The Electricity Market of Southeast Europe:

THE IMPACT OF NEW TRENDS AND POLICIES

THE NEW NUCLEAR WATCH INSTITUTE

FOREWORD BY TIM YEO, CHAIRMAN, THE NEW NUCLEAR WATCH INSTITUTE.

In its inaugural report The New Nuclear Watch Institute (NNWI) exposes the severity of the challenges facing the electricity market of southeast Europe. Suffering from chronic underinvestment since the dissolution of the Eastern Bloc and the breakup of the Yugoslav state, the region is now beset by an energy infrastructure that is unreliable, inefficient, and unsustainable. The report makes clear the urgent need for significant investment in low-carbon generation capacity, not only to protect energy supply security in the decades to come but also to achieve post-Paris Agreement climate action commitments. In particular, an accelerated phase-out of coal in tandem with a steady increase in the unit cost of carbon emissions - combined with imminent demand-side disruptions - could see an electricity deficit opening up as early as 2027.

Should lawmakers fail to expand capacity in the near future, southeast Europe is forecast to become a net importer of electricity around 2030. This outcome would weaken regional energy security and expose households and businesses to higher electricity prices. Ultimately, electricity generation shortfalls could slow and even curtail the economic and social development of the region. Southeast Europe's energy problem could very quickly become its defining characteristic. Thus far, the policy response to this issue - at home and in Brussels - has been to accelerate plans to improve natural gas infrastructure at a pan-European level. Such a course of action would entail dependence on a highly concentrated supplier market starkly at odds with the EU commitment to diversify its supplier base. To meet the projected electricity deficit using natural gas alone would result in the emission of an extra 1.3 billion tonnes of CO_2 equivalent. This heavy environmental cost would be accompanied by an equally undesirable financial one, €40 billion at President Macron's proposed €30 per tonne emission price.

Opponents of nuclear power point to other low-carbon energy sources and while they certainly have a role to play in the energy balance of the EU moving forward, they cannot alone deliver the secure, affordable and sustainable electricity on which Europe's future prosperity depends. The use of hydropower in southeast Europe is approaching its technical limit and faces environmental challenges of its own, while wind and solar power - despite technological advances - remain unable at present to provide dispatchable, cost-effective electricity. Therefore, this report concludes with a call for investment in the nuclear capacity in the region. It is only by making a firm commitment - politically and financially - to nuclear power today that the future prosperity of southeast Europe can be safeguarded. The completion timetable for a new nuclear plant is lengthy and the projected electricity deficit is less than a single decade away. The time to start is now.

ABOUT TIM YEO

Tim Yeo was a Member of the UK Parliament for over 30-years, from 1983-2015. During his time as an MP, Tim was Chair of the influential Energy & Climate Change Select Committee (2010-2015), and of the Environmental Audit Committee (2005-10). Prior to this he served in several Government departments (1988-1994) including Minister for the Environment and Countryside (1993-1994) in the John Major Government.

Since leaving the House of Commons in 2015, Tim has been working in various energy and climate change related roles in the business and academic worlds. These include Chair of New Nuclear Watch Europe (NNWE), an industry supported body which campaigns for new nuclear development across Europe, Board membership (and former chair) of AFC Energy plc, an AIM listed UK based hydrogen fuel cell developer, and Chair of the University of Sheffield Energy 2050 Industrial Advisory Board. Tim remains a director of Getlink SE (formerly Groupe Eurotunnel), one of the largest listed companies in France, where he chair's the Board Strategy and Sustainable Development Committee.

In 2016 KOTRA, the South Korean trade office, appointed Tim as the Honorary Ambassador of foreign investment. He is also a frequent visitor to China where he works with the UK-China (Guangdong) CCUS Centre on carbon capture projects, with academic collaborators on the design of China's emissions trading system and with business colleagues on inward investment from China to the UK.

Founded by Tim Yeo at the end of 2014 New Nuclear Watch Europe (NNWE) is an interest group which has been established to help ensure nuclear power is recognised as an important and desirable way for European governments to meet the long-term security needs of their countries. Membership is open to all companies, individuals and organisations active in the nuclear industry including those involved in the supply chain.

The New Nuclear Watch Institute (NNWI) is the first think-tank focused purely on the international development of nuclear energy. It believes that nuclear energy is vital for the world to achieve their binding Paris Climate Agreement objectives. Its research will aim to promote, support, and galvanise the worldwide community to fight the greatest challenge of our time: climate change.

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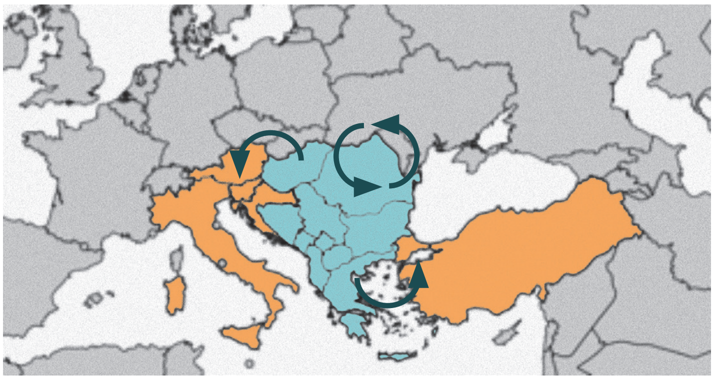
EXECUTIVE SUMMARY

Southeast Europe — consisting mainly of the nations of the Balkan peninsula – has long been pivotal to both the economic and political fortunes of continental Europe and western Asia. Today, the region plays an important role in EU energy strategy.



CLASSIFICATION:

Southeast Europe Region

External Energy Markets

Source: *Author (with use of MapChart)*

For the purposes of this report, the region shall be comprised of:

BULGARIA / ROMANIA / HUNGARY / GREECE

all EU member states

as well as **ALBANIA /** and several of the republics of former Yugoslavia, namely **SERBIA / KOSOVO / MONTENEGRO / MACEDONIA (FYROM) / BOSNIA AND HERZEGOVINA**

In this report, reference shall be made to two major external energy markets

a composite of nearby **WESTERN EU STATES** (consisting of Austria, Croatia, Italy, and Slovenia) **AND TURKEY.**

EXECUTIVE SUMMARY

This report presents an impact assessment of new polices and trends – principally those related to the data economy and the post-Paris Agreement climate action consensus – that have recently emerged. These have far-reaching implications for the energy markets, especially the electricity market, of southeast Europe.

Impending demand-side disruptions, including the rapid spread of electric vehicles and the widespread adoption of electricity-intensive data-processing technologies, together with the progressive introduction of more stringent climate and environmental policies, pose significant risks to the security of energy supply. Their full effect has not yet been quantified or factored into established projections.

Underestimating the impact of these factors leads to a complacent view on the need for more electricity generation capacity. This could lead to generation shortfalls as early as **2027** and disrupt the region's electricity balance, transforming it from an exporter of electricity into an importer. This will drive up electricity prices and make the low economic growth forecasts used in other publications self-fulfilling. Underinvestment today and higher electricity prices in the near future will act as a brake on future economic growth.

Our report builds upon the findings of the following publications: the **EU Reference Scenario 2016 (EURS16),** the proposed National Energy Strategy released by **the Bulgarian Academy of Science (BAS),** and the Network Development Plan of the European Network of **Transmission System Operators for Electricity (ENTSO-E).**
In addition, the report is informed by a thorough evaluation of academic literature, policy analysis, and regional research papers.

THE MODEL: SCENARIO-BASED ANALYSIS

The assumptions underlying our scenario-based approach are as follows:

	Baseline	Alternative – 'New Trends and Policies'
Demand	Zero Growth Urbanisation as per WUP Dynamic Electricity Share Constant Export Demand No Technological Disruption	Zero Growth Urbanisation as per WUP Dynamic Electricity Share Technological Disruption — Transitory *Increases Internal Electricity Demand* *Increases Export Electricity Demand in Proportion to Existing Trade Flows*
Supply	EU States: *as per EURS 16* Non-EU States: *as per BAS (2017)*	As per Baseline, with Following Modifications: *Accelerated Phase-out of Coal Plants* *Decreasing Coal Capacity Factor post-2030*

WUP: *World Urbanisation Prospects, Population Division, United Nations*
EURS16: *European Union Reference Scenario 2016*
BAS: *Preparation of a National Strategy in the Field of Energy (with a Focus on Electricity), The Bulgarian Academy of Science, 2017*

PRINCIPAL OBSERVATIONS AND FINDINGS:

POLICY

#1

REFORM:

The international policy context will be affected by reform of the EU Emissions Trading Scheme (ETS), the withdrawal of transitional carbon allowances to certain EU member states, and the conceivable implementation of an EU-wide carbon pricing arrangement – a direct levy collected by Brussels – to neutralise the negative impact of Brexit on the EU budget. These measures will raise the effective price of carbon and so weaken the business case for coal firing.

#2

EU ACCESSION:

Of the six non-EU states in the region – Albania, Bosnia and Herzegovina, Kosovo, FYR Macedonia, Montenegro, and Serbia – four are candidate countries and the other two, Bosnia and Herzegovina and Kosovo, have potential candidate status. Indeed, Jean-Claude Juncker expects Montenegro and Serbia to join the bloc by 2025[1]. Membership would bring strict environmental regulations and stiffer emission targets to the largest economies of southeast Europe. The legislative implications of accession will discourage new investment in carbon-intensive capacity.

#3

DECARBONISATION:

Current carbon reduction targets do not have a significant impact on southeast Europe due to their base in 1990 emission levels. Industry – heavy industries, in particular – sharply declined in southeast Europe between 1987 and 1997, following the disintegration of both the Eastern Bloc and Yugoslavia. As a result, emissions were depressed throughout the period (without an improvement in unit carbon intensity). Nonetheless, air quality concerns[2] and tougher decarbonisation targets will spur pan-European regulation designed to accelerate the coal phase-out.

DEMAND

#4

ELECTRICITY SHARE:

This report indicates that previous projections of electricity demand have failed to adequately account for the tendency of electricity use as a share a total energy consumption to increase as economies develop. The statistic is often assumed to remain constant or increase slightly by many forecasts. Our research – based upon historical data published by the World Bank and the OECD – demonstrates that the growth of the electricity share displays a meaningful correlation with per capita income growth (ρ = 0.96) and urbanisation (ρ = 0.99).

[1] *https://www.euractiv.com/section/enlargement/news/eu-advances-membership-talks-for-serbia-montenegro/*
[2] *Pollution from fine particles emitted by coal-fired plants in the EU are estimated to cause between 12,000 and 22,900 premature deaths a year, including 3,740 in Bulgaria and Romania alone, according the Climate Action Network (2016). See Hansen J. Europe's Dark Cloud, (2016)*

PRINCIPAL OBSERVATIONS AND FINDINGS:

#5

TECHNOLOGICAL DISRUPTION:

The electric vehicle revolution in Europe – the termination of conventional vehicle production by major manufacturers and the outright banning of the combustion engine in some countries as early as 2040[3] – in conjunction with the widespread adoption and application of electricity-intensive data processing technologies – the Blockchain, autonomous vehicles, and the Internet of Things (IoT) – will cause a temporary increase in the electricity share. Our research on historical technological disruptions indicates that such periods – the development of personal computing and the World Wide Web in the 1990s, for instance – span 15 years and at their peak cause an increase in annual electricity consumption of 6% above the otherwise expected level.

#6

IMPACT:

The timing of a given technological disruption within a particular region depends upon its level of economic development. This report assumes that the impact of electricity-intensive innovation occurs in western Europe in 2025 and in southeast Europe in 2030. For the latter, the incremental increase in the electricity share over the disruption period is equivalent to 15 TWh per year. That is more than the net generation capacity of Albania or FYR Macedonia in 2020. Moreover, the impact on the neighbouring west European energy market will create an additional export demand for the southeast region of up to 50 TWh over the disruption period.

CAPACITY AND GENERATION

#7

CARBON INTENSITY:

According to the EURS16, 40.2% of electricity generated in the EU in 2020 will be either coal- or gas-fired. The figure for southeast Europe will be higher – up to 53.8% – which is a cause for concern on both environmental and energy security grounds. Moreover, the European Coal Plant Database (ECPD) indicates that projects amounting to 9,663 MW of coal-fired capacity have been announced or are pre-permit in the region. As a result, a concerted effort to reduce the region's fossil fuel dependency – while maintaining system capacity – will require significant investment in low-carbon generation.

[3] *https://www.ft.com/content/7e61d3ae-718e-11e7-93ff-99f383b09ff9*

PRINCIPAL OBSERVATIONS AND FINDINGS:

#8

COAL PHASE-OUT:

Between 2020 and 2040, the generation capacity of coal-fired thermal plants in the EU is projected to fall by 61.3% (from 146,098 MW to 56,565 MW), reflecting its commitment to reducing emissions. As the EU expands and the influence of the Energy Community increases it will – with all probability - expect similar action by new member states. In our alternative scenario, we model the impact of an enforced decommissioning of coal-fired capacity in southeast Europe that is more than 50 years old. Currently, about a quarter of such capacity in the region was commissioned before 1975 and so is removed from the model in 2030 (with similar modifications then made at the end of each five-year period). As a result, the projected output of coal-fired capacity in 2040 falls from 56 TWh in the baseline scenario to 26 TWh.

#9

CARBON PRICING:

The price of a European Union Allowance (EUA) is forecast to rise throughout the period to 2040. Phase 4 (2021-2030) of the EU ETS contains reforms[4] designed to increase the historically depressed EUA price. Our margin analysis – incorporating both EUA and coal price forecasts – indicates that the economic rationale of coal production weakens post-2030. We proportionately decrease the capacity factor of coal after this point in order to model the producer response. All else being equal, we observe a decrease of coal-fired generation of 20 TWh in 2040 (to 6 TWh).

