ENERGY TRANSFORMATION
REST OF EUROPE

Regional analysis covers:

- Albania
- Andorra
- Belarus
- Bosnia and Herzegovina
- Iceland
- Liechtenstein
- Monaco
- Montenegro
- Norway
- Republic of Moldova
- Russian Federation
- Serbia
- Switzerland
- North Macedonia
- Ukraine

STATUS/CHARACTERISTICS AND NEEDS:

Population (millions)

Current: **3% of global population,** mainly in the Russian Federation (61%) and Ukraine (19%).

2050 outlook: Average **0.3% per year decrease** to **208 million**, or 2.2% of global population.

IRENA analysis based on E3ME.

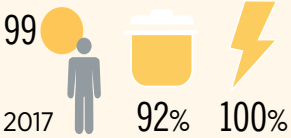
GDP per capita (thousand USD 2015)

Current: **Above the global average** (10.9).

2050 outlook: **Slight development;**
▶ **PES:** CAGR = 1.5%

IRENA analysis based on E3ME.

Energy consumption (GJ/capita) and **energy access** (%)



Energy consumption per capita:

Current: well above the global average (51 GJ/year).

Electricity access:

The region has **long achieved full electrification.**

Clean cooking access:

8% lacks; marginal use of inefficient biomass stoves for cooking and home heating continues, mainly in rural areas.

Source: Access to electricity, 2017 values (World Bank Group, 2019a), access to clean cooking, 2016 values (World Bank Group, 2019b), TFEC, 2017 values (IEA, 2019), 2050 values based on IRENA analysis.

Fossil fuel net import

Current status: **Net fossil-fuel exporter, mainly due to the Russian Federation,** the world's largest oil and gas exporter, covering almost 6% of energy consumption in the rest of the world (2018).

2050 outlook: **Vast untapped renewable potential.**

▶ **PES:** The total generation (est. 1997 TWh) represents **7%** of overall renewable power potential.

Source: IRENA analysis based on proportion of net imports of fossil fuels in TPES, 2017 values (IEA, 2019). 2050 outlook, IRENA analysis and potential based on Deng *et al.* (2015).

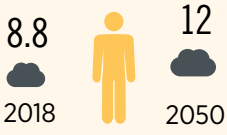
Energy-intensive industries (% in global consumption)

Current status: Accounts for over **11% of global energy demand for iron and steel,** around **8% for chemical and petrochemical industries** and **7% for food and tobacco**.

2050 outlook: Need for alternative emission-free technological solutions.

Note: Current status, IRENA analysis based on 2017 values (IEA, 2019).

Energy-related CO_2 emissions per capita (tCO_2/capita)



Recent: **Region's annual emissions: 2.1 Gt** (2018). 6% of global energy-related emissions.

2050 outlook: ▶ **PES: 7% increase to 2.3 Gt** based on current policies.

Note: 2050 values based on IRENA analysis and historical data based on Global Carbon Atlas (2019).

Urban air quality (%)

28%
Good

123 Cities

Good Moderate Unhealthy

Air pollution is problematic for some countries, such as in Southeast Europe, which have high levels of PM 2.5 compared to Norway and Switzerland that have better air quality.

IRENA analysis based on PM 2.5 concentration, 2016 and 2017 values (WHO, 2019).

