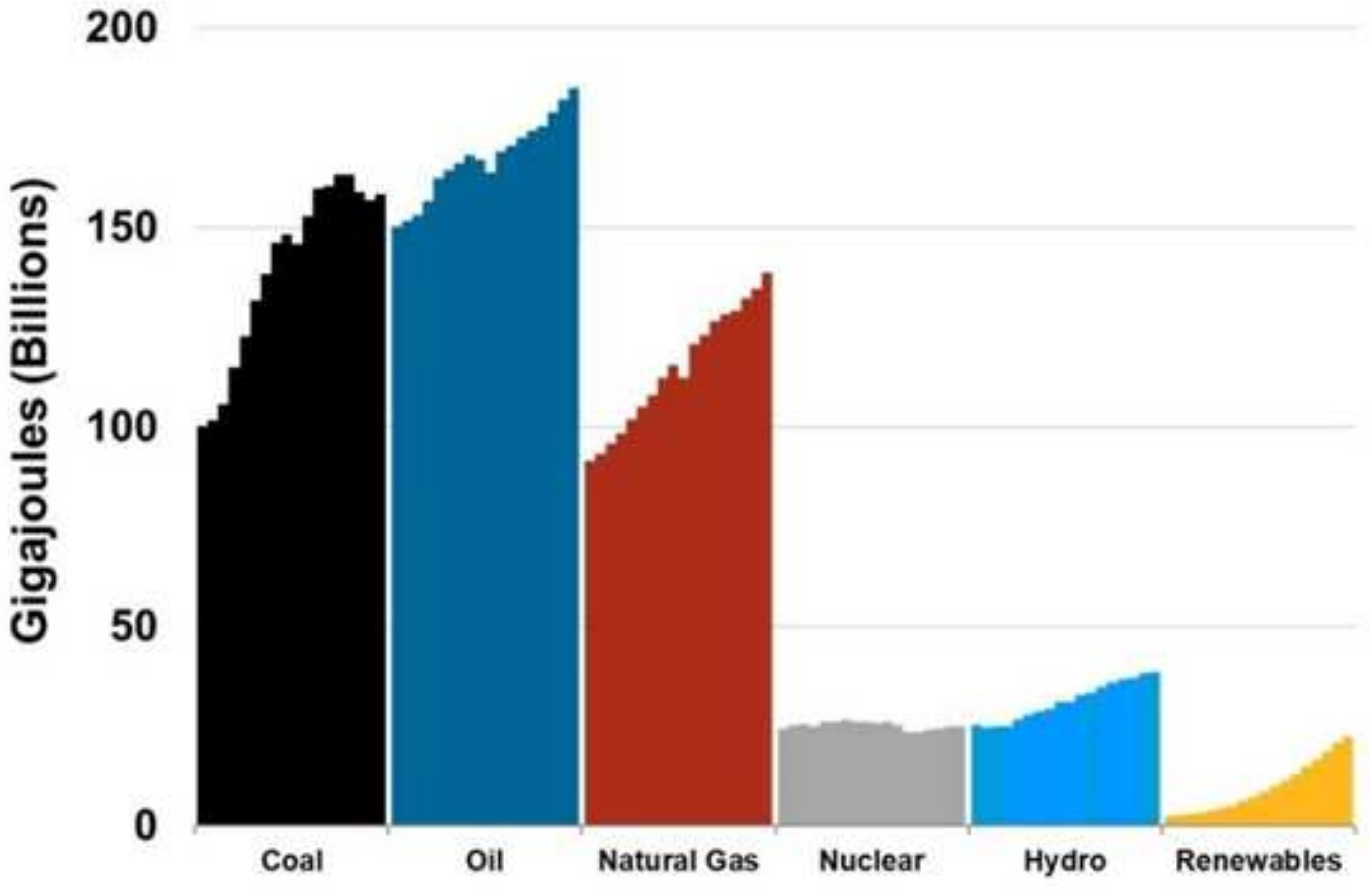
Share of fossil fuels stable around 81% (**)

YEAR	2000	2016
PC FOSSIL FUELS (**)	79,5%	72,8%

(*) BP Statistical Review of World Energy June 2018
(**) IEA

Evolution of Primary Energy Consumption

Figure 1: Global Consumption of Primary Energy Sources
Annual; 2000 to 2017e



Source: BP Statistical Review (2000 – 2016), International Energy Agency (2017 estimate)

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An example of energy transition - EU policy framework on energy and climate

		2020	2030	2050
GHG emissions (1)	Non ETS(2)	**-10%** with regard to 2005 Binding national targets	**-30%** with regard to 2005 Binding national targets	**-80% / -95%** with regard to 1990
	ETS(3)	**-21%** with regard to 2005	**-43%** with regard to 2005	
Renewable Energy		**20%** RES on final energy consumption overall and 10% on transport Binding national targets	**32%** (4) RES on final energy consumption 14% on transport	**N/A**
Energy Efficiency		**20%** improvement compared to the BAU scenario (2007)	**32,5%**(4) improvement compared to the BAU scenario (2007)	
Transport		**Standards for new vehicles**	**Lower Standards for new vehicles (95 grCO2/km since 2021)**	**-60%** with regard to 1990