MARKET OUTLOOK

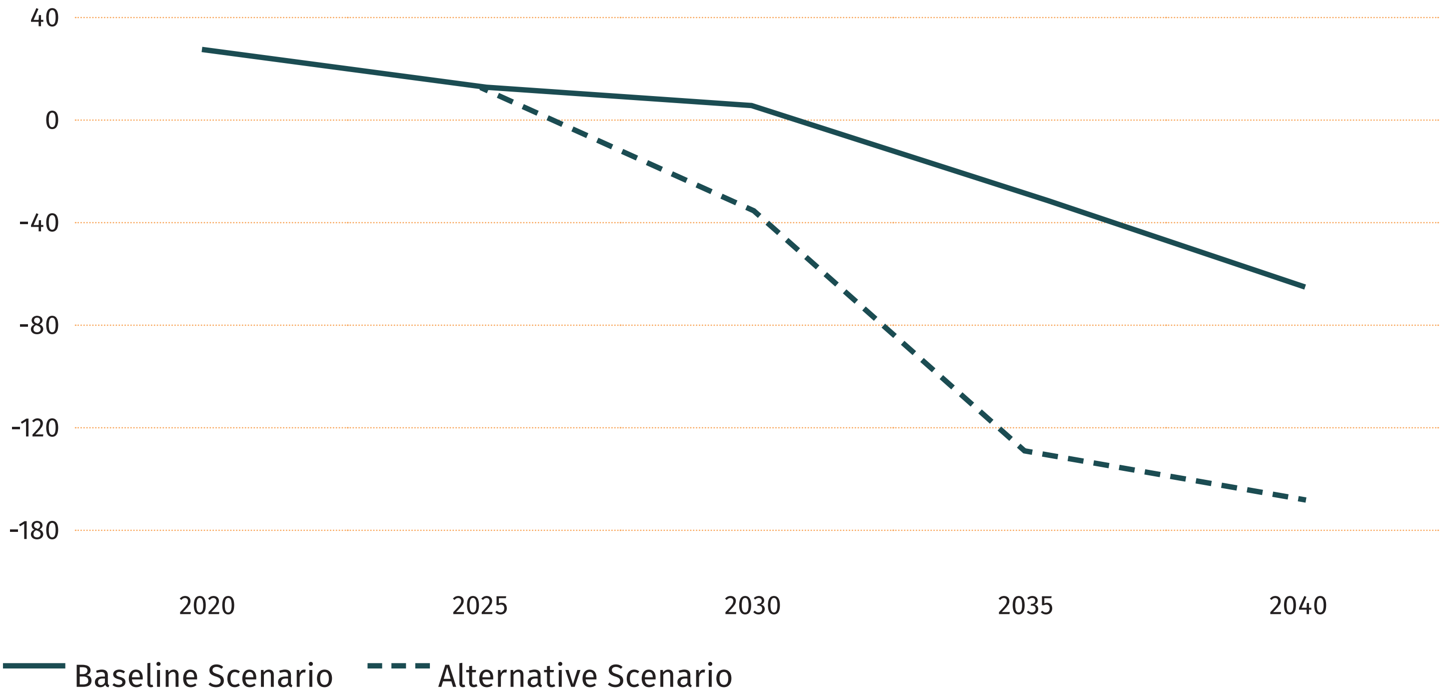
#10

SURPLUS TO DEFICIT:

Our projections indicate that in the 'New Trends and Policies' scenario, without additions to generation capacity in excess of what is currently planned and reflected in the EURS16 and the BAS projections, the electricity market of southeast Europe risks falling into deficit as early as in 2027, reaching up to 35 TWh per year by 2030 and up to 150 TWh by 2040. As a result, the region will switch from net exporters of electricity to net importers, leading to electricity prices of €160-170 (per MWh, 2013€) as opposed to the €120-140 now forecast for the same period. It should be noted, that even in our baseline scenario, the model forecasts an electricity deficit as early as 2031.

[4] *https://ec.europa.eu/clima/policies/ets/revision_en*

MARKET BALANCE (TWH) — SCENARIO COMPARISON



CONCLUDING REMARKS:

The electricity market in southeast Europe is far more precarious than current forecasts indicate. The likelihood of external shocks – whether supply- or demand-driven – have been underestimated, putting future system resilience at risk. As a result, in the absence of a concerted, swift response, the regional electricity market will function under much tighter constraints than perceived today.

Should the decision to expand capacity – by means of investment in low-carbon infrastructure – not be made, southeast Europe faces an electricity shortfall as early as 2027. This would likely raise electricity prices – by up to 30% according to the EURS16 – for the region and so endanger household living standards and dampen business activity. The region's economic development would be slowed and its energy balance dislocated. The projected deficit may arrive in 2027 – or 2031 according to our baseline scenario – so decisions have to be made by the early 2020s at the latest to ensure additional generation capacity is available when required.

The clear course of action is to commit – politically and financially – to an expansion of low-carbon, baseload capacity in the region. As such, the installation of new nuclear facilities to be operational between 2025 and 2030 is a necessary hedge against future instability. An increase in nuclear generation capacity – beyond the straightforward enhancement of the electricity market balance – has the further advantage of being resilient to future climate and environmental policies.

A FAILURE TO ACKNOWLEDGE AND TO FACE THE CHALLENGE POSED BY THESE DISRUPTION RISKS UNDERMINING THE FUTURE ENERGY SECURITY AND ULTIMATELY THE ECONOMIC PROSPERITY OF SOUTHEAST EUROPE.

A NOTE ON THE MODEL:

It should be emphasised that the model of the electricity market – and its conclusions – presented herein is to be used as part of a broad risk management consideration rather than as a direct forecast. Southeast Europe is unique in many respects, the Yugoslav Wars and abrupt transition to the market economy as well as the future accession to the EU of its nations. Establishing predictive relationships built upon historical data – in itself a complex process due to the poor quality of statistical records in the region – or analysing future political decisions is not a straightforward task.

However, the output and conclusions presented in this report are potential eventualities and so must be assessed and evaluated as befits them. This report presents an account of future electricity demand in southeast Europe that is both plausible and robust. Given the dichotomous nature of our two scenarios – **the baseline** encapsulating a 'business as usual' approach and **the alternative** a far more severe response – the two should be viewed as lower and upper bounds on a range-driven forecast. Our conclusions represent a material likelihood – with a clearly substantive impact – and so must be treated as a viable risk and incorporated into strategic and policy discussions.

SECTION 1: OVERVIEW — THE SOUTHEAST EUROPE REGION

In this section of the report, we shall start by presenting a brief overview of the southeast Europe region, focusing on the economic and political issues most relevant to our study. Subsequently, we shall cite and analyse existing regional energy forecasts and conclude with an outline of the scenario-based approach used in this report.

KEY FEATURES

Southeast Europe — principally composed of the nations of the Balkan Peninsula although here deemed to include Hungary too – has been a crossroads of almost every facet of humanity since antiquity. In recent history, the experience of southeast Europe has been dominated by the fallout from the collapse of the Soviet Union and the challenges posed by the ensuing transition to democratic, free-market societies. Since the 1990s, southeast Europe has returned to prominence as befits a region that lies at the intersection of Europe, Asia, and the Commonwealth of Independent States (CIS). Four nations in the region belong to the European Union **(Bulgaria, Greece, Hungary, and Romania),** another four are candidate countries **(Albania, Montenegro, FYR Macedonia , and Serbia),** while the remaining two **(Bosnia and Herzegovina, and Kosovo)** are considered potential candidates. Indeed, for as yet non-member states, EU integration is often an overt aim of foreign policy.

KEY FEATURES

Country	GDP[5] (Current US$M)	GDP per Capita (Current US$)	GDP Growth	Population	Population Growth	HDI[6]
Albania	11,864	4,125	3.4%	2,876,101	-0.2%	0.764
Bosnia and Herzegovina	16,910	4,808	3.1%	3,516,816	-0.5%	0.750
Bulgaria	53,238	7,469	3.9%	7,127,822	-0.7%	0.794
Kosovo	6,650	3,661	3.4%	1,816,200	0.8%	n/a
Greece	192,691	17,891	-0.2%	10,746,740	-0.7%	0.866
Hungary	125,817	12,820	2.2%	9,817,958	-0.3%	0.836
Macedonia, FYR	10,900	5,237	2.4%	2,081,206	0.1%	0.748
Montenegro	4,374	7,029	2.9%	622,781	0.1%	0.807
Romania	187,592	9,523	4.6%	19,705,301	-0.6%	0.802
Serbia	38,300	5,426	2.8%	7,057,412	-0.5%	0.776

All Data Refers to 2016
***Source:** The World Bank DataBank*

[5] *Gross Domestic Product*
[6] *Human Development Index*

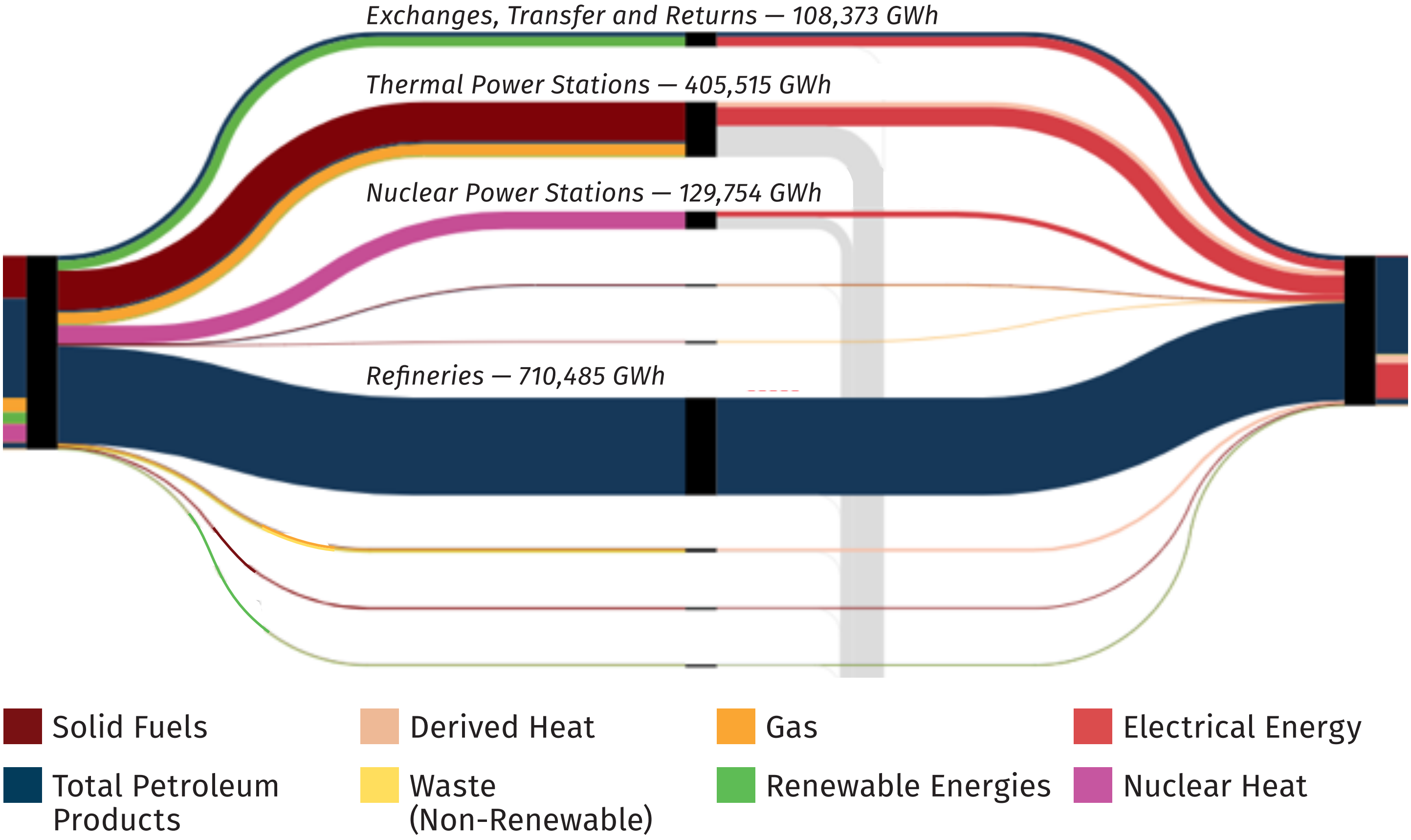
THE ENERGY LANDSCAPE

As the diagram on the following page illustrates, the southeast Europe region is a net importer of energy, indicating that more can be done to reduce energy dependence and strengthen supply security. This situation reflects the current state of the production facilities of the region, which are in need of renewal and replacement, as well as inefficient infrastructure and transformation networks. A lack of regional integration is also to blame – an indication of the value placed on national energy independence in southeast Europe – and inhibits the development of a regional energy market. Moreover, energy exports to the region are dominated by Russia – the CIS also serves as a leading supplier but to a lesser degree – and the post-Ukraine fallout between Russia and the EU has thus made the issue of energy security that much more critical.

The energy balance of southeast Europe is characterised by a high dependence on coal and petroleum products at the expense of both natural gas and nuclear power. The region itself has limited oil reserves and so a shift away from the product would have beneficial trade implications. Petroleum is also carbon-intensive – reflected in the high CO_2 emissions per unit of regional national output compared to the EU – and so a rebalance of the energy mix would prove advantageous to both EU member states and candidate countries in light of the stricter regulations embodied in Phase 4 (2021-2030) of the EU ETS.

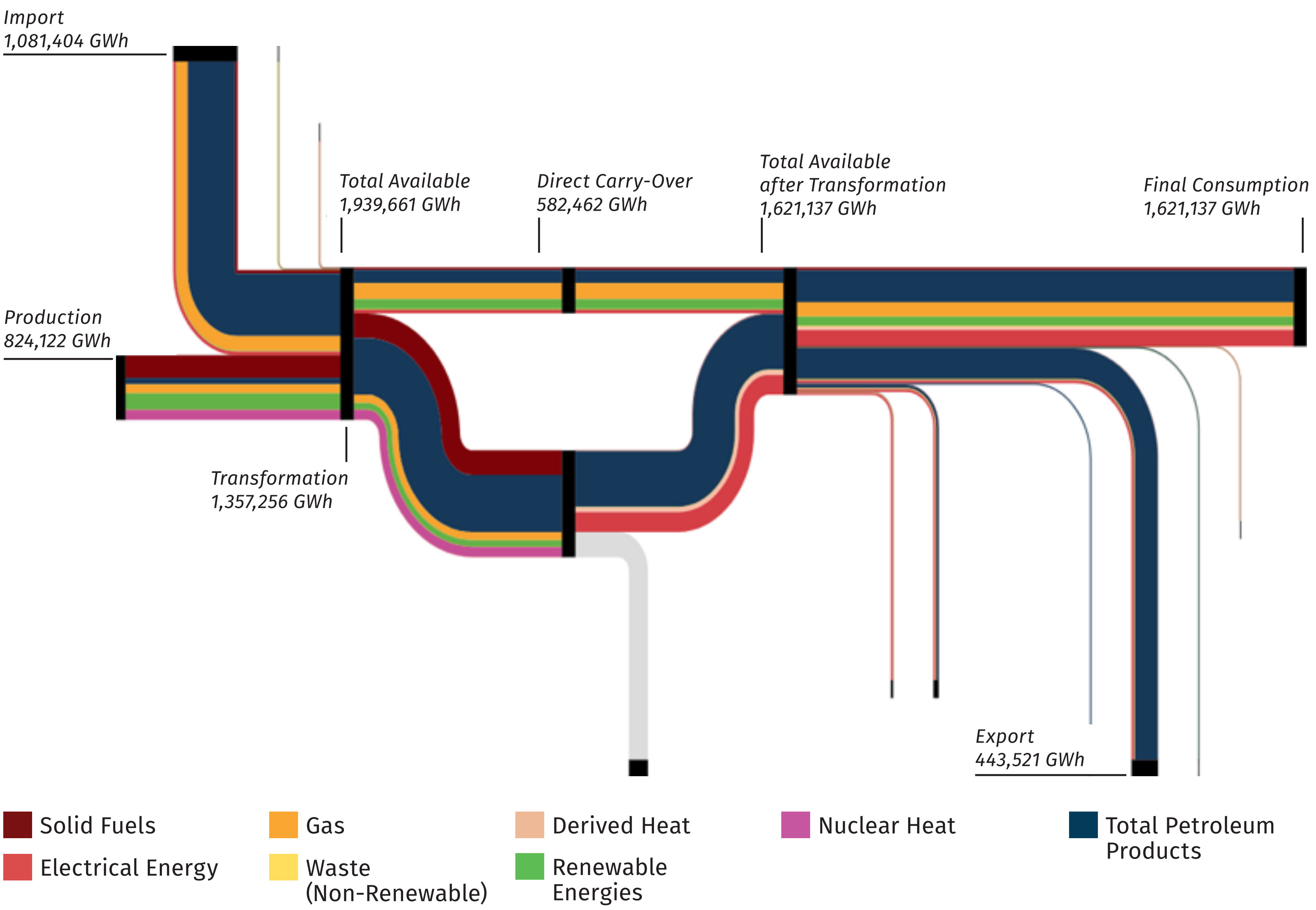
With regards to electric power, the Southeast Europe region is highly dependent on coal, reserves of which are relatively plentiful (see Region Energy Balance Sankey Diagram) in southeast Europe and – in contrast to most EU states – the governments of the region are planning to invest in new lignite power plants in the short- to-medium term (such as the Stanari plant that is under construction in Bosnia and Herzegovina). Of note, in terms of energy security, is the not insignificant role played by natural gas, which is primarily imported from Russia.