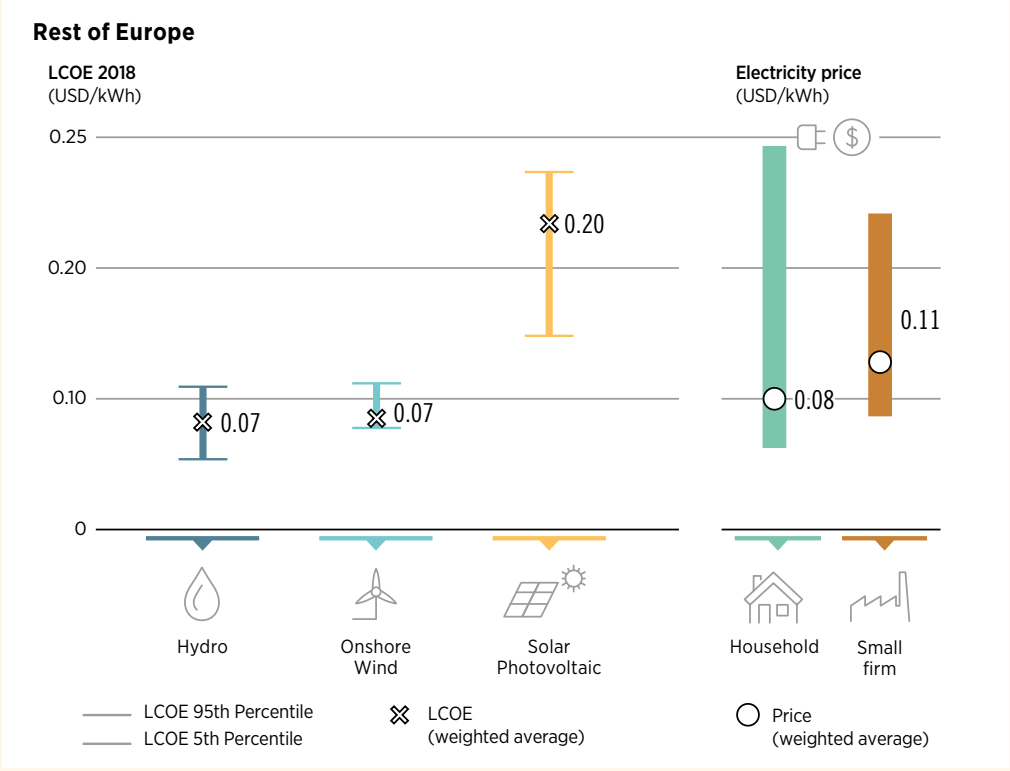
Electricity prices and renewables costs

Electricity price:

Among the lowest in the world, only in MENA is lower. Similar to Rest of Asia.

Renewables cost and auctions:

Average prices for historical projects are around USD 0.08/kWh and USD 0.05/kWh for solar and wind, respectively.



LCOE based on IRENA (2019a) and electricity prices based on Global Petrol Prices (2019).
Note: The LCOE data is for projects commissioned in 2018. Real weighted average cost of capital (WACC) is 7.5% for OECD countries and China and 10% for the rest of the world.

ENERGY TRANSFORMATION: KEY BENEFITS

1

SUSTAINABLE DEVELOPMENT

- Affordable energy for citizens
- Economic growth and competitiveness
- Increase in energy sector jobs
- Improved welfare

2

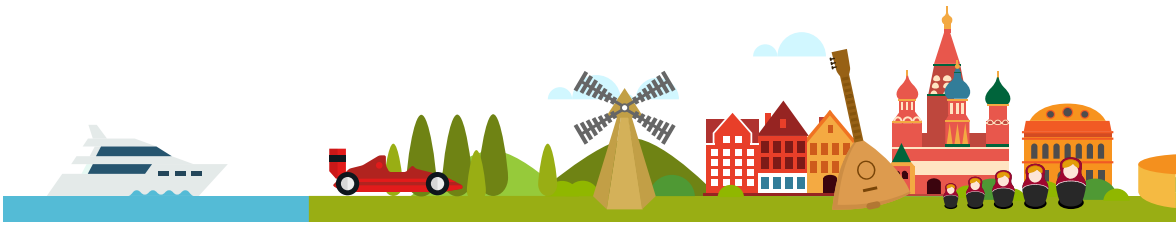
ENERGY SECURITY

- Reduce oil and gas dependence (net importers)
- Diversified economy and energy supply (net exporters, e.g. Russian Federation)

3

CLIMATE SUSTAINABILITY

- Better air quality
- Increased use of renewables
- Cost-effective path to achieve climate goals



ENERGY TRANSFORMATION ROADMAP TO 2050

Rest of Europe	2017	Where we are heading 2030 (PES)	2040 (PES)	2050 (PES)	Where we need to be 2030 (TES)	2040 (TES)	2050 (TES)
Energy (EJ)							
Supply (TPES)	39	46	46	47	38	36	33
Consumption (TFEC)	24	29	30	30	23	21	18
Renewables shares (modern)							
Supply (TPES)	6%	10%	10%	12%	19%	34%	54%
Consumption (TFEC)	7%	9%	11%	12%	20%	37%	61%
Power generation	27%	28%	28%	31%	42%	63%	82%
Electricity share in final energy consumption							
End-use consumption	18%	18%	20%	22%	23%	28%	38%
Industry	20%	22%	24%	25%	27%	30%	35%
Transport	6%	6%	8%	12%	12%	21%	37%
Buildings	21%	24%	26%	28%	28%	33%	42%
Renewable installed capacity (GW)							
Bioenergy	2	3	6	17	27	56	83
Hydropower	111	105	95	94	127	140	157
Solar PV	3	25	25	38	39	58	107
Wind	2	16	31	45	33	57	79
Biofuels							
Liquid biofuels (billions of litres per year)	1	12	18	23	22	34	47
CO_2 emissions (energy-related)							
Annual level (Gt CO_2/yr)	2	2.4	2.3	2.3	1.6	1.2	0.7
Reduction vs. today	NA	17%	15%	12%	-19%	-42%	-68%

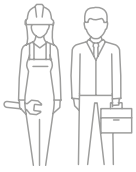
● Rest of Europe	Where we are heading **Planned Energy Scenario 2016 - 2050** (PES)	Where we need to be **Transforming Energy Scenario 2016-2050** (TES)
Energy system investments (average annual, 2016-50) USD billion/year		
Power	25	33
– Renewable	4	21
– Non-renewable	16	5
– Power grids and system flexibility	5	6
Industry (RE + EE)	5	7
Transport (electrification + EE)	12	20
Buildings (RE + EE)	57	83
Biofuel supply	2	8
Renewable hydrogen – electrolysers	0.1	1

Note: RE = renewable energy; EE = energy efficiency
The findings in this report consider targets and developments as of April 2019. The wind and solar PV capacities in the Transforming Energy Scenario in 2030 in this report are slightly higher than the estimates presented in IRENA's reports (IRENA, 2019b; 2019c) which consider developments as of the third quarter of 2019.