EU climate policy framework will allow a deep decarbonisation of the energy model

Individual MS might increase ambition (e.g. the UK with its Carbon floor or Sweden, first country to commit to total decarbonisation in 2045)

(1) Emissions related to air and sea international transport routes are not included.
(2) Emissions from transportation, building, food industry, waste and agriculture sector, and other non-energy uses are included
(3) Emissions from power generation, solid transformation, oil refining, industry (except food sector) and other non-energy uses are included
(4) Agreements at trialogue still to be confirmed by Council and Parliament

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Many organisations are publishing energy outlooks

TYPE	ORGANISATION AND NAME OF THE SCENARIO
OIL COMPANIES	• BP (*2018 BP Energy Outlook)* • SHELL (*Sky Scenario. Meeting the Goals of the Paris Agreement)* • EXXONMOBIL *(Outlook for Energy: A view to 2040)*
ENERGY AGENCIES	• IEA *(WEOs)* • EIA *(International Energy Outlook)* • IRENA *(Global Energy Transformation)*
EUROPEAN COMMISSION	• *Energy Roadmap 2050, Reference Scenarios* • *Eucos*
CONSULTANCIES	• ENERDATA *(EnerOutlook)* • DNV-GL *(Energy Transition Outlook 2017)* • BNEF (*NEO*)
TSOs	• ENTSO-e & ENTSOG *(TYNDP 2018)*
ASSOCIATIONS or NGOs	• ECF *(Roadmap 2050 – Power) – (Energy 2050)* • IEEJ *(Outlook 2018. Prospects and challenges until 2050)* • WEC *(World Energy Scenarios – The Grand Transition)*

Some results from ambitious scenarios in 2040

CONCEPT	VALUES IN 2016 (*)	RANGE 2040 (*)
ENERGY EMISSIONS	31,7 Gt	15 – 22 Gt
FINAL ENERGY CONSUMPTION	9.250 Mtoe	8.598 – 10.270 Mtoe
FOSSIL FUEL SHARE PRIMARY ENERGY MIX	82,3%	43 – 63%
DEGREE OF ELECTRIFICATION	19%	27 - 33%
ELECTRIC VEHICLES	3m (2017)	875 – 1.400 m
CCS (fossil fuels equipped plants)	0	0 – 10%

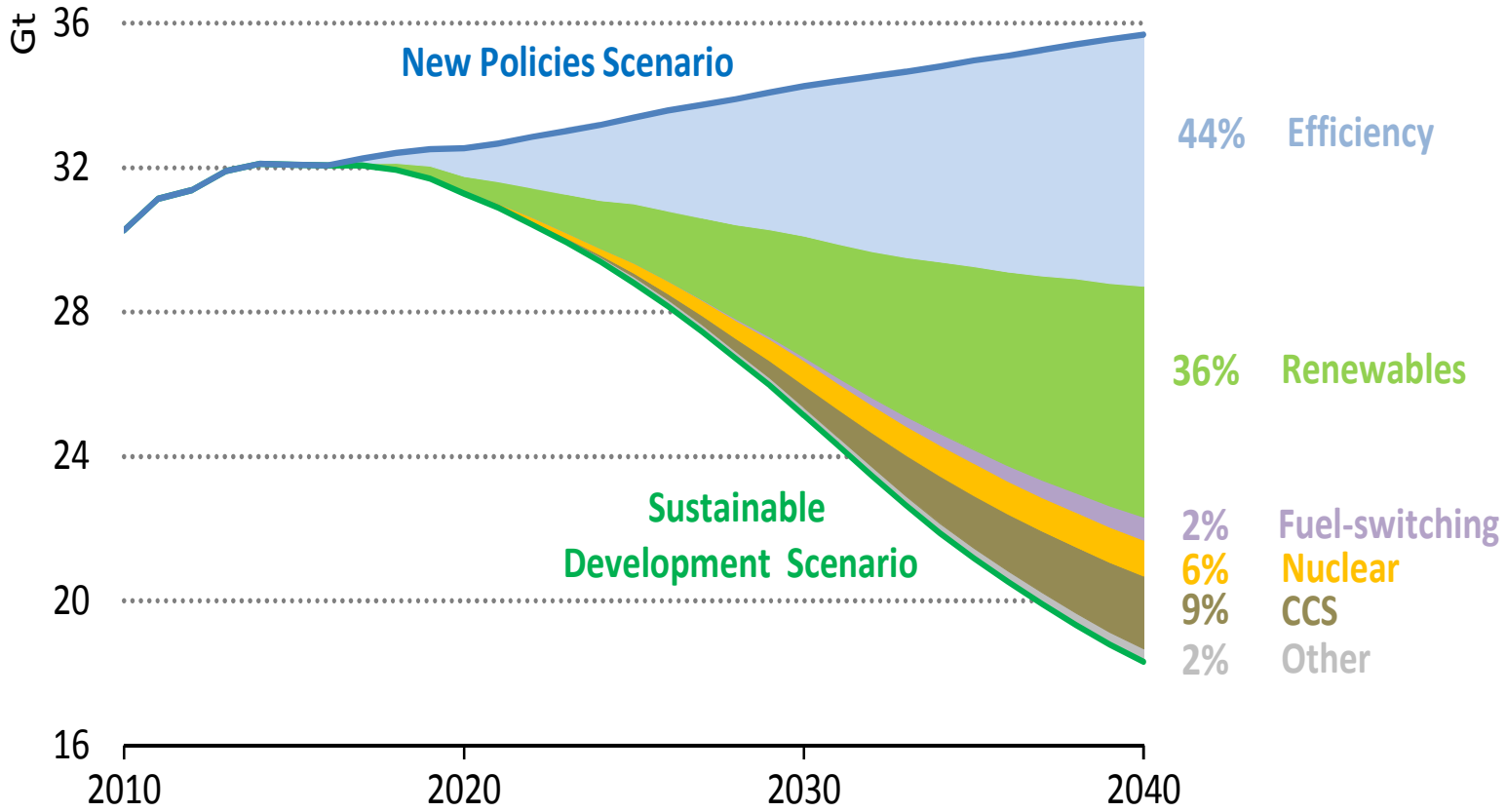
(*) Average or range values from scenarios of IEA (SDS), IRENA and DNV-GL