SOUTH EAST EUROPE POWER GENERATION (2016)



Source: *Eurostat (Energy Balance Flows – Sankey Diagram)*
Note: *Excludes Bosnia and Herzegovina (Data Not Available)*

SOUTHEAST EUROPE REGION ENERGY BALANCE (2016)



Source: *Eurostat (Energy Balance Flows – Sankey Diagram)*

Note: *Excludes Bosnia and Herzegovina (Data Not Available)*

EUROPEAN UNION – ENERGY STRATEGY (BULGARIA, GREECE, HUNGARY, AND ROMANIA)

The three main objectives of EU energy policy are:

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• to secure energy supplies to ensure reliable provision and reduce the energy import burden;
• to ensure that the energy market operates competitively and that prices are affordable;
• and, for energy consumption to be sustainable.

The first two objectives are to be brought about by the formation of a European Energy Union, which will support the free flow of energy throughout an integrated energy market. It will be underpinned by investment in transmission infrastructure, grid management systems, and new technologies.

The third objective – sustainable energy use – is embodied in a number of formulated targets for 2020, 2030, and 2050.

Between 2010 and 2020, the 2020 Energy Strategy aims to:

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• reduce greenhouse gases by at least 20%;
• increase the share of renewable energy in the energy mix of the EU to at least 20% of consumption;
• and, to improve energy efficiency by at least 20%.

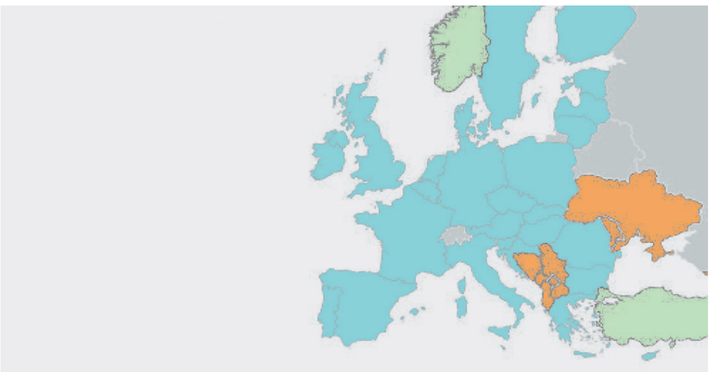
The EU Emissions Trading System (ETS) is the cornerstone of EU attempts to lower greenhouse gas emissions. The ETS functions as a 'cap and trade' scheme; emission allowances – permitting a certain volume of emissions – are auctioned by the EU and subsequently traded by firms. The number of allowances is controlled by the EU and is reduced over time hence reducing total emissions. The ability to trade allowances ensures that emissions are reduced where it costs least to do so and the price of the allowances – and indeed the cost of the fines for companies emitting beyond their allocation – spurs investment in low-carbon and renewable technologies.

Thus far, however, the EU ETS has failed to deliver the desired results and so has been targeted for reform. An oversupply of allowances at auction has depressed unit prices and so the pace of decarbonisation has been slower than expected. In the short-term, lawmakers have attempted to rectify the situation by means of a process known as 'backloading', in which auctions of allowances have been postponed (the auctioning of 900 million allowances were postponed during Phase 3 of the

ETS (Utility Week, 2018)). To bring about a permanent solution, a market stability reserve (MSR) – to be established in January 2019 – will be employed to absorb excess market allowances. Moreover, the annual reduction in the cap on issued allowances will be increased from 1.74% in Phase 3 to 2.2% during Phase 4 (2021-2030). Of note is that in Britain, power generators pay both the European carbon price and an additional levy, known as the Carbon Price Support (CPS); a policy that may attract increasing attention amongst EU states.

THE ENERGY COMMUNITY (ALBANIA, BOSNIA AND HERZEGOVINA, KOSOVO, FYR MACEDONIA , MONTENEGRO, AND SERBIA)

The Energy Community is an international organisation that aims to bring together the EU and neighbouring nations with the aim of establishing a pan-European energy market. It was founded upon the signing of the Energy Community Treaty in 2005 and has been in force since 2006. The overarching aim of the Energy Community is to extend the internal energy market of the EU – its rules and principles – to southeast Europe and the Black Sea region, by means of legally binding agreements. With direct concern for the southeast Europe region, the organisation aims to develop competition at the regional level and facilitate the exploitation of economies of scale within the regional energy market. In this regard, the contracting parties of the Energy Community (the non-EU states) committed to implementing the EU Third Energy Package, which aimed to improve the functioning of the internal electricity market and resolve structural problems (such as the limited independence of some energy regulators).



Source: *The Energy Community, Energy Community Facts in Brief*

NATIONAL POLICY — CONCERN FOR ENERGY INDEPENDENCE AND SECURITY

The southeast Europe region – due to the absence of a common political platform to a large degree – is characterised by a high degree of fragmentation; this applies to the energy market, in which regional cooperation is rare. As such, despite the relatively small size of many nations in the region, energy issues are often tackled separately, with a number of negative consequences, including: the risk of overcapacity (and subsequent risk of stranded assets), the inefficient use of natural resources, and the dampening of private investor interest.

EXISTING FORECASTS AND PROJECTIONS

THE EU REFERENCE SCENARIO 2016 (EURS16)

The EURS16 presents the results of a simulation of the EU energy market subject to the market conditions and adopted policies observed before end-2014. It is based upon the assumption that 2020 energy targets are met and presents projections for the time period up to 2050.

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The simulation presents the following results:
• Energy Security: the energy production of the EU will continue its decline, leading to a small increase in import dependence;
• Internal Market: the energy mix of EU power generation will alter – to the benefit of renewable energy sources – and the price of electricity increases slightly;
• Energy Demand: primary energy demand and GDP will further decouple and electricity will continue its penetration of the fuel mix;
• Decarbonisation: both CO_2 and non-CO_2 greenhouse gas emissions decrease, driven by renewables, carbon pricing, and policy;
• Research, Innovation, and Competitiveness: some renewable technologies begin to be fully competitive.

Source: *The European Commission, Presentation on EU Reference Scenario 2016 Main Results*

BULGARIAN ACADEMY OF SCIENCE (BAS) REPORT ON NATIONAL ENERGY STRATEGY (WITH A FOCUS ON ELECTRICITY)

The BAS report (commissioned by Bulgarian Energy Holding) provides an energy strategy for Bulgaria until 2050 and evaluates the proposed nuclear project at Belene. In so doing, the BAS present both supply and demand forecasts for Bulgaria and the wider southeast Europe region.

SCENARIOS

In the following sections we shall present and compare two key scenarios of future developments of the region's electricity market.

The first one, **The Baseline** scenario is based on a set of conservative assumptions on the demand side (including the absence of economic growth and a constant, not growing, share of electricity in overall energy consumption) implying a low growth in electricity consumption (0.7% over the forecast period) while assuming – in line with the EURS16 and BAS's estimates – that all planned new power generation capacity in the region is connected to the grid on schedule with no accelerated phase-out of old capacity due to environmental concerns.

By contrast, the second, New Policies and Trends or **Alternative** scenario is built on the assumtions that the Paris process and air quality concerns in Europe would promt an accelerated phase-out of the most polluting old coal generation capacity while the 'technology shock' caused by the Electric Vehicles revolution, wider application of block-chain technologies and the growth of data consumption related to the Internet of Things (IoT) is expected to translate into a higher share of electric power in energy consumtion and higher demand for electricity both in the region and in neighbouring countries.

SECTION 2: BASELINE SCENARIO ANALYSIS

In this section of the report, we shall outline our baseline analysis. In turn, we shall define the assumptions of our models for electricity demand and supply and present their projections. Then, we shall integrate them into a single, unified forecast for the electricity market of south-east Europe. Finally, in light of the projected baseline market balance, we shall offer concluding remarks.

DEMAND

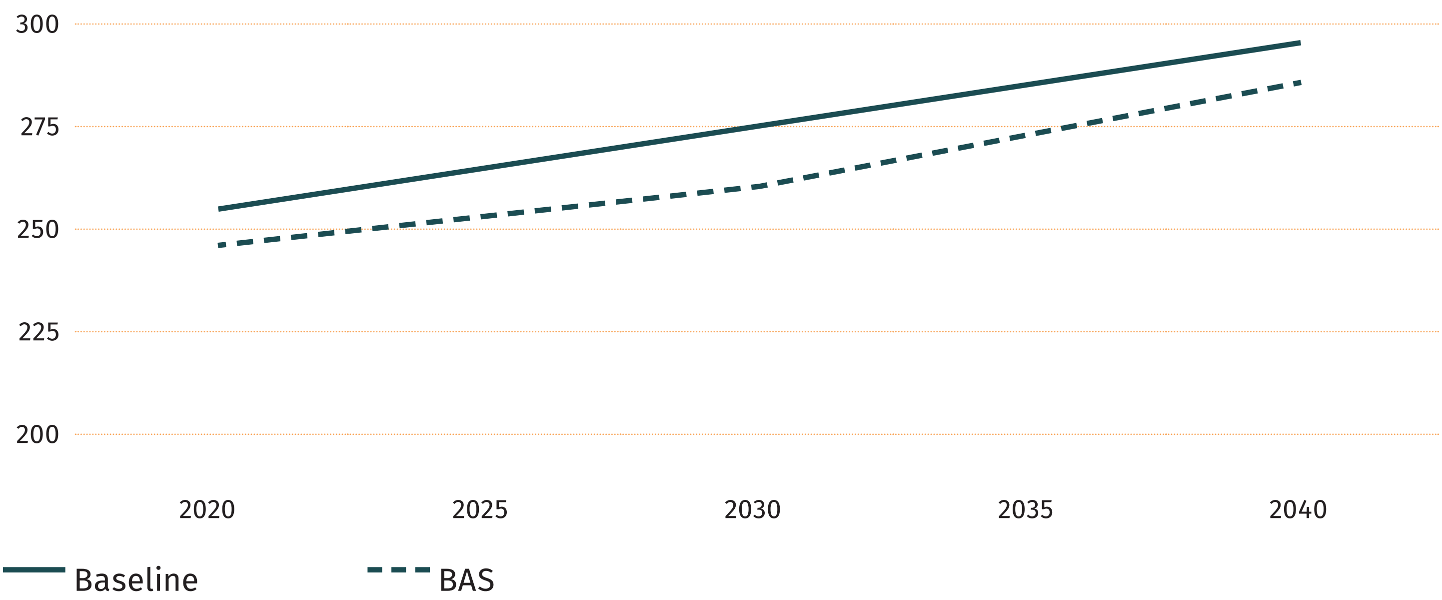
#A

Our demand forecast is the product of regression analysis built upon data from the World Bank, the OECD, and 'World Urbanisation Prospects' (WUP) (published by the Population Division of the Department of Economic and Social Affairs at the United Nations). The analysis is based upon the assessment of two variables: per capita national income growth and urbanisation (measured as the percentage of the total population that live in urban agglomerations). These independent variables were selected after a survey of relevant academic literature – focused upon the drivers of electricity demand – and a subsequent correlation analysis of long-run, historical data demonstrated them to be of explanatory significance to our forecast. In brief, when taken together, these variables capture both the volume and the intensity of economic activity and in doing so capture the principal drivers of electricity demand.

Our baseline demand forecast – presented in the graph below – exhibits an average annual growth rate comparable with that predicted in the BAS report; while electricity demand grows at 0.70% per annum in our model, it does so at 0.69% in the BAS report. Consequently, the absolute discrepancy – indicated by the vertical distance between the two projections – results from the use of disparate origin values; our base figure for 2015 (244 TWh) is derived from the World Bank DataBank.

SECTION 2:
BASELINE SCENARIO ANALYSIS

Regional Electricity Demand (TWh p.a.) - Forecast and BAS



Our baseline demand forecast is based upon an assumption of zero economic growth in the region and urbanisation trends as per the predictions of WUP. While the latter shall not be modified in the ensuing iterations – the WUP projections are employed throughout this report – the former shall be varied to present a more constructive account of future electricity demand.

The initial construction of the baseline scenario is also based upon the assumption that the share of electricity in total energy use remains constant (at close to 16%); in turn, this assumption shall be withdrawn and the effects of a dynamic electricity share modelled.

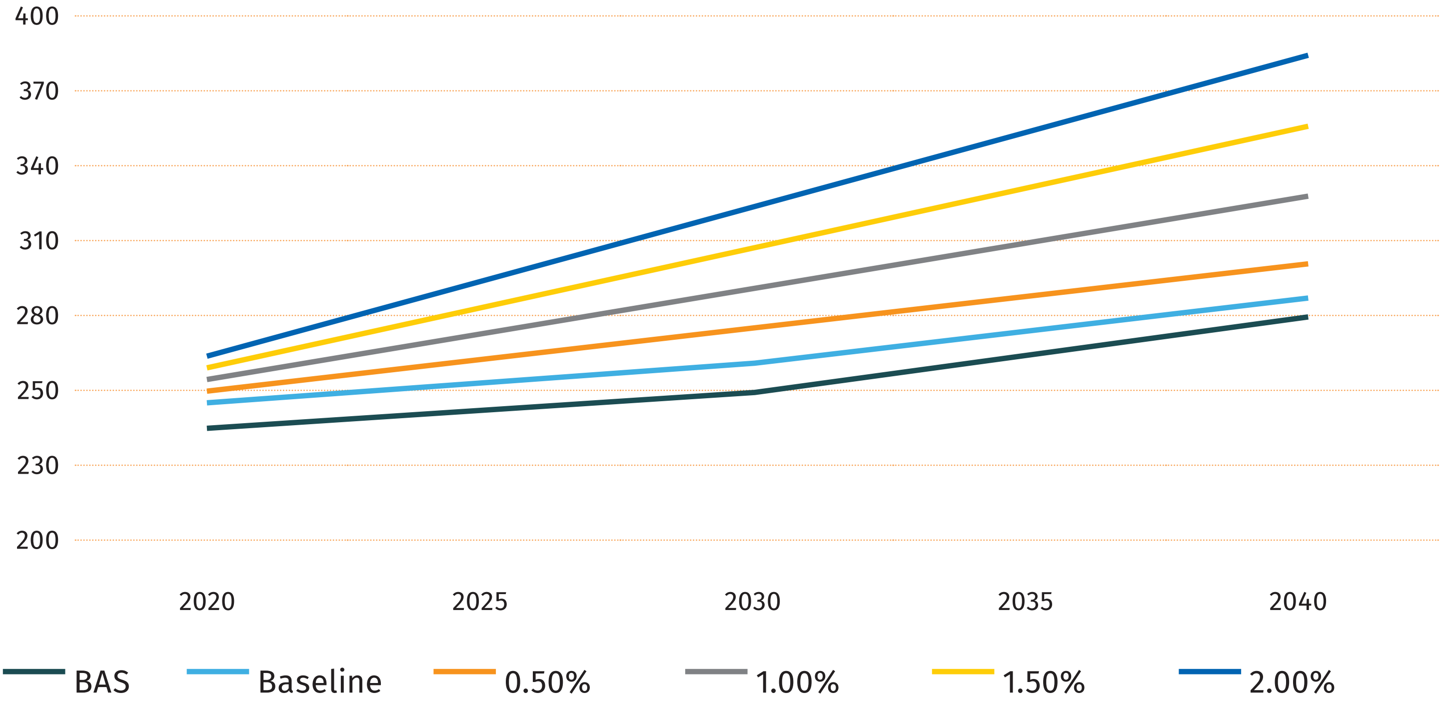
ECONOMIC GROWTH

#1

An increase in the amount of goods or services produced over a period of time – in other words, economic growth – cannot take place without a concomitant increase in energy consumption. Certainly, the elasticity of energy demand with respect to fluctuations in national output will not remain constant – economies of scale can be achieved as production increases and improving technological and technical efficiency will expand the frontier production function – but it cannot ceteris paribus be negative. As such, we have incorporated economic growth – assessed in discrete increments – in to our forecast.