SOCIO-ECONOMIC OUTLOOK TO 2050

● Rest of Europe	2019e	2030	2050
Population (thousands) region-wide	230 174	223 224	208 212
GDP (USD 2015)			
GDP (million): PES	2 991 058	3 242 176	4 289 467
GDP (million): TES	3 150 705	3 181 845	4 356 940
GDP changes (million): TES vs. PES	159 647	-60 332	67 473
GDP changes (%): TES vs. PES	5.3	-1.9	1.6
Per capita GDP (thousand): PES	13.0	14.5	20.6
Per capita GDP (thousand): TES	13.7	14.3	20.9
Employment			
Economy-wide employment (thousands)			
Employment: PES	144 339	148 766	154 839
Employment: TES	144 472	148 635	154 527
Employment changes: TES vs. PES	133	-131	-313
Employment changes (%): TES vs. PES	0.09%	-0.09%	-0.20%

Rest of Europe	2017	2030 (PES)	2050 (PES)	2030 (TES)	2050 (TES)
Energy sector jobs (thousands)					
Nuclear power	167	181	184	148	65
Fossil fuels	3 139	3 085	2 962	2 771	2 407
Renewables	275	500	716	1 044	1 730
Energy efficiency	420	373	435	577	940
Power grids and energy flexibility	927	964	1 001	978	1 063
Total	**4 928**	**5 103**	**5 298**	**5 518**	**6 205**
Energy jobs in economy-wide employment (%)		3.4%	3.4%	3.7%	4.0%
Renewable energy jobs (thousands)					
Bioenergy	97	228	395	579	1 049
Solar	31	82	169	193	450
Hydropower	143	128	50	171	86
Wind	4	61	97	95	122
Geothermal	1	1	5	5	23
Ocean	0	0	0	0	0
Total	**275**	**500**	**716**	**1 044**	**1 730**
Renewable energy jobs in energy-sector employment (%)		9.8%	13.5%	18.9%	27.9%



Job differential in 2050 (thousands) TES vs. PES	
Economy-wide	-313
Changes in conventional energy (A)	-674
Changes in transition related technologies (B)	1 581
Net jobs (A+B)	908

▶ Jobs in 2050: TES / ● Rest of Europe

Technology jobs (thousands)		Segment value chain (thousands)		Occupational requirements (thousands)	
Solar PV	311	Construction & installation	400	Workers and technicians	485
Solar water heaters (SWH)	138	Manufacturing	34	Experts	49
Onshore wind	122	Operation and maintenance	160	Engineers and higher degrees	53
Offshore wind	-	Biofuel supply	-	Marketing and administrative	8
Geothermal	23				
Total	**594**		**594**		**594**

Welfare improvement (%): TES vs. PES	2030	2050
Indicator		
Economic	(0.3)	0.2
Social	4.2	7.8
Environmental	2.1	4.5
Total	**6.0**	**12.4**

REFERENCES:

Deng, Y., Haigh, M., Pouwels, W., Ramaekers, L., Brandsma, R., Schimschar, S., Grözinger, J. & de Jager, D. (2015), *Quantifying a realistic, worldwide wind and solar electricity supply, Global Environmental Change 31, 239-52,* https://doi.org/10.1016/j.gloenvcha.2015.01.005.

Global Carbon Atlas (2019), *Global Carbon Atlas – CO_2 emissions*, https://doi.org/10.5194/essd-11-1675-2019.

Global Petrol Prices (2019), *Electricity prices around the world*, www.globalpetrolprices.com/electricity_prices/ (accessed 5 March 2020).

IEA (2019), *IEA Beyond 20/20 – 2019 edition*, International Energy Agency, Paris.

IRENA (2019a), *Renewable Cost Database*, 2019.

IRENA (2019b), *Future of solar photovoltaic – Deployment, investment, technology, grid integration and socio-economic aspects*, International Renewable Energy Agency, Abu Dhabi.

IRENA (2019c), *Future of wind – Deployment, investment, technology, grid integration and socio-economic aspects*, International Renewable Energy Agency, Abu Dhabi.

WHO (2019), *WHO Global Ambient Air Quality Database* (update 2018), World Health Organization, www.who.int/airpollution/data/cities/en/ (accessed 5 March 2020).

World Bank Group (2019a), *Access to electricity (% of population)*, World Bank Group.

World Bank Group (2019b), *Access to clean fuels and technologies for cooking (% of population)*, World Bank Group.