Policy is key. Technology and other factors can also help

Policies

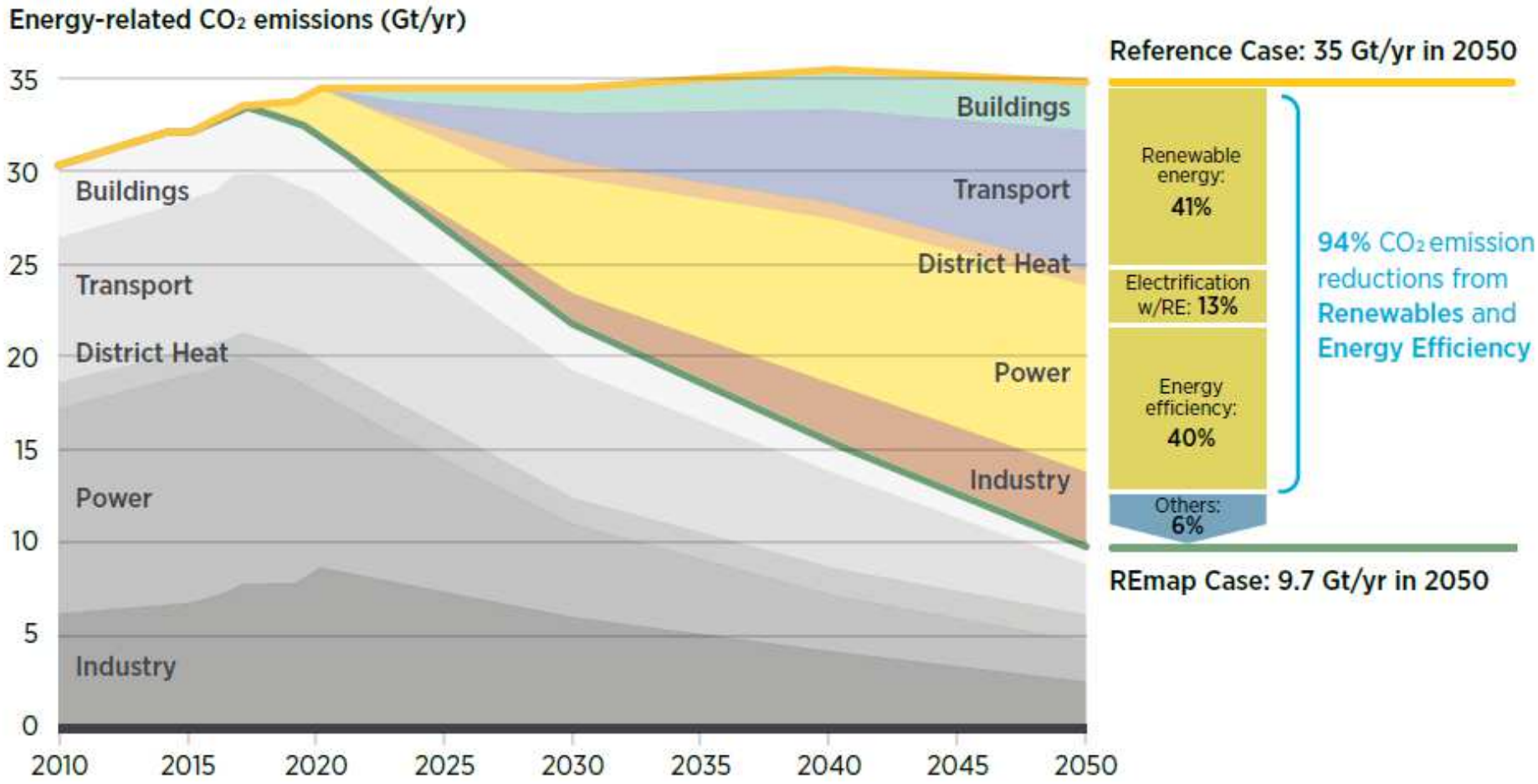
Horizontal Policies	• *Energy taxation must contribute to decarbonisation, phasing out fossil fuel subsidies, including carbon prices or taxes reflecting environmental costs and removing artificial overcosts in low carbon energy sources*
Energy Efficiency	• *Barriers to energy efficiency shall be removed so that cost-efficient measures can take place.*
Decarbonise the electricity sector	• *Electricity sector can easily integrate production from different energy sources, including low carbon ones, like VRES.* • *Storage and other flexible sources can be required in systems with large quotas of VRES*
Electrify transport and H&C	• *Transport and heat & cooling sectors can be decarbonised through electrification that will also contribute to improve air quality*
Technology	• *Costs reductions are taking place in technologies that are key to decarbonisation, like RES (in particular PV) and batteries. Decarbonisation will be cheaper than initially thought.*
Financial Sector	• *Financial sector is requiring higher transparency, disinvesting in fossil fuel sectors and investing in low carbon energy companies*
Cities - Alliances	• *Cities and alliances are taking decisions like imposing clean energy use in cities or phasing out the use of coal in electricity production.*