SECTION 2: BASELINE SCENARIO ANALYSIS

Electricity Demand - Variable Economic Growth (Growth in GDP per Capita p.a.)



To position our economic growth projections in context, we evaluated forecast data for the World and the OECD (World Bank DataBank) and for Hungary (OECD Data). These datasets indicate that the average rate of annual growth for these regions will be 2.85%, 2.08%, and 1.92% respectively between 2015 and 2050. To clarify, Hungary has been included as a comparator as its economy is characterised by drivers common in the southeast Europe region – sharing some common ground with middle-income trap – and due to the availability of long-term growth forecasts by virtue of its OECD membership

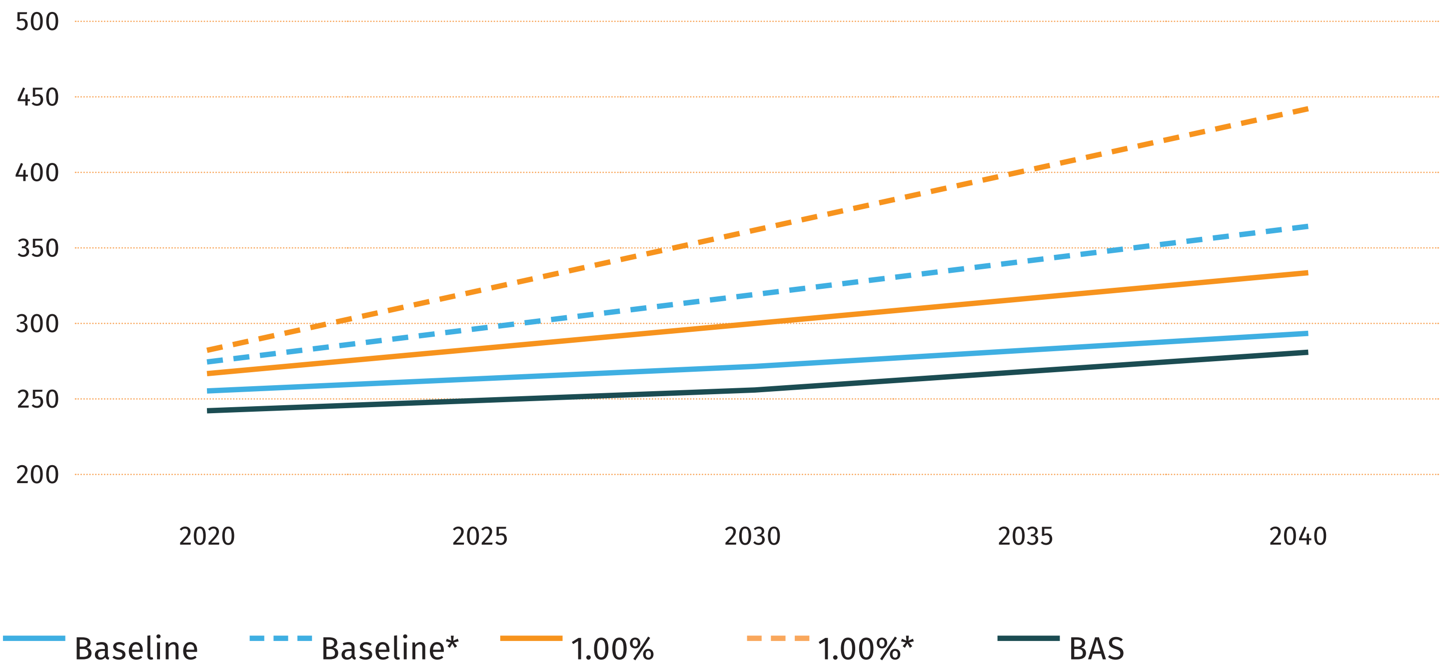
SECTION 2: BASELINE SCENARIO ANALYSIS

SHARE OF ELECTRICITY IN FINAL CONSUMPTION

#2

The composition of final energy demand – the proportions of final use accounted for by the various energy types – for a given region is dynamic and reflects, in part, the economic circumstance of the particular location. Development, for instance, has long been associated with the decline of the agricultural sector vis-à-vis industry and services. This tendency, in turn, leads to higher electricity demand for a given level of output due to the higher electricity intensity of those sectors. As such, we shall now treat the electricity share as variable and model the rate at which it grows in partnership with economic growth and rising urbanisation.

Electricity Demand (TWh) - Variable Electricity Share in Total Energy Use



The impact of treating the electricity as a variable is clear; the average annual rate of electricity demand growth – holding economic output fixed — is higher. For example, under the assumption of zero economic growth, consumption growth increases from a rate of 0.70% per annum to 1.64% (an increase of 134%), establishing a divergence that widens as the forecast progresses.

SECTION 2: BASELINE SCENARIO ANALYSIS

#3

EXTERNAL CONSIDERATIONS — EXPORT DEMAND

We shall now forecast external electricity demand in southeast Europe so as to complete our baseline scenario. Herein, external demand will be thought of as dualistic; the two foreign demand sources are deemed to be Turkey and a western European composite populated by nearby countries (Austria, Croatia, Italy, and Slovenia). Of particular note, when analysing effective export demand, is the interregional transmission network as its capacity imposes a ceiling upon potential trade volumes.

The methodology of our external electricity demand forecasts follows that of our internal projections. As such, national income per capita and urbanisation are treated as the independent variables within a regression analysis. As previously, we collected data from the World Bank DataBank, the OECD, and the UN WUP.

Due to the availability of long-term growth data for the economies in question, the zero-economic growth assumption has been dropped from the external model and instead national income is modelled according to OECD projections.

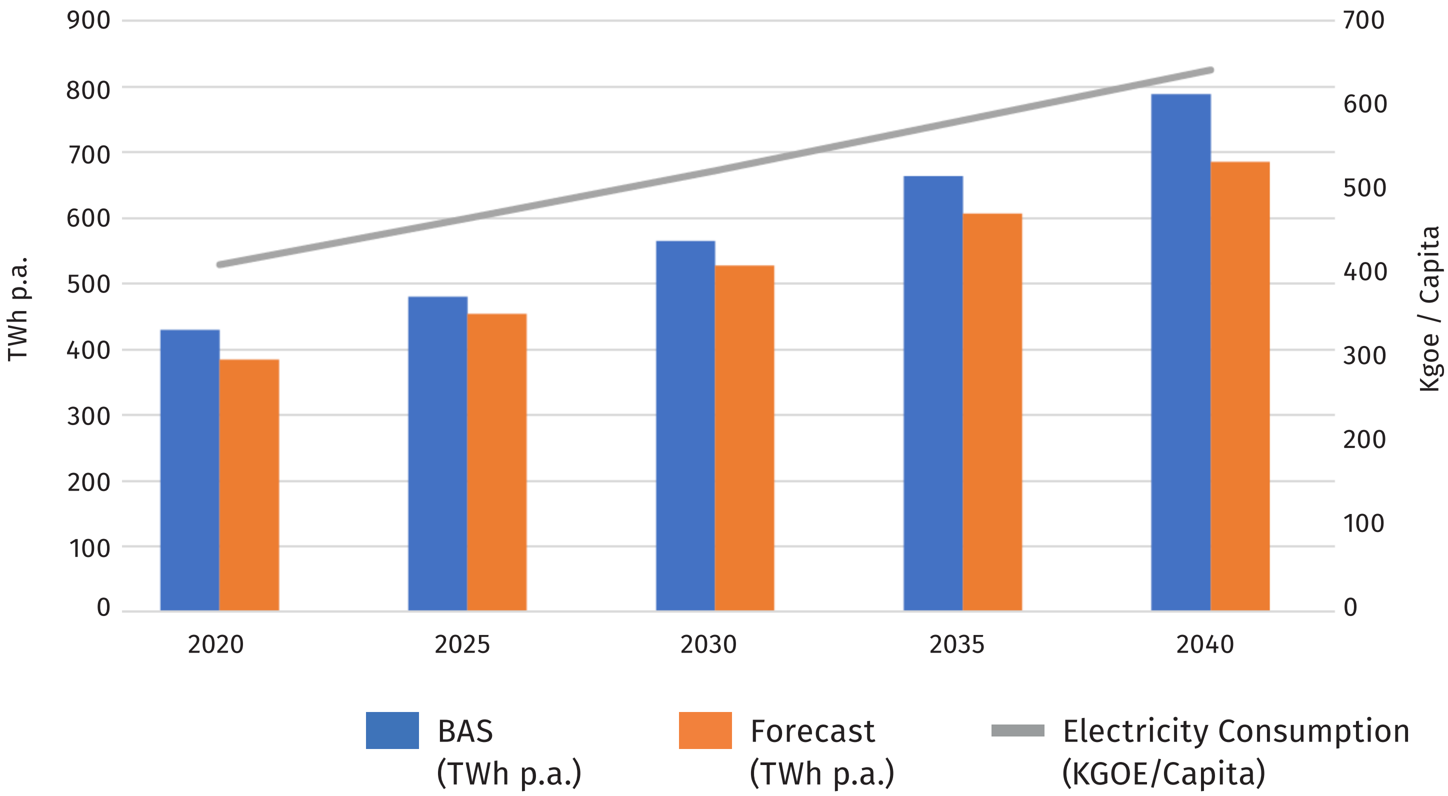
Turkey

We forecast that total electricity demand in Turkey will grow from 384 TWh in 2020 to 685 TWh in 2040, at an average annual rate of 2.9%, which is comparable to that projected by the BAS report (3.1%).

Our model indicates that demand growth will be driven primarily by growth in total energy consumption – accounting for 65.49% of growth – and to a lesser degree by an increase in the electricity share. There is a slight increase in the proportional effect of the electricity share over the forecast horizon but it remains the less significant factor, accounting for 33.95% of growth between 2020 and 2025 and 39.1% between 2045 and 2050.

SECTION 2:
BASELINE SCENARIO ANALYSIS

Electricity Consumption Forecast



As the preceding graph makes clear, the BAS report presents higher projections of Turkish electricity demand than our forecast. In 2020, for instance, the BAS report projects electricity demand amounting to 430 TWh, as opposed to the 384 TWh projected herein. The compounded annual growth rates implied by both forecasts (3.1% and 2.9%) are comparable, so the cause of the forecasts' diversion is the starting demand taken by the BAS (430 TWh).

To evaluate the 430 TWh figure, data on the most recent actual figures for electricity consumption was gathered from Eurostat, the Turkish Ministry of Energy and Natural Resources, and International Energy Association (IEA). This information, as well as the compounded growth rates required to reach the 2020 forecasts above, is presented below. It should be noted that, according to IEA data, Turkish electricity demand grew at an annual average rate of 5.74% between 2005 and 2010, and 4.79% between 2010 and 2015.

SECTION 2: BASELINE SCENARIO ANALYSIS

Institution:	Most Recent Data (TWh)	CAGR to BAS (2020)	CAGR to Forecast (2020)
Eurostat (2016)	*228*	*17.14%*	*13.87%*
Turkish MENR (2016)	*278*	*11.52%*	*8.41%*
IEA (2015)	*301*	*9.33%*	*6.28%*
****Average***	*269*	*12.43%*	*9.29%*

To assess the potential influence of Turkish import demand on south-east Europe, we analysed both the energy balance of Turkey itself – with regards to trade position and generation dependence – as well as the current condition of its transmission system. As the table below demonstrates, Turkey is a net importer of both energy – all products – and electricity. However, in volume terms, Turkey is not a particularly significant importer of electricity, importing 6.3 TWh in 2016. In all, Turkey imported $325m of electric energy in 2015 (UN Comtrade) of which over half (56.08%) was exported from Bulgaria. Power generation in Turkey is principally dependent on natural gas and coal, primarily bought from Russia and Iran (47.1% by value).

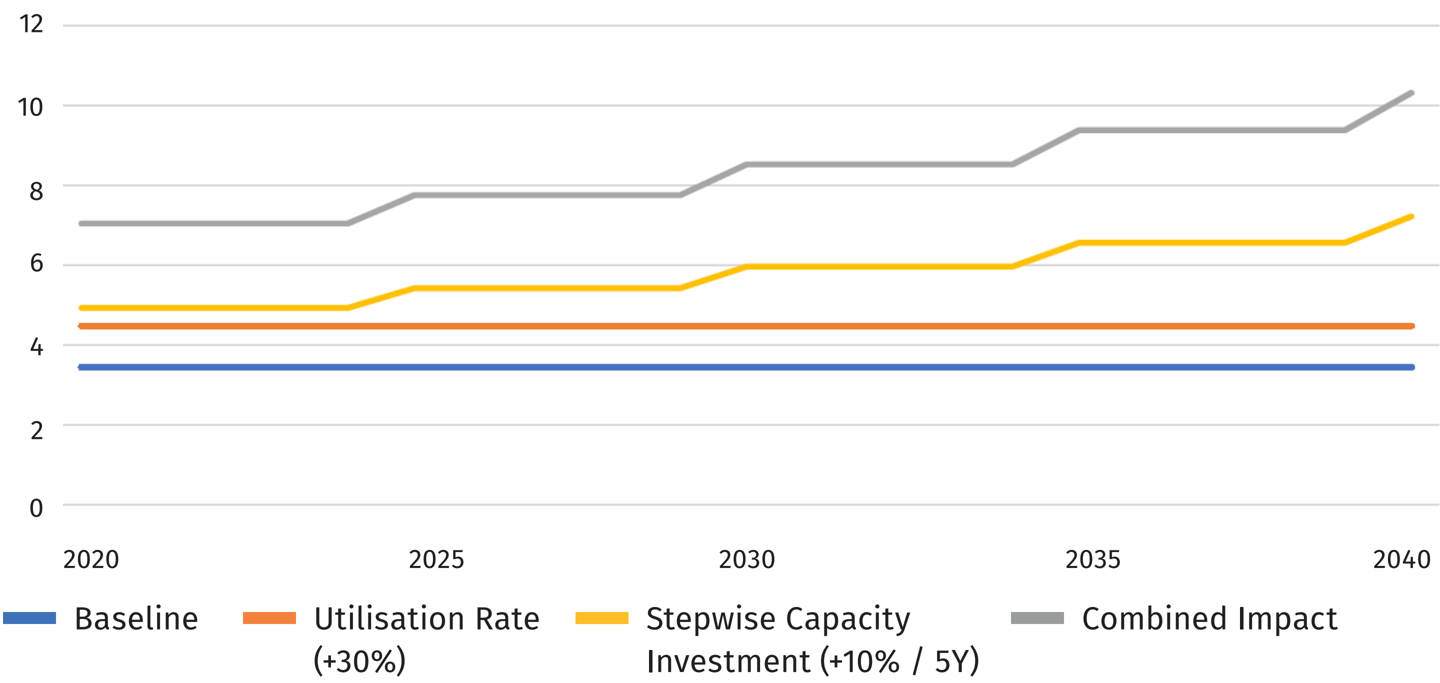
TWh	All Products	Electricity
Gross Inland Consumption	*1 625*	*5*
of which: Primary Production	*413*	
of which: Imports	*1 310*	*6*
of which: Exports	*86*	*1*
Transformation Input	*908*	
Transformation Output	*618*	*191*
Exchanges and Transfers, Returns	*0*	*84*
Energy Branch Consumption	*69*	*15*
Distribution Losses	*36*	*36*
Available for Final Consumption	*1 230*	*228*
Final Non-Energy Consumption	*94*	
Final Energy Consumption	*1 127*	*228*

SECTION 2: BASELINE SCENARIO ANALYSIS

The transmission infrastructure between Turkey and southeast Europe is sparse. As of December 2016, there existed two 380-400 kV AC lines between Turkey and Bulgaria and a single 380-400 kV AC line between Turkey and Greece (ENTSO-E). This transmission infrastructure has an annual capacity of 9.86 TWh (assuming an efficiency rate of 75%). Turkey imported 3.46 TWh of electricity via this system in 2015 – a utilisation rate of 35.1% – and so left 6.40 TWh of capacity unused. Currently, there are no plans to increase transmission capacity, according to the ENTSO-E 2017 Regional Investment Plan.