Global CO_2 emissions reductions in the New Policies and Sustainable Development Scenarios

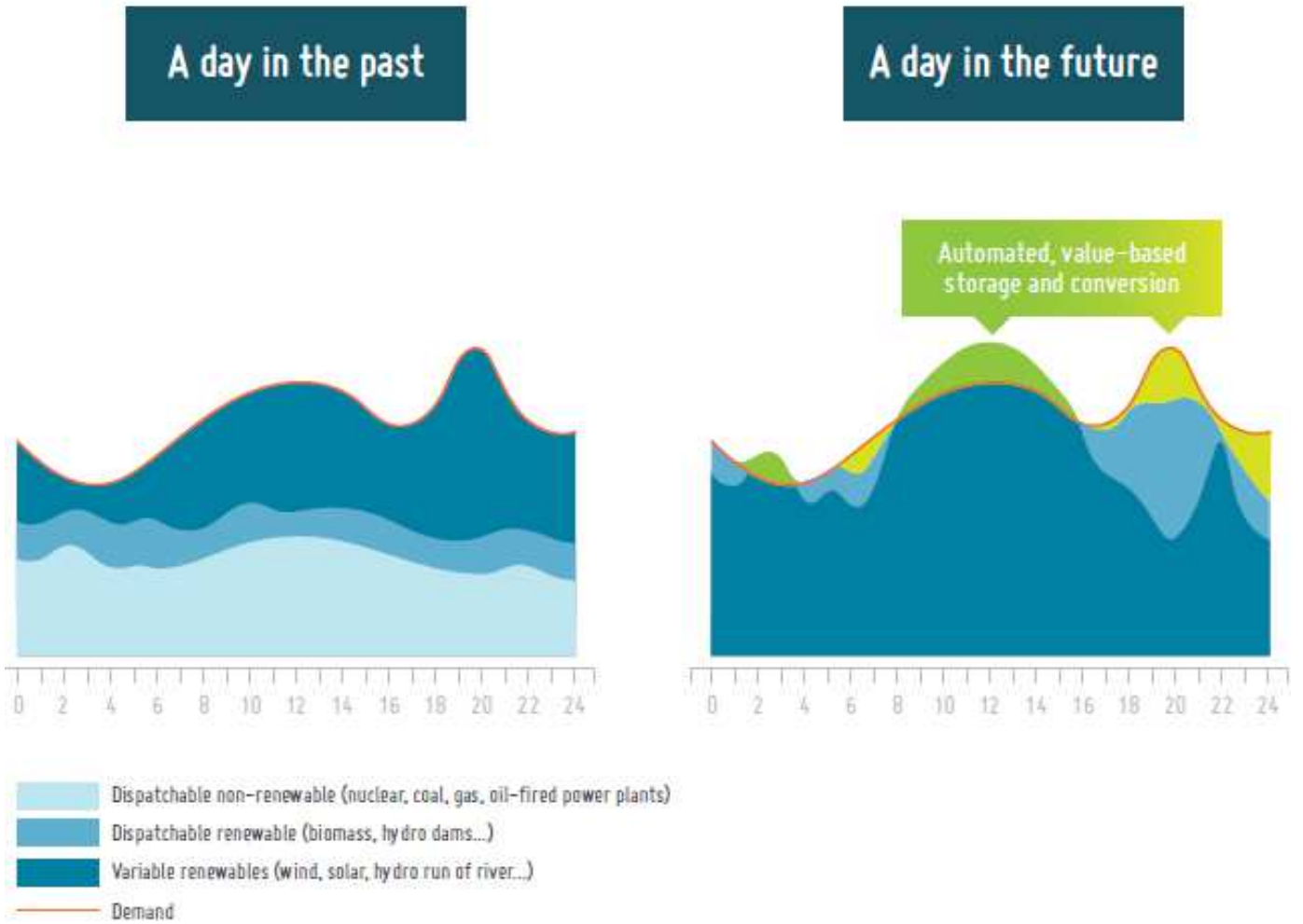


Energy efficiency and renewables account for 80% of the cumulative CO_2 emissions savings in the Sustainable Development Scenario

Annual energy-related CO_2 emissions and reductions in the Reference and the Remap cases



Storage and flexible renewables are essential to follow future load curve



Source: ETIP – SNET Vision 2050

RES technologies are increasingly competitive

RES auctions records since 2011

Solar PV

2011	US$ **17,0** c/kwh	Spain
2015	US$ **5,84** c/kwh	UAE
2016	US$ **2,99** c/kwh	UAE
2017	US$ **2,69** c/kwh	Mexico
2018	US$ **1,97** c/kwh	Mexico

- 88%

Wind Onshore

2011	US$ **8,00** c/kwh	USA.
2015	US$ **6,00** c/kwh	Australia
2016	US$ **4,50** c/kwh	USA.
2017	US$ **3,00** c/kwh	Morocco
2018	US$ **1,77** c/kwh	Mexico

- 78%

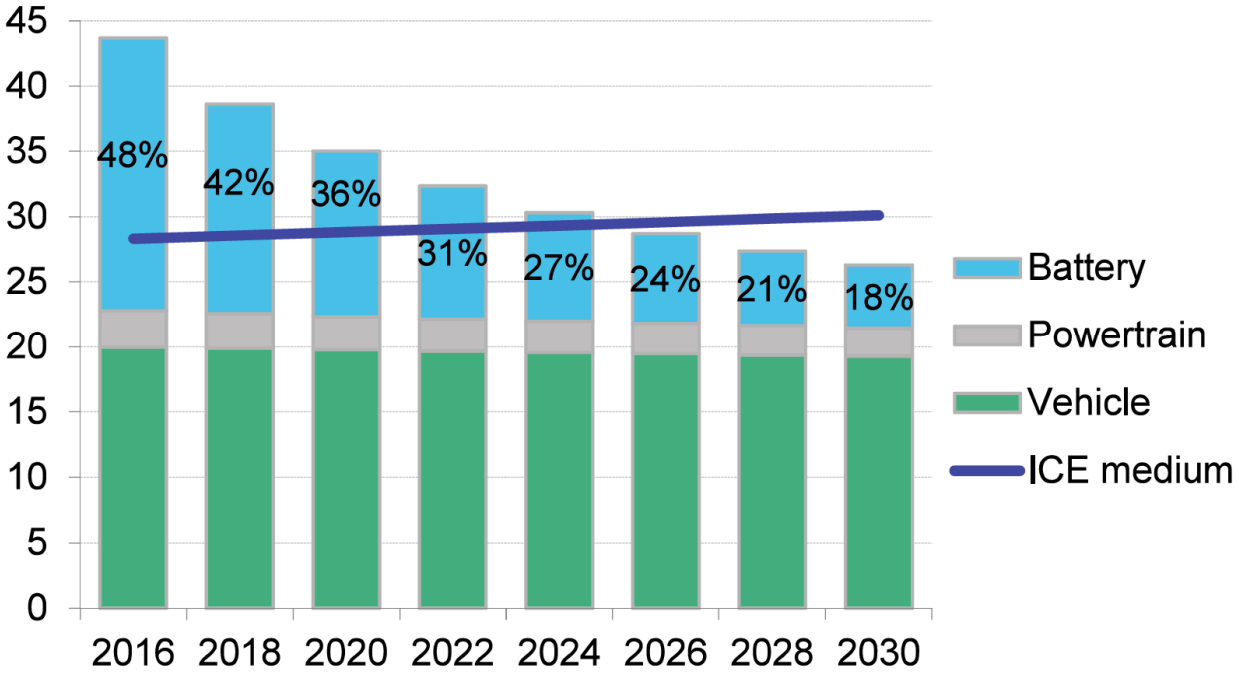
Wind Offshore

2011	US$ **17,0** c/kwh	U.K.
2015	US$ **12,3** c/kwh	Denmark
2016	US$ **5,30** c/kwh	Denmark
2017	US$ **4,90** c/kwh	Germany
2018	US$ **4,90** c/kwh	Germany