Our baseline model maintains this position – 3.45 TWh of annual demand – until 2040, which represents an electricity export demand of 72 TWh over the forecast period. Additionally, we modelled the impact of a 30% increase in the utilisation ratio (to 46%) and a stepwise transmission capacity increase of 10% every 5 year, the former leads to an increase of export demand of 30%, the latter of 140%.

Annual Effective Electricity Export Demand from Turkey (TWh)

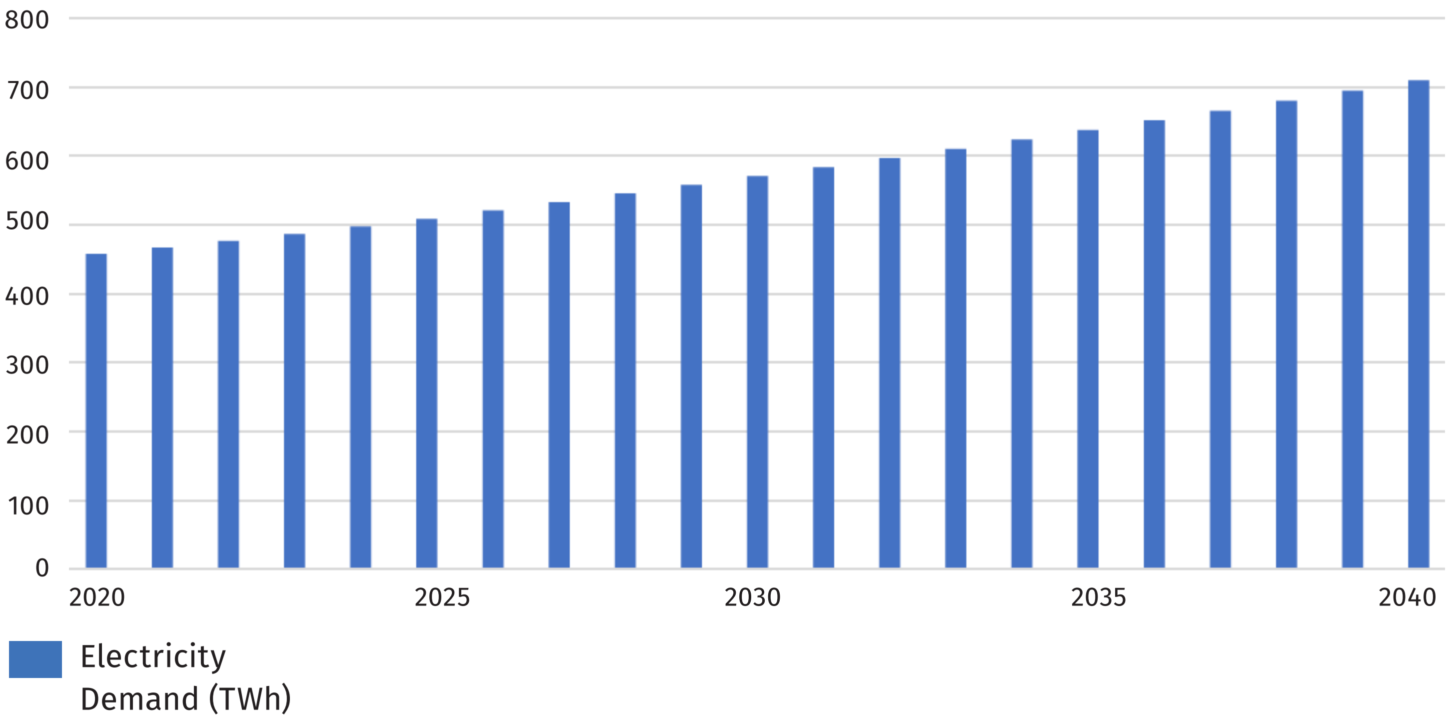


SECTION 2: BASELINE SCENARIO ANALYSIS

WESTERN EUROPE REGION (AUSTRIA, CROATIA, ITALY, AND SLOVENIA)

Electricity consumption in the western Europe composite is projected to rise from 458 TWh in 2020 to 708 TWh in 2040, at a compounded rate of 3.31%. As with Turkey, this increase is driven primarily by growth in total energy use – at an average annual rate of 1.81% over the forecast – and to a lesser degree by growth in the electricity share (1.48%).

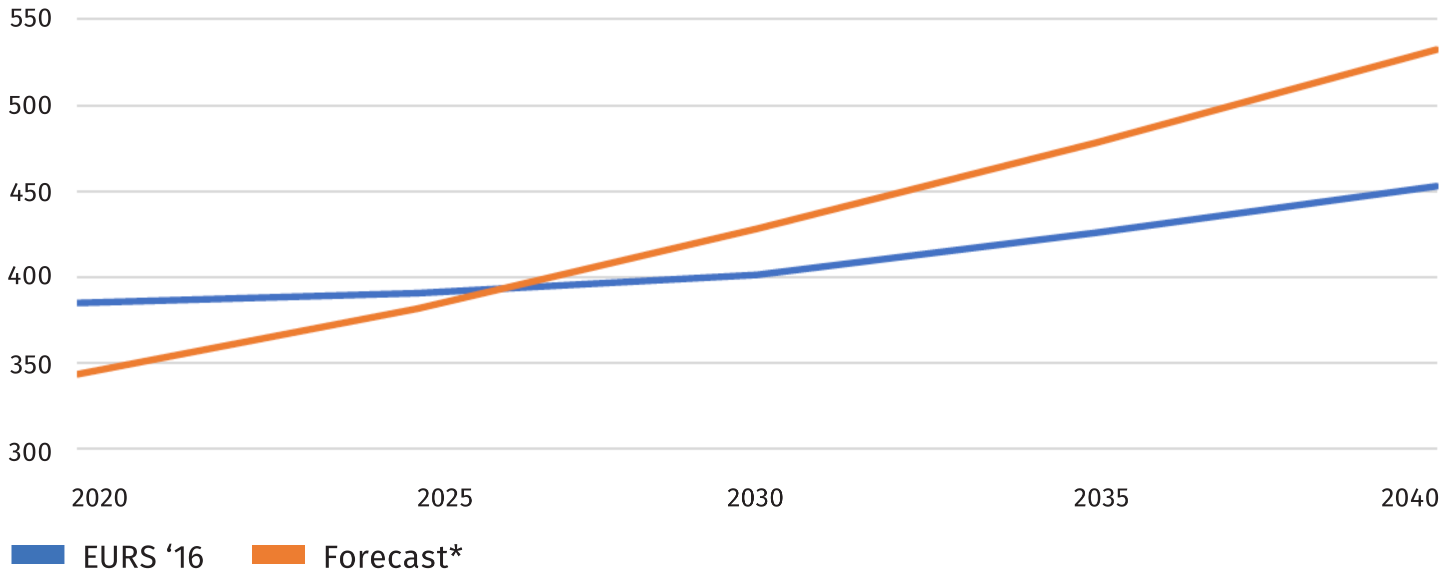
Evolution of Electricity Consumption



As the following graph illustrates, our forecast differs from that presented in the EURS16 (Croatia has been excluded as it is not a member state and so no covered by the EURS16); our forecast compounds at an annual rate of 2.2% whereas the EURS16 does so at rate of 0.8%. The cause of this divergence is – at least in part – due to differing economic growth projections. In Italy, for instance, the EURS16 forecasts growth of 1.19% p.a. between 2020 and 2030 while our model – based upon OECD forecasts – is based upon annual growth of 1.92%. Overall, for the region excluding Croatia, the EURS16 assumes annual growth of 1.25% while our forecast assumes 1.93%.

SECTION 2:
BASELINE SCENARIO ANALYSIS

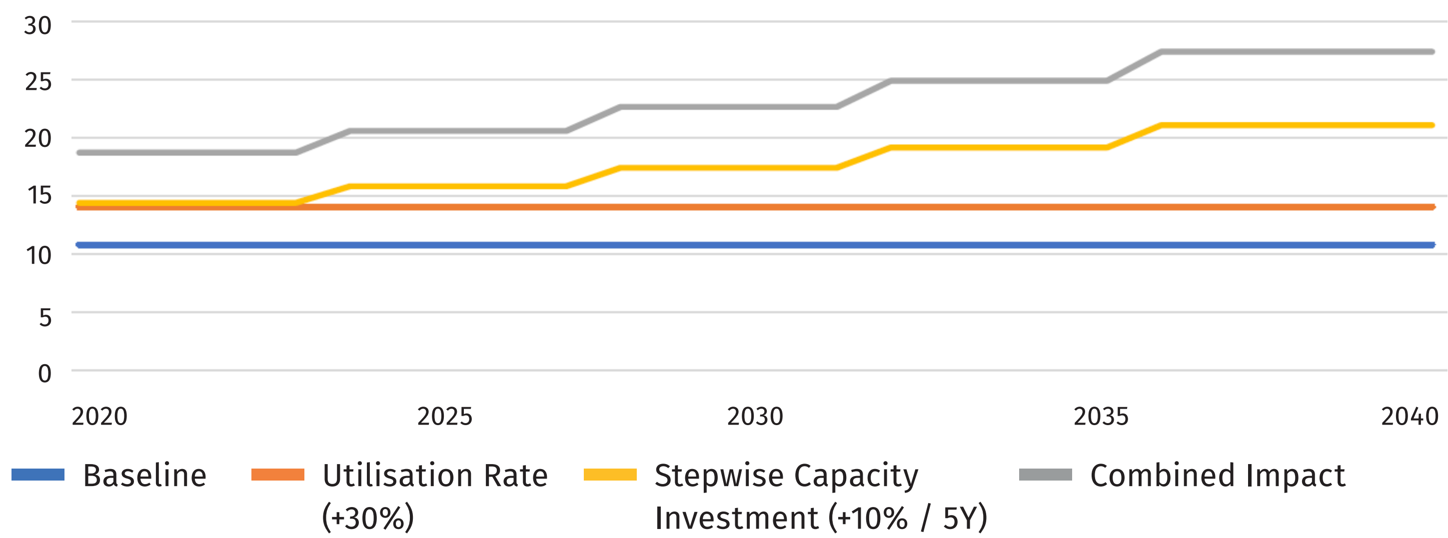
Western Europe Region (ex. Croatia) Electricity Consumption Growth (TWh)



The transmission network connecting the region to southeast Europe has a capacity of 70 TWh (ENTSO-E), with 15.6 TWh of capacity connecting Croatia to Hungary alone. In 2015, the western region imported 10.8 TWh of electrical power from the southeast region (5.44% of total electricity import volume).

Our baseline model maintains this position – 10.8 TWh of annual demand – until 2040, which represents an electricity export demand of 226 TWh over the forecast period. Additionally, we modelled alternative scenarios – varying the transmission utilisation rate and capacity investment – as performed in the analysis of export demand from Turkey.

Annual Effective Electricity Export Demand from Turkey (TWh)



SECTION 2: BASELINE SCENARIO ANALYSIS

SUPPLY

#B

Our baseline supply forecast is based upon the methodology proposed in the EURS16 and BAS reports and so is founded upon similar assumptions, namely that:

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• the EU states will implement measures that align with existing legally binding 2020 targets and EU legislation;
• the non-EU state will continue to implement measures outlined in their existing energy policies;
• the investment rate in the energy sector remains unchanged throughout the forecast period;
• explicit targets for CO_2 emissions or renewables for 2040 will not be agreed upon or implemented;
• and, that national debt – public and external – relative to GDP will remain largely unchanged (with the exception of Greece, whose national debt profile remains volatile in the wake of the national debt crisis).

CAPACITY

#1

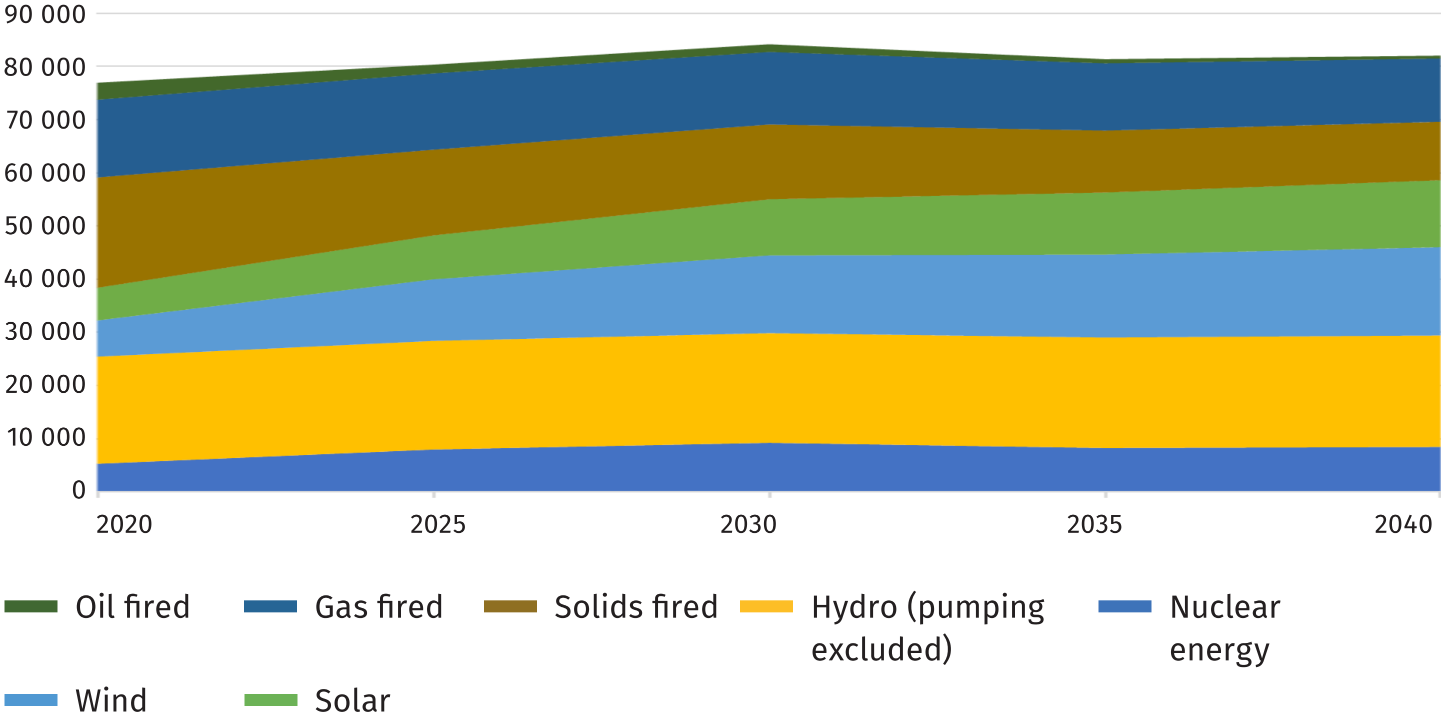
As indicated in the diagram below, our baseline supply scenario indicates that net generation capacity in southeast Europe will rise over the forecast period, from 78,214 MW in 2020 to 83,674 MW in 2040. Over the same time period, the share accounted for by baseload generation – here defined as thermal and nuclear power – is forecast to decline from 57.0% to 39.4%, while the proportion provided by renewable energy sources (excluding hydropower) rises from 17.2% to 35.5%.