- 71%

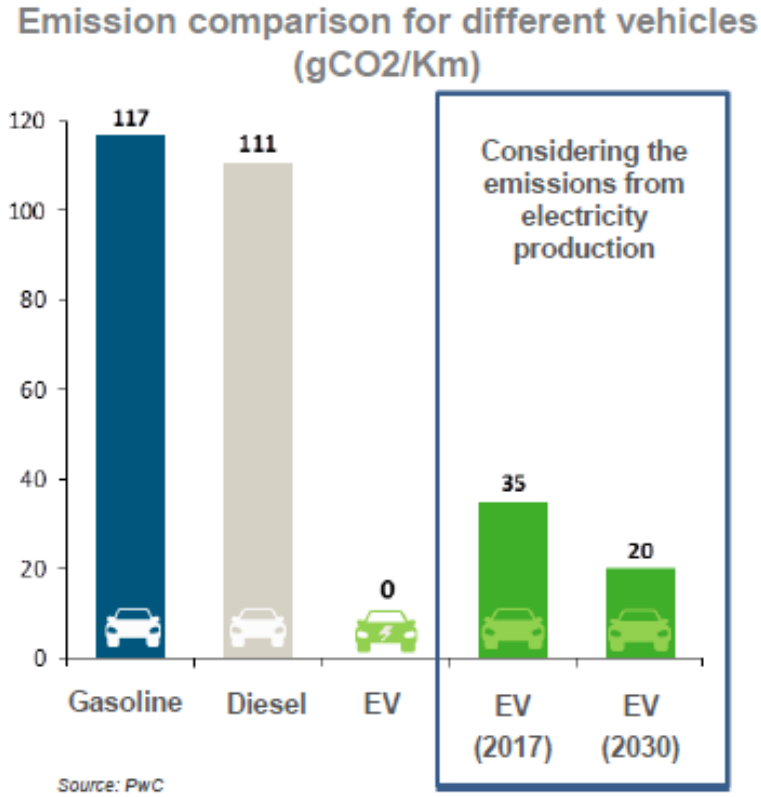
Electric vehicles are becoming cheaper and cleaner as electricity is decarbonising

US medium BEV price breakdown, ICE price and share of battery costs, 2016-2030 (thousand 2016 $ and %)



Source: Bloomberg New Energy Finance Note: Estimated pre-tax retail prices

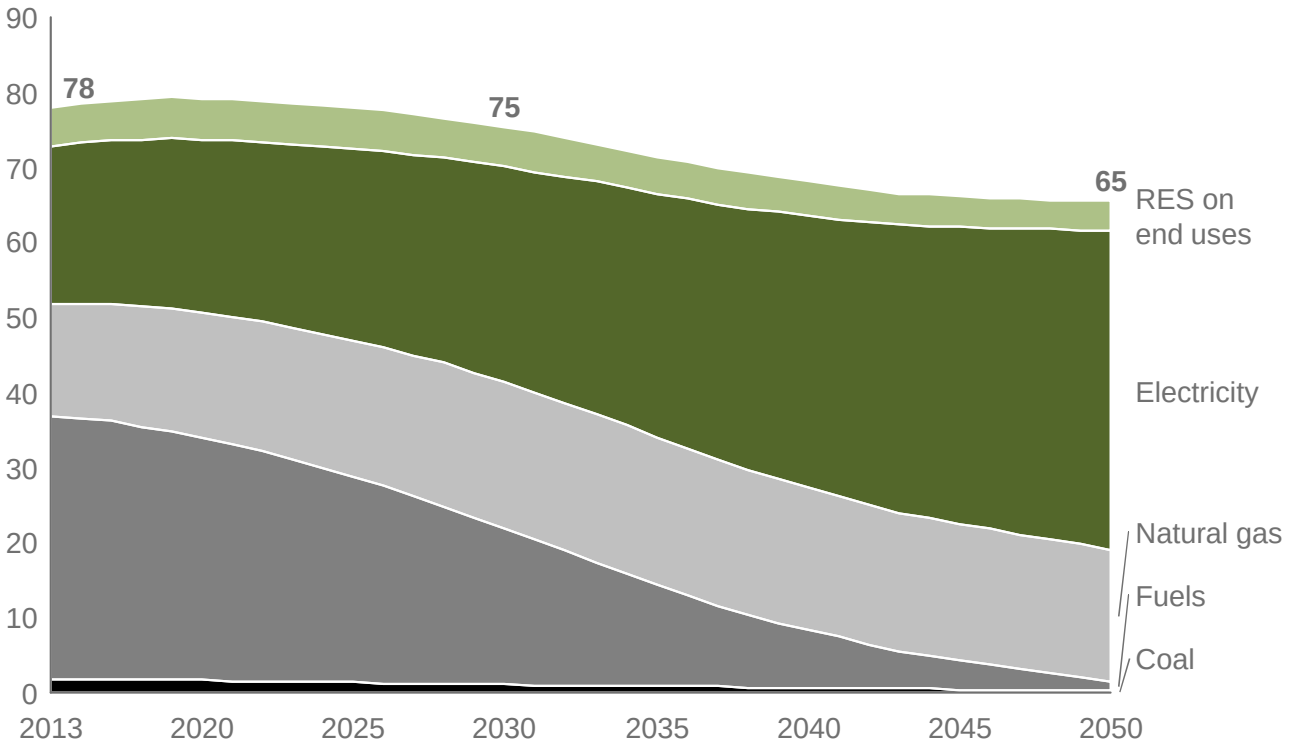
Emission comparison in the case of Spain



An increasing role of electricity in the energy mix is key to meet long term climate goals

Final energy consumption[(1)] by energy source in a "Sustainable Scenario" that meets EU goals
(Mtoe)

Emissions ($MtCO_2$)	**~322**	**~310**	**~250**	**~88**
Fulfilment of EU goals		✓		✓

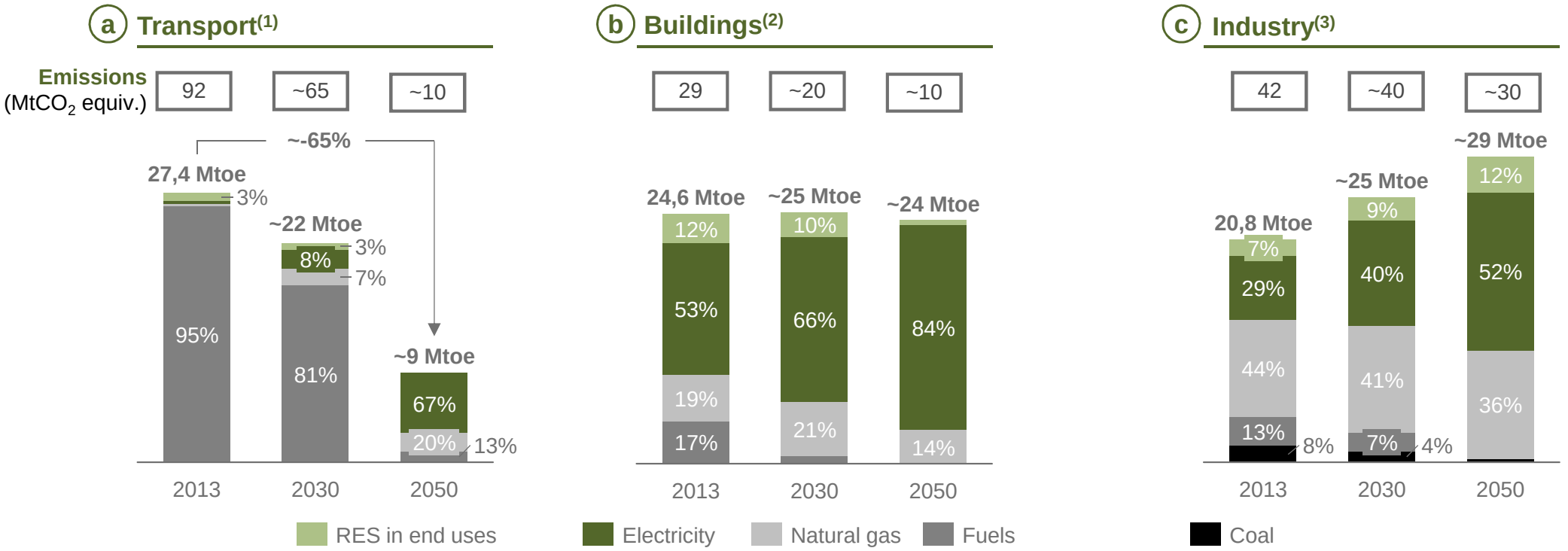


- Reduce **energy consumption**
- Phase out **oil and coal**
- Maintain **gas** as a transition energy source wherever electrification is not feasible
- Reach high penetration of **renewables**, through the **electricity** sector

(1) Emissions from energy consumption of international air and sea transport routes or other non-energy uses not included
Source: Own development based on IDAE, MAGRAMA, and EC

Electrification of transport & buildings is key to meet climate goals in a cost effective way

Breakdown of final energy consumption by sector
(Mtoe)



- **Electrification ~100%** of **light vehicle fleet** and increase of **rail and electric trucks** in freight transport (~85%) by 2050

- **Electrification of Heating & Cooling in Buildings** (important role of Heat Pumps)