Unsurprisingly, given the conditions of the EURS16 forecast and its implied partial phase-out of coal, the contribution of coal-fired thermal power exhibits the sharpest decline, falling from 20,734 MW in 2020 (26.5% of total net generation) to 10,949 MW in 2040 (13.1%).

The evolution of net nuclear power capacity is not unidirectional; starting at 5,294 MW in 2015, it rises to 9,230 MW in 2030 before falling to 8,440 MW in 2040. This dynamic is caused by Hungary, which is forecast to expand nuclear capacity until 2030 at which time it starts to decrease.

SECTION 2: BASELINE SCENARIO ANALYSIS

Capacity by Energy Type (MW)



GENERATION

#2

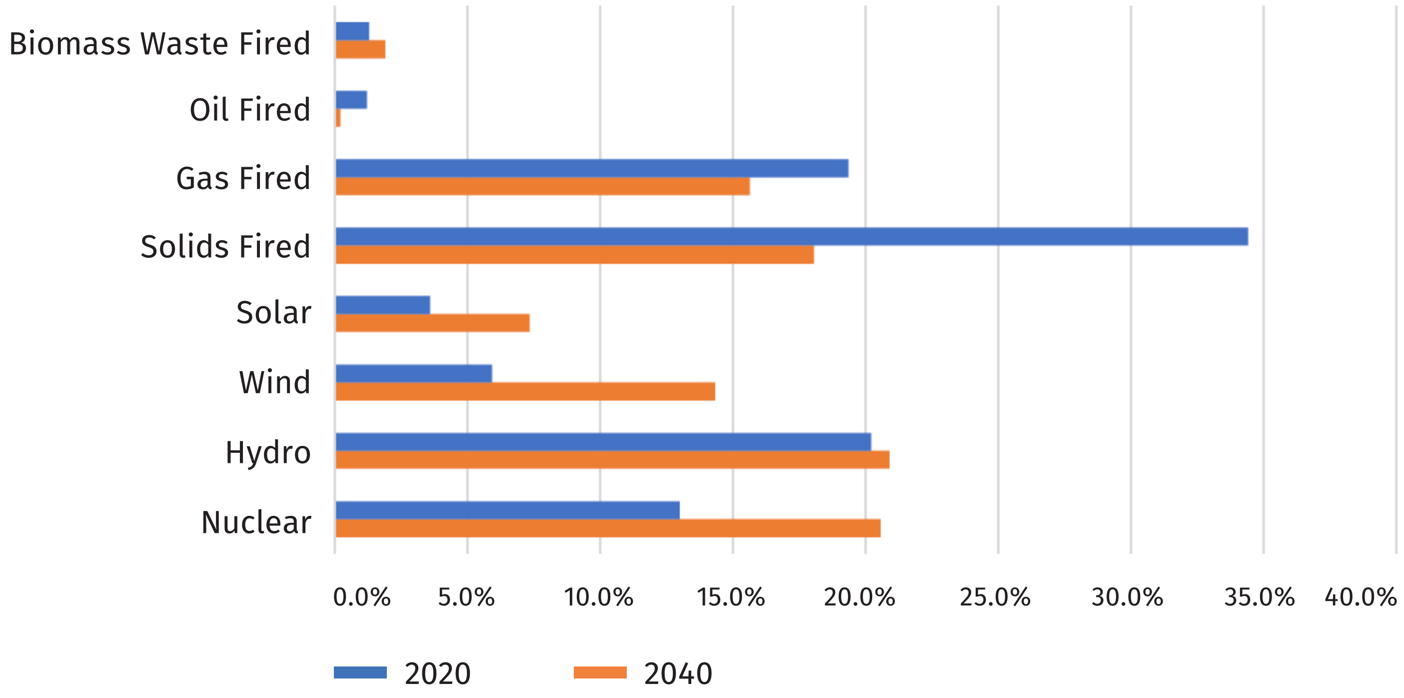
To quantify and evaluate generation, we applied an appropriate capacity factor – defined as the average of the capacity factors achieved in the United States (EIA) and the EU-28 (EURS16) – to each source of energy. It should be noted that the actual factor achieved for a given energy type in a particular location is dependent on both the quality of local energy infrastructure and the configuration of the national energy mix.

Nuclear	*86.7%*
Solids	*58.6%*
Oil	*13.3%*
Gas	*46.8%*
Biomass-Waste	*62.1%*
Hydro	*35.4%*
Wind	*30.7%*
Solar	*20.6%*
Geothermal and Other Renewables	*63.9%*

SECTION 2: BASELINE SCENARIO ANALYSIS

Our baseline projection indicates that generation in southeast Europe will remain steady over the forecast period, reaching 310 TWh in 2020 and 312 TWh in 2040. There is a peak of 330 TWh in 2030 that is the result of the aforementioned fluctuations in nuclear energy capacity in Hungary. However, while the headline figure changes only slightly, the composition of electricity generation undergoes a pronounced shift; in particular, the prominence of coal deteriorates, accounting for 34.4% of total generation in 2020 and only 18.1% in 2040. The decline in coal is offset by rises in renewable sources – wind and solar – and nuclear power of 12.1% and 7.6% respectively.

Evolution of Generation Composition



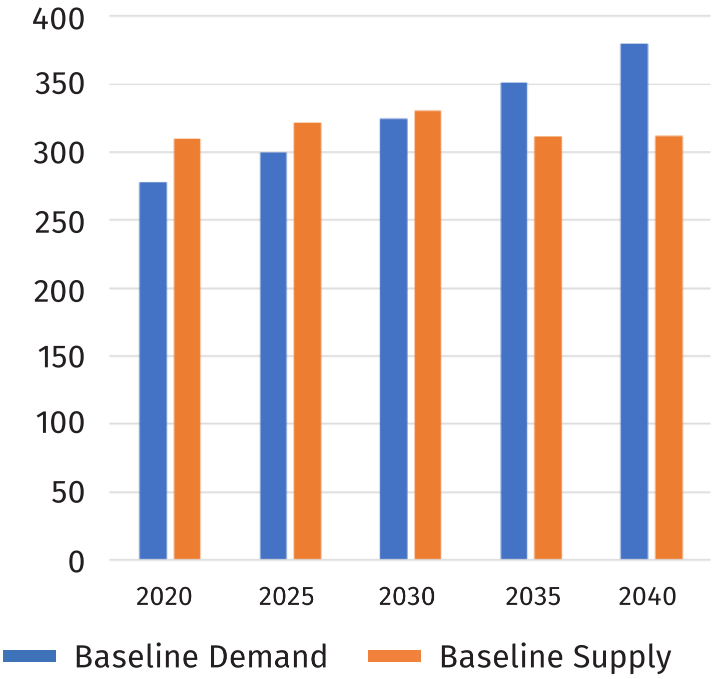
SECTION 2: BASELINE SCENARIO ANALYSIS

THE MARKET FOR ELECTRICITY

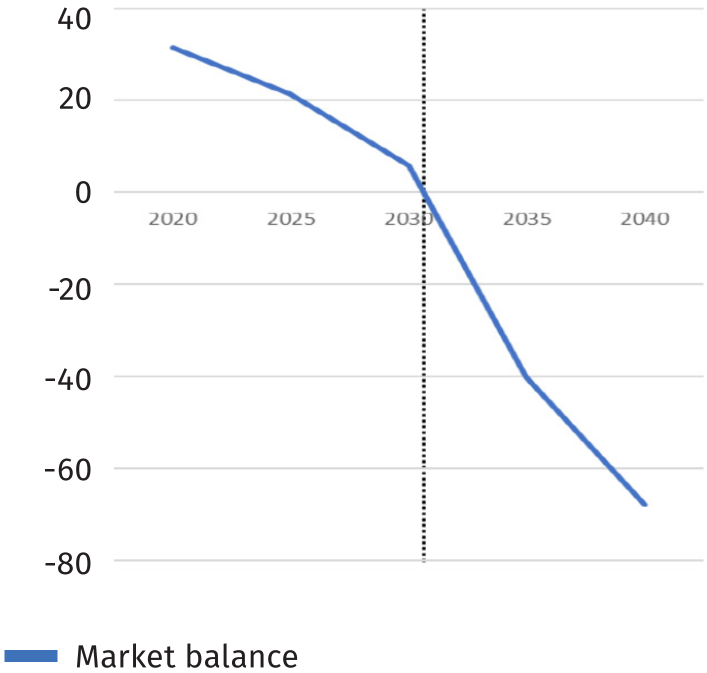
#3

The baseline market forecast is established upon the analysis detailed thus far. As illustrated below, the baseline scenario indicates that the electricity market will enter deficit in 2031 (2.3 TWh). Subsequently, the electricity deficit widens, to 40 TWh in 2035 and 68 TWh in 2040.

Supply and Demand (TWh)



Market Balance (TWh)



As noted previously, the capacity provided by coal-fired power plants as projected in the EURS16 and BAS reports has not been modified or altered. However, it should be noted that the European Coal Plant Database indicates that 9,213 MW of new capacity has been announced or is in pre-permit in southeast Europe (the ten largest projects are shown below). Given the growing political census – amongst European lawmakers and citizens alike – for an accelerated coal phase-out, these projects must be regarded as controversial and perhaps ultimately unviable. Moreover, with the exception of a single 129 MW plant in FYR Macedonia, the proposed coal-fired capacity expansions are to be lignite-fired, a rank of coal with unit CO_2 emissions second only to anthracite (216 lbs of CO_2 per million Btu compared to 227 lbs, according to EIA data).

SECTION 2: BASELINE SCENARIO ANALYSIS

Unit Name	Country	Project Status	Capacity (MW)	Fuel Type
Rovinari Power Station Unit 7	*Romania*	*Pre-permit*	*600*	*Lignite*
New Kosovo power station	*Kosovo*	*Pre-permit*	*500*	*Lignite*
Matra power station Unit 6	*Hungary*	*Pre-permit*	*500*	*Lignite*
Meliti-II	*Greece*	*Announced*	*450*	*Lignite*
Tuzla Thermal Power Plant Unit 8	*Bosnia and Herzegovina*	*Announced*	*450*	*Lignite*
Tuzla Thermal Power Plant Unit 7	*Bosnia and Herzegovina*	*Permitted*	*450*	*Lignite*
Kolubara B Power Station Unit 1	*Serbia*	*Announced*	*375*	*Lignite*
Kolubara B Power Station Unit 2	*Serbia*	*Announced*	*375*	*Lignite*
Nikola Tesla B Unit 3	*Serbia*	*Announced*	*375*	*Lignite*
Nikola Tesla B Unit 4	*Serbia*	*Announced*	*375*	*Lignite*

Source: *European Coal Plant Database*

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

In this section of the report, we shall present our alternative forecast based upon a 'New Trends and Policies' scenario. On the demand side, this scenario acknowledges the impact of impending technological disruptions – the consequences of both the electric vehicle revolution and the widespread adoption of energy-intensive data-processing technologies on electricity consumption. On the other hand, in terms of supply, we analyse the effect of an accelerated coal phase-out – brought upon by stricter emission targets and vociferous legislative support for decarbonisation – on system capacity and generation.

DEMAND

#A

We shall now assess the impact of several impending technological 'shocks' on electricity demand in southeast Europe and relevant external markets. In particular, we shall focus upon two significant developments.

ELECTRIC VEHICLES:

To date, the use of electric vehicles has been restrained by two core factors: the upfront acquisition cost (in the absence of national subsidies, consumers in Europe have to pay a premium of up to 100% for smaller vehicles, according to the European Environment Agency (EEA)) and the absence of a dense, connected charging infrastructure. As a result, only 150,000 new plug-in hybrid and battery electric vehicles were sold in the EU in 2015 (moreover, six individual member states accounted for almost 90% of this total), which represented 1.2% of all new car sales. Today, only 0.15% of passenger vehicles in the EU are electric.

However, the electric vehicle is gradually being embraced by policymakers and political leaders in the EU and beyond (India, for example, has set itself the target of ensuring that all new passenger vehicle sales are electric by 2030; meanwhile, the Chinese vehicle market contains 400 types of electric vehicle compared to Europe's six (EU Climate and Energy Commissioner, Miguel Arias Canete)) due to the increasing prevalence – post-Paris Agreement – of binding commitments to reduce CO_2 emissions. While the environmental cost of producing an electric vehicle currently exceeds that required to build a conventional vehicle – requiring approximately 70% more primary energy – the in-use environmental cost – exhaust emission – is nil.

Therefore, the electric vehicle is on the path to ubiquity, especially in the EU, which has pledged to cut greenhouse gas emissions to at least 40%

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF ‘NEW TRENDS AND POLICIES’

below 1990 levels by 2030 (and by 80-95% by 2050) and whose policy-makers see it as a powerful tool in achieving these targets. Tangible policy support – such as the ‘Green eMotion’ initiative – will accelerate electric vehicle adoption beyond that which would otherwise be expected (based on decreasing costs and improving performance). Consequently, this will result in an increase in electricity demand – the comprehensive environmental impact of electric vehicles will in turn depend on the energy source used to supply the required electricity – whose volume is as yet unclear (although the EEA have forecast that if 80% of cars were electric in 2050, an additional 150 GW of electric power generation would be required).

DATA PROCESSING:

The projected growth of data usage – particularly of mobile data – cannot be understated.

The Cisco Visual Networking Index 2016-2021 (Cisco VNI) presents a number of striking statistics, including that:

!!!

- global internet traffic in 2021 will be equal to 127 times the volume of the entire internet in 2005;
- total monthly IP traffic will reach 278,108 PB by 2021 (tripling the 2016 figure), growing at an annual rate of 24%;
- and, mobile data will reach 48,270 PB per month by 2021, growing at a rate of 46% per year.

An inevitable upshot of this development is an associated expansion in data processing capacity. It is estimated that total data centre traffic (within or exiting) will reach 17.5 ZB per year (17,500,000 PB) by 2021 (Cisco); the largest component of total data centre traffic is forecast to be internal (within) data centre traffic, which is forecast to reach 14.7 ZB per year by 2021.

In our analysis, we shall focus on two specific drivers of data-processing demand, the Blockchain and the Internet of Things (IoT).

BLOCKCHAIN TECHNOLOGY

#1

The blockchain – not to be confused with the bitcoin cryptocurrency with which it has mistakenly become synonymous – is a shared ledger than can be examined by any individual but that no single individual controls. An unintended by-product of cryptography research, the blockchain functions – and indeed, is to be trusted – by relying on the finding of original pieces of code, known as a 'hashes', that are added to the ledger with each transaction and prevent anyone from tampering with it.

The notion of protected databases (with both public and private access) has attracted a significant amount of interest beyond the cryptocurrency space. The World Food Programme (WFP), for instance, has installed an internal blockchain-payments system to reduce bank fees associated with currency transfers (the WFP distributes $1.4 billion annually in the form of food vouchers and digital entitlements, according to its director, Robert Opp). Likewise, Lantmäteriet, the Swedish land registry, has made significant steps towards transferring their work to the Blockchain, with the aims of reducing cost and the risk of fraud. In a world in which 70% of the population lack access to land titling (World Bank) this single application has a potentially wide-ranging effect.

With regards to energy demand, it is the computational processing requirements – critical to the 'proof of work' algorithm by which new codes are calculated – that are of particular note. As of March 2018, the Bitcoin Energy Consumption Index estimates that the electricity consumption associated with Bitcoin alone is comparable to that of Israel, amounting to an estimated annual electricity consumption of 55 TWh (or 0.25% of global electricity consumption). As noted above, Bitcoin represents a fraction, albeit one that has attracted the majority of media attention, of the potential uses for Blockchain technology and so the anticipated impact of its widespread adoption on electricity consumption will be far greater.

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF ‘NEW TRENDS AND POLICIES’

THE ‘INTERNET OF THINGS’

#2

The IoT is defined as “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies” (International Telecommunication Union (ITU)). In substance, the IoT is a network of information in which devices – physical and virtual – are interconnected and ‘talk’ to one another; communication can adopt three forms: information collection, monitoring, and data analytics. Given the prevalence of sensors – devices that detect changes in their environment and communicate that information to other electronic devices – in modern technology, IoT devices – reliant upon electrical power - collect a significant volume of data. This trend is amplified by the rise in the number of networks devices per capita (reaching 3.5 in 2021, from 2.3 in 2016).

It is the prospect of analysing the data collected by the IoT – using ‘big data’ analytical tools – that has generated the most interest, from households, businesses, and governments, due to its potential value in improving process efficiency and outcomes. A survey of business executives conducted by SAP, reported that the IoT’s capacity to improve productivity was regarded as its most tangible benefit to enterprise (78%), followed by the ability to automate processes (72%) and to better manage value chains (64%). The Boston Consulting Group (BCG) has identified predictive maintenance, self-optimising production, and remote patient monitoring (in healthcare) as the three IoT use cases that will attract the most investment up to 2020. The data processing vital to these functions – beyond the energy use of the IoT devices themselves – will drive electricity demand growth.

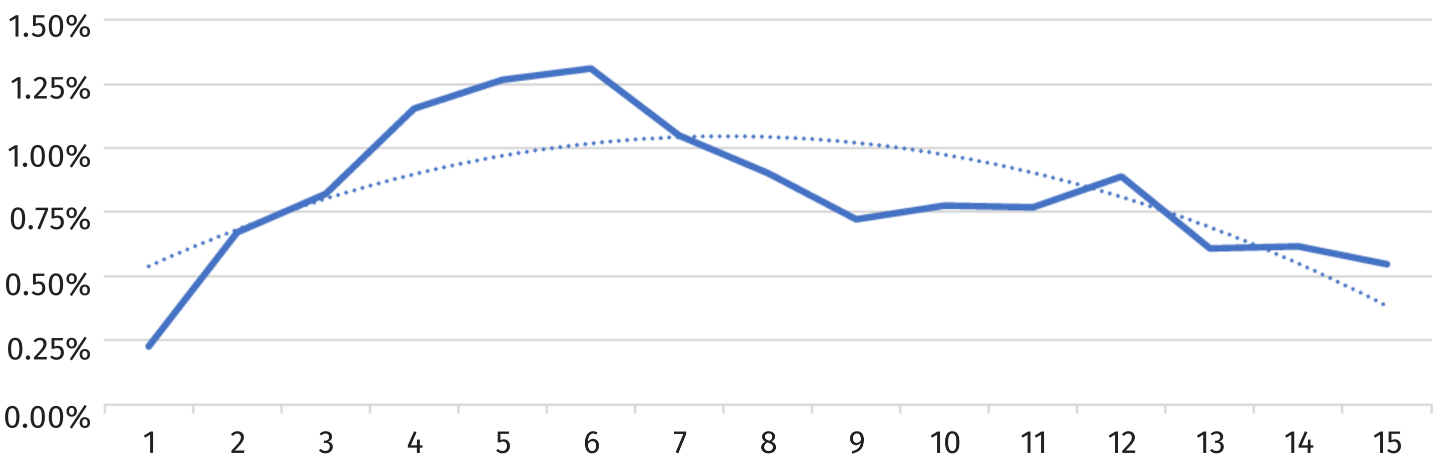
To date, according to the BCG, the use of IoT has been driven by ‘specific use case scenarios’ and has been primarily employed to automate existing business practices (Cisco), but the development of complementary technologies – cloud computing, machine learning, and the Blockchain – has greatly expanded its scope and potential impact. The projected increase in IP traffic per capita from 13 GB in 2016 to 35 GB in 2021 has also amplified the potential impact of the IoT.

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

TECHNOLOGY DISRUPTIONS - QUANTIFYING THE EXOGENOUS INCREASE IN ELECTRICITY USE

To assess the impact on electricity demand of the factors above, we first sough to quantify the impact of similar technological disruptions that have occurred in the past. To do this, we used our model of electricity demand – as described in the baseline scenario – to 'predict' historical electricity consumption in OECD members. We selected the OECD based upon our assumption that the effects of a new technology would be more pronounced in the most developed nations. The pattern of a typical technology-caused deviation from predicted electricity share was then derived. Periods of technological innovation – as illustrated by the simplified diagram below – act as exogenous disturbances on the electricity share that are associated with positive deviations from trend.

Typical Residual Pattern (Deviation from Predicted Electricity Share)



The most noteworthy example of this phenomenon is the creation and subsequent application of the Internet. This caused a positive deviation in the electricity share as computers began to consume more electricity. However, as technical infrastructure evolved and the allocation of system energy adjusted, the positive deviation was eroded and the electricity share returned to trend. As illustrated, this cycle – and indeed similar cycles, such as the rise of household appliances in the 1970s and the surge in personal computing in the late 1990s and early 2000s – occurred together with an increase in the electricity share of 0.5% to 1% over a period of 15 years.

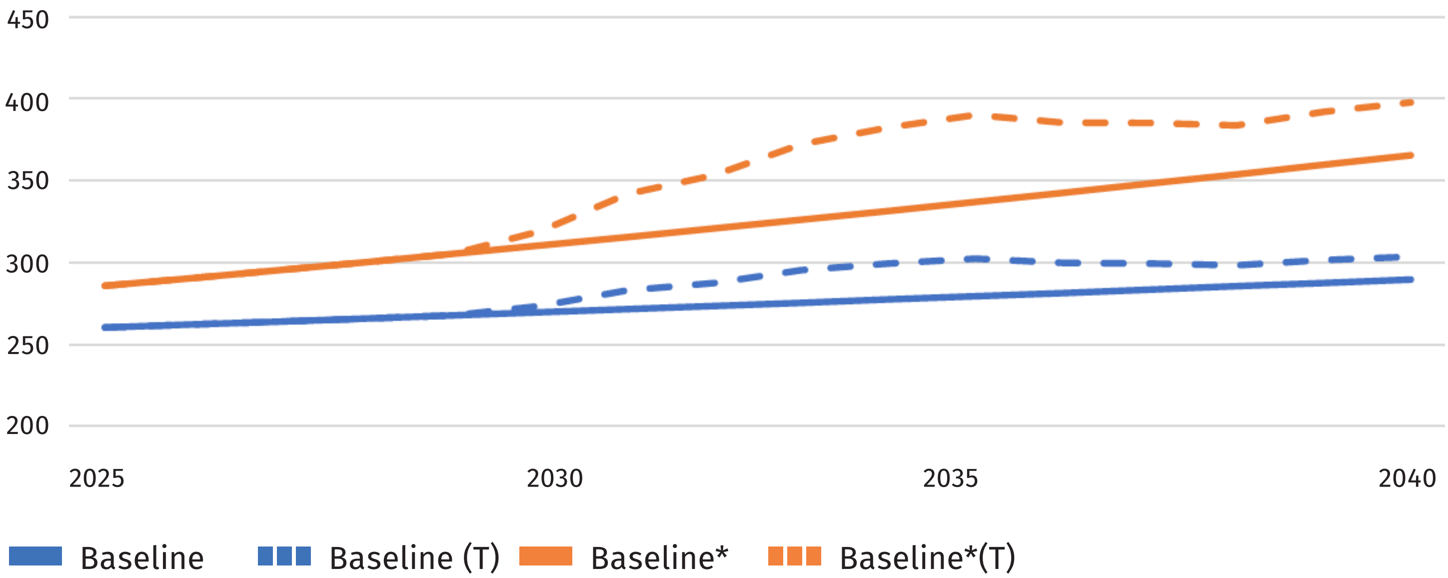
SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

Technology Disruptions – Impact on Overall Electricity Demand

Southeast Europe:

To quantify the impact of technological disruption on electricity demand in southeast Europe, our forecast was modified to account for a transitional period of above-trend electricity share. The disruption was assumed to first impact southeast Europe in 2030 and so last until 2045. Compared to our baseline forecast, electricity consumption increases by 5.02% over the disruption period. In detail, the largest upwards deviation occurs in 2033 – the fourth year of the disruption period – at which time electricity consumption rises by 14.1% (compared to the unmodified demand forecast).

Incremental Effect of Technological Shock on Electricity Demand (TWh)



External Markets

To model the impact on external electricity demand in southeast Europe, two assumptions were made, namely that:

1: the impact of the exogenous shock will be felt in western Europe in 2025 and in Turkey in 2040;

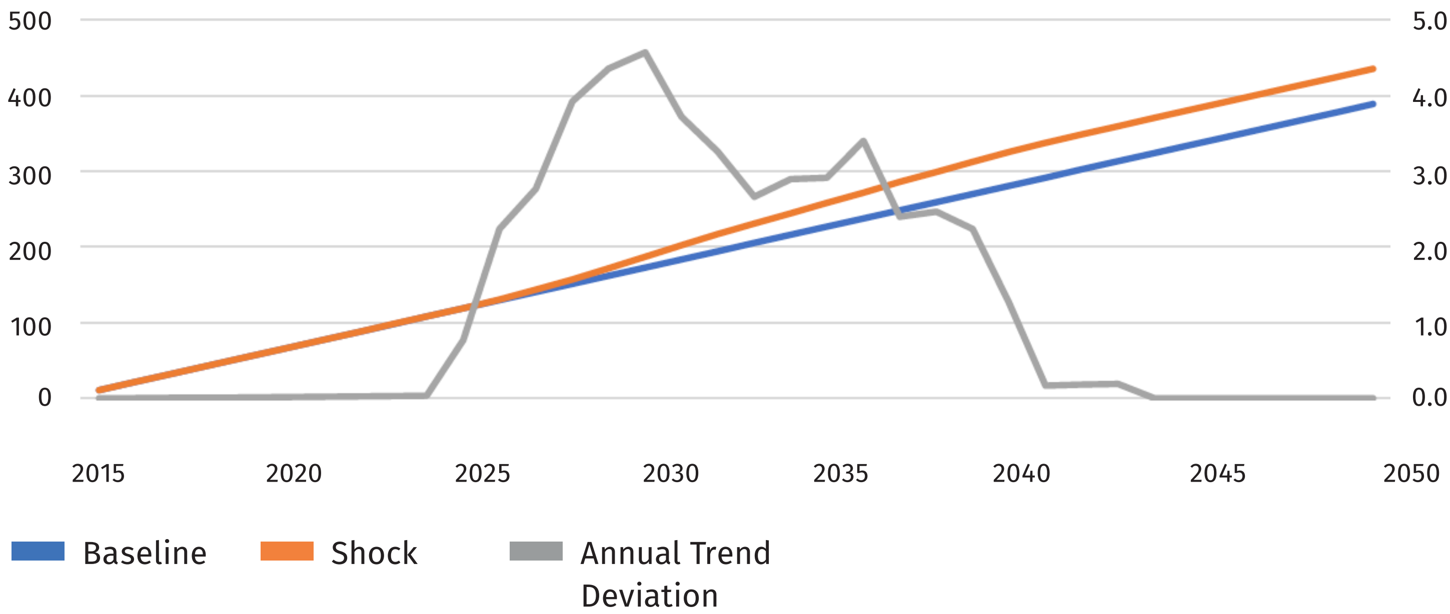
2: the additional electricity demand will be met wholly by imports;

3: and, the proportion of additional demand met by an individual trade partner will equal its pre-shock value.

As such, only the impact on western Europe shall be analysed, the impact on Turkey occurring beyond our forecast horizon.

To estimate the impact of higher electricity demand in western Europe, we again modified our demand forecast and included transitory deviations as per southeast Europe. Subsequently, using UN Comtrade data, we calculated the proportion of western European electricity import demand that was supplied by southeast Europe (11.21%). To conclude, the baseline demand forecast was joined to the transitional disruption impact and an adapted model of effective export demand established.

The Cumulative and Discreet Impact of Technological Shock on Effective Southeastern Europe Export Demand (TWh)



SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

#B

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SUPPLY

Our alternative supply model is based on three assumptions, that:

• the pace of a pan-European coal phase-out, a key part of EU-driven decarbonisation efforts, accelerates;
• the unit cost of carbon emissions – the price of an EUA – increases as per the EURS16;
• and, that as the marginal cost of coal-fired electricity production rises – principally caused by the two preceding conditions – plant activity decreases.

To incorporate these assumptions in the function of the supply forecast, we:

!!!

• identified all coal-fired capacity in southeast Europe in excess of 50 years old by 2025 and withdrew it from the model with a five-year delay, so, for example, all coal-fired capacity commissioned before 1975 was withdrawn in 2030;
• evaluated the marginal production decision of coal producers – using EURS16 forecasts for coal and EUA prices as well as the average cost of electricity production in the EU-28 – and proportionately reduced the capacity factor of coal-fired production from the time at which this margin becomes negative (2033) to imitate the producer response.

Otherwise, the alternative supply model operates as per the baseline supply model.