- **Different penetration depending on the characteristics of each industry**

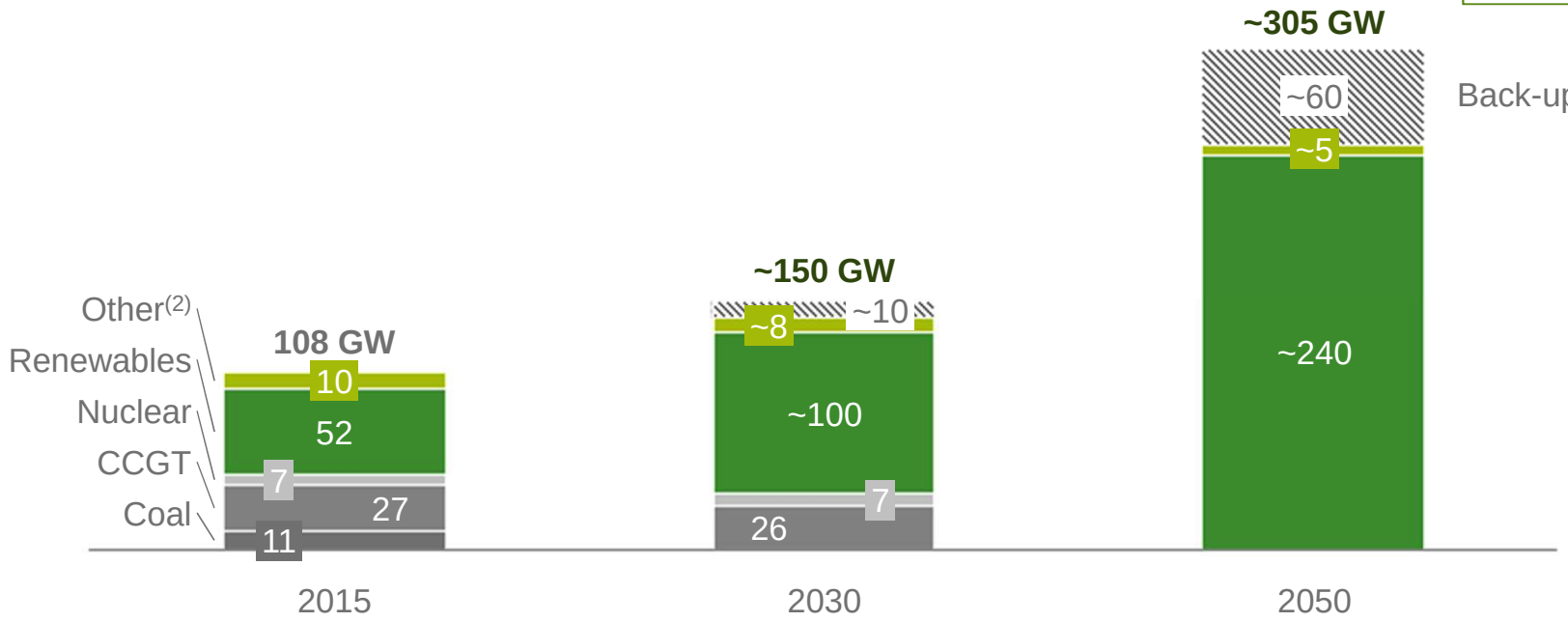
(1) Road light duty transport (17,9 Mtoe in 2013), road truck transport (7,2 Mtoe in 2013) and other transport systems are included. Air and sea international transport routes are not included. Emissions form oil refining are included
(2) Residential (15,0 Mtoe in 2013) and service sector (10,0 Mtoe in 2013)
(3) Final energy consumption associated to industry sector contribution to GDP growth. Efficiency gains from energy vector switching are not considered
Source: Own development based on IDEA data

Electricity shall be based on clean energies

Electricity mix in Spain
(GW)

	2015	2030	2050
Gross demand (TWh)	263	~370	~540
Emissions(1) ($MtCO_2$ equiv.)	58	~45	~5

Corresponds to the least favourable case where back-up is provided by natural gas turbines



(1) Emissions from CHP not included
(2) Including fuelgas, CHP and other
(3) Back-up technology subject to technology development. Data shown correspond to the situation where this back-up is provided by gas turbines. Interconnections do not provide back-up.

Source: IDAE, REE, own development

Electricity generation will double in 2050 and will come mainly from renewable sources

- **Energy use is the main contributor of GHG. Current energy model is not sustainable and should be transformed**
- **Scenarios show that a decarbonisation of the energy sector is possible, based on energy efficiency, renewables and electrification of transport and heat & cooling. Action is urgently needed**
- **Policy and technology are key. Other factors like the role of the financial sector, cities and alliances can help in this transformation**
- **Modelling, reporting and interchange of experiences in energy transition can help countries, cities and citizens achieve decarbonisation in an effective and efficient way**

Thank you for your attention