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

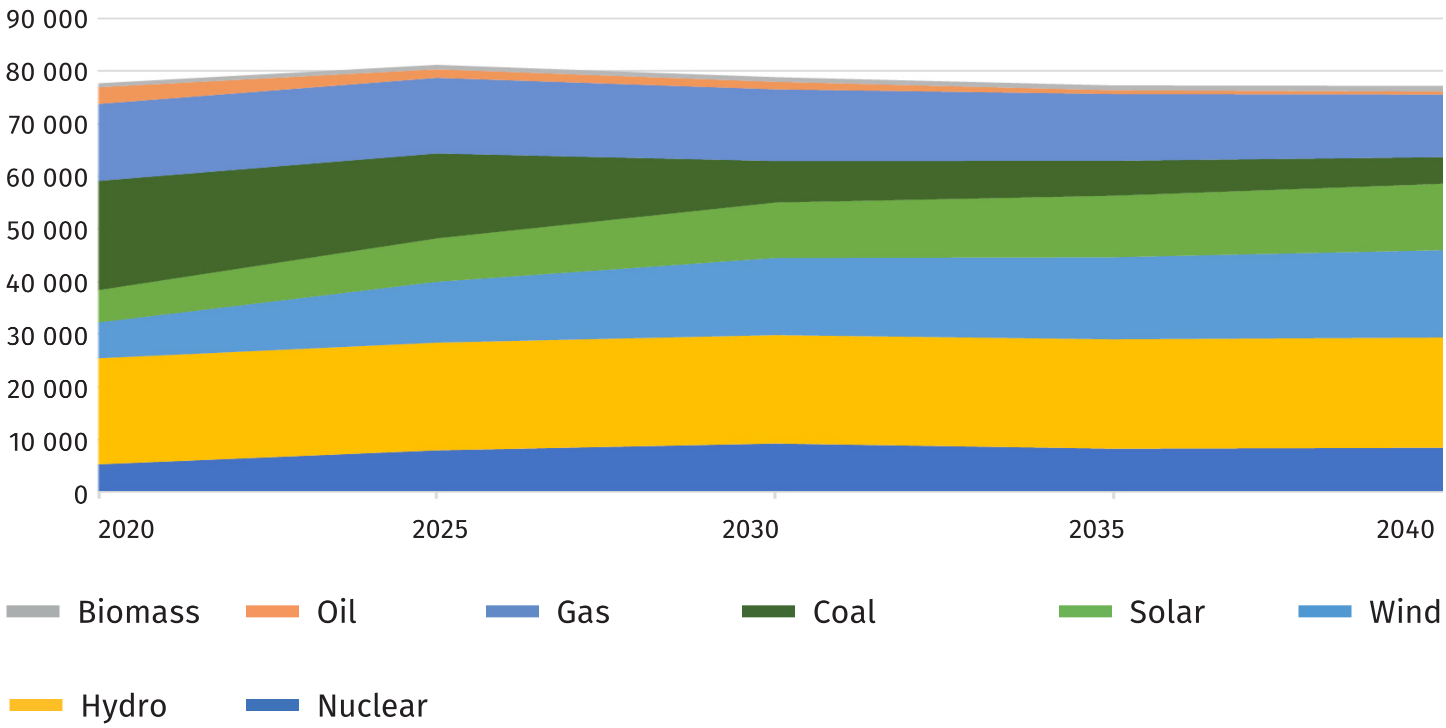
CAPACITY

#1

The alternative forecast for net generation capacity in southeast Europe exhibits a decrease by 0.6% over the projection horizon, from 78,124 MW in 2020 to 77,747 MW in 2040. The enforced decommissioning of old coal-fired plants that is included in the alternative model causes a sharp drop of 75.8% in coal-fired capacity, from 20,734 MW in 2020 to 5,022 MW in 2040 (compared to 10,949 MW in the baseline forecast).

The loss of 20,278 MW of thermal-fired production – including natural gas and oil as well as coal – over the course of the forecast is partially offset by an increase in renewable energy source capacity of 17,115 MW.

Capacity by Energy Type (MW)



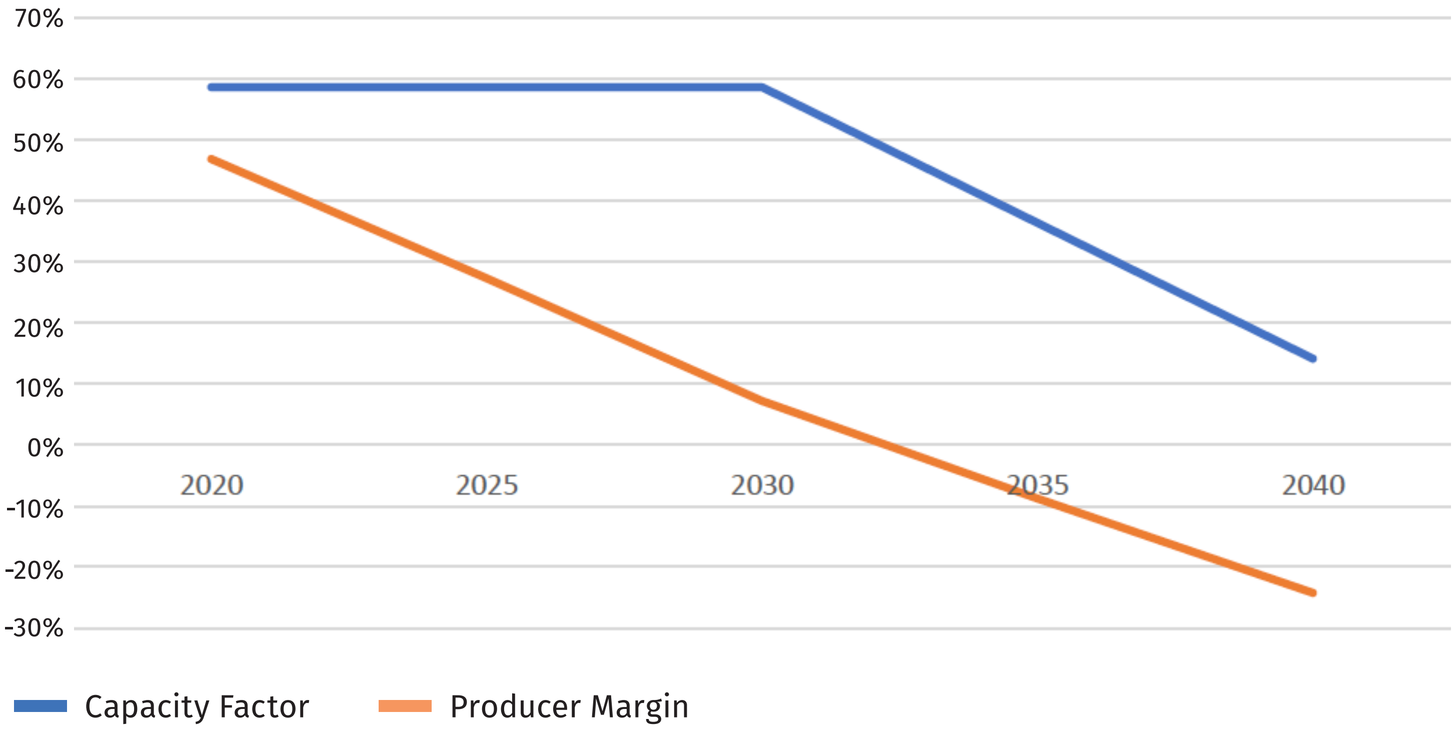
SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

#2

GENERATION

As per the baseline analysis, a capacity factor – taken as the average of capacity factors observed in the United States (EIA) and in the EU-28 (EURS16) – was applied to each energy source to forecast real generation. The single exception to this procedure was made with regard to coal – as per the assumptions described at the start of this section – which was decreased in line with the production margin faced by coal producers post-2033 (at which point the margin becomes negative).

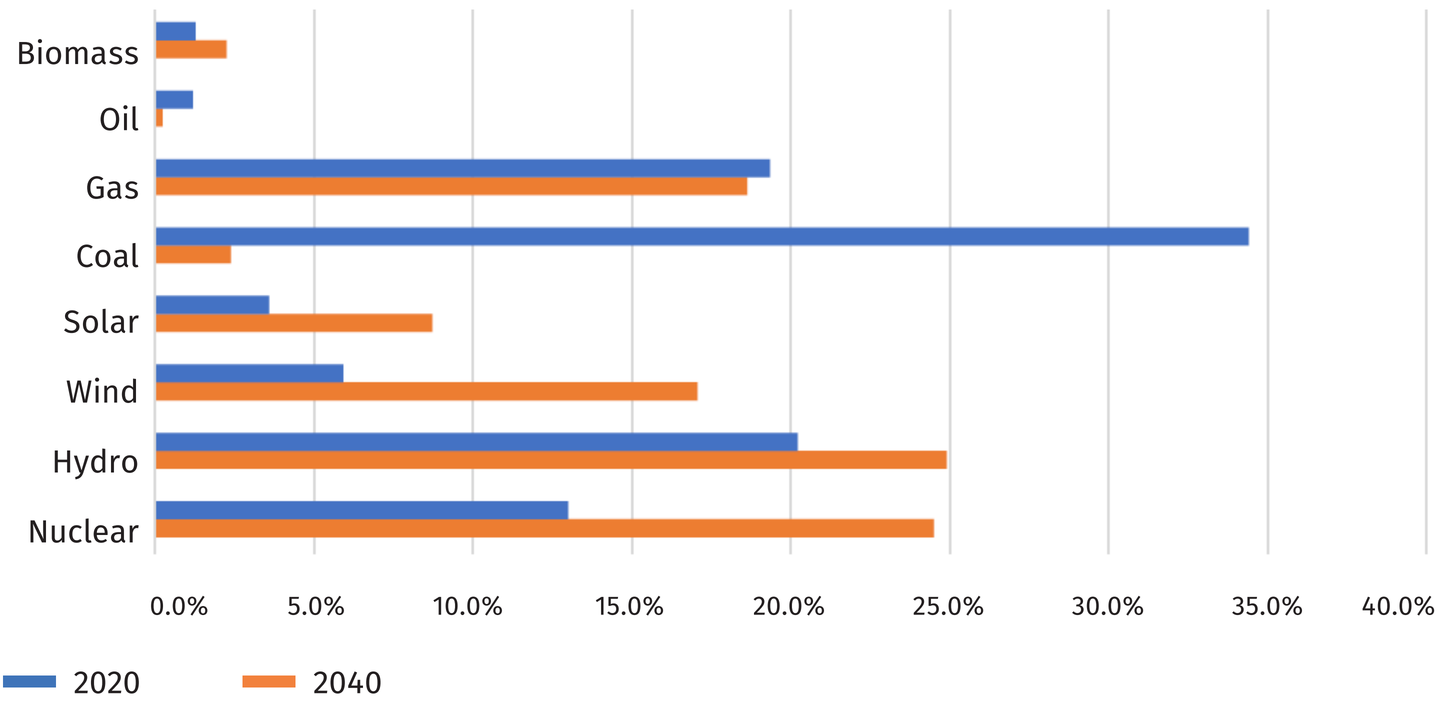
Coal-Fired Capacity Factor and Producer Margin



SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

Overall, the alternative supply model forecasts a generation decrease of 15.5% (from 310 TWh to 262 TWh) over its duration. The combined effect of reducing coal-fired capacity and decreasing the capacity factor of coal is to diminish coal-fired electricity generation from 107 TWh in 2020 to 6 TWh in 2040 (a fall of 94.2%). A secondary impact of the alternative scenario assumptions is that the share of low-carbon energy sources – nuclear, hydropower, wind, and solar – in total generation rises from 43% to 75% over the forecast period. It should also be noted that baseload generation – based on nuclear and carbon-fired sources – as a share of total generation falls from 69% to 48%. Generation from baseload energy sources amounts to 126 TWh in 2040, down from 214 TWh in 2020.

Evolution of Generation Composition



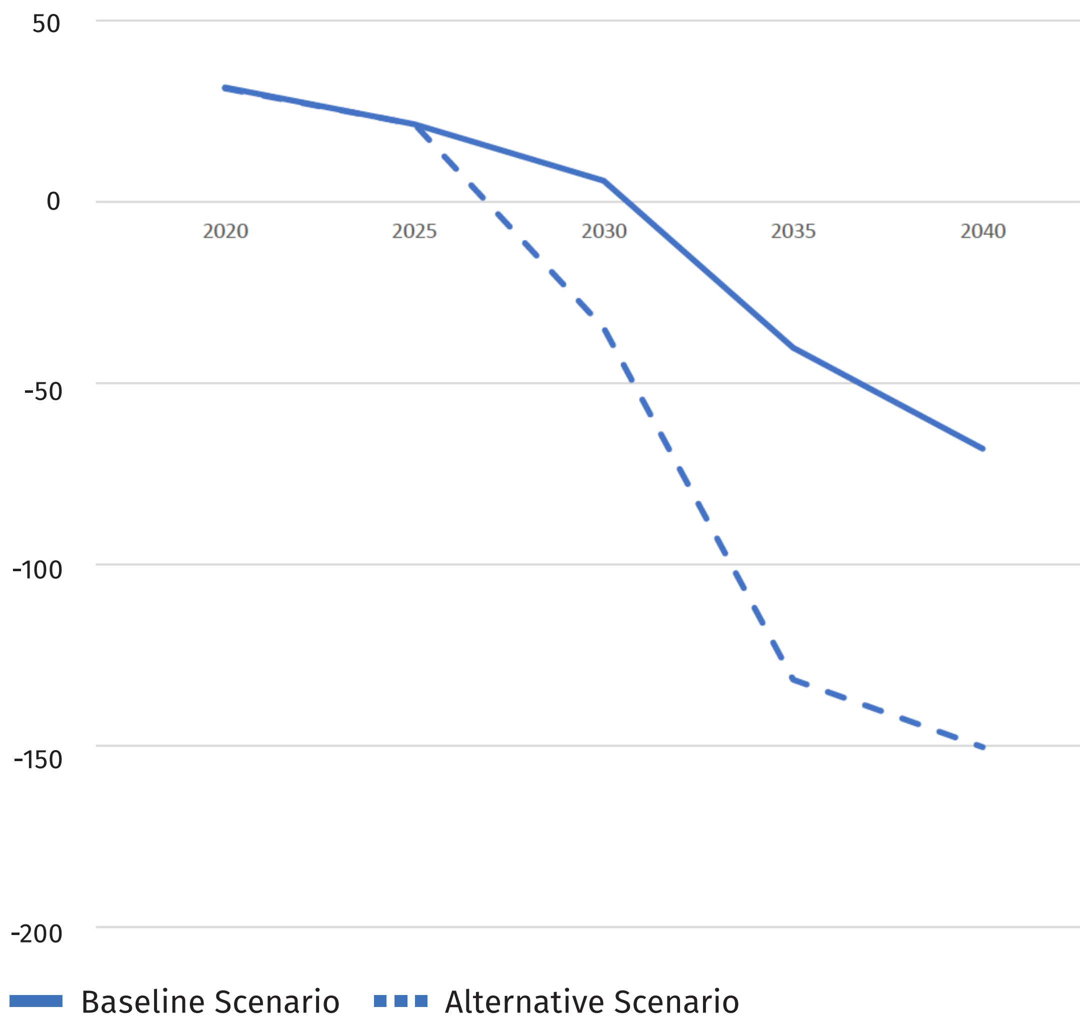
SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF ‘NEW TRENDS AND POLICIES’

THE MARKET FOR ELECTRICITY

#C

The alternative market forecast – the ‘New Trends and Policies’ scenario – incorporates the demand and supply analysis above. As illustrated below, the alternative scenario demonstrates that the electricity market in southeast Europe will enter deficit in 2027 (1 TWh), widening to 35 TWh, 132 TWh, and 150 TWh in 2030, 2035, and 2040 respectively.

Market Balance (TWh) — Scenario Comparison



SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

THE DEFICIT

#D

In this subsection, we shall identify and analyse the alternative means by which the 150 TWh deficit in 2040 could be met. In particular, we shall focus on the capacity required of each energy type – were the deficit to be met by a single energy type – and quantify the expected volume of CO_2 emissions of each alternative. Finally, we shall highlight the risks – from a political as well as an energy-minded viewpoint – inherent to each course of action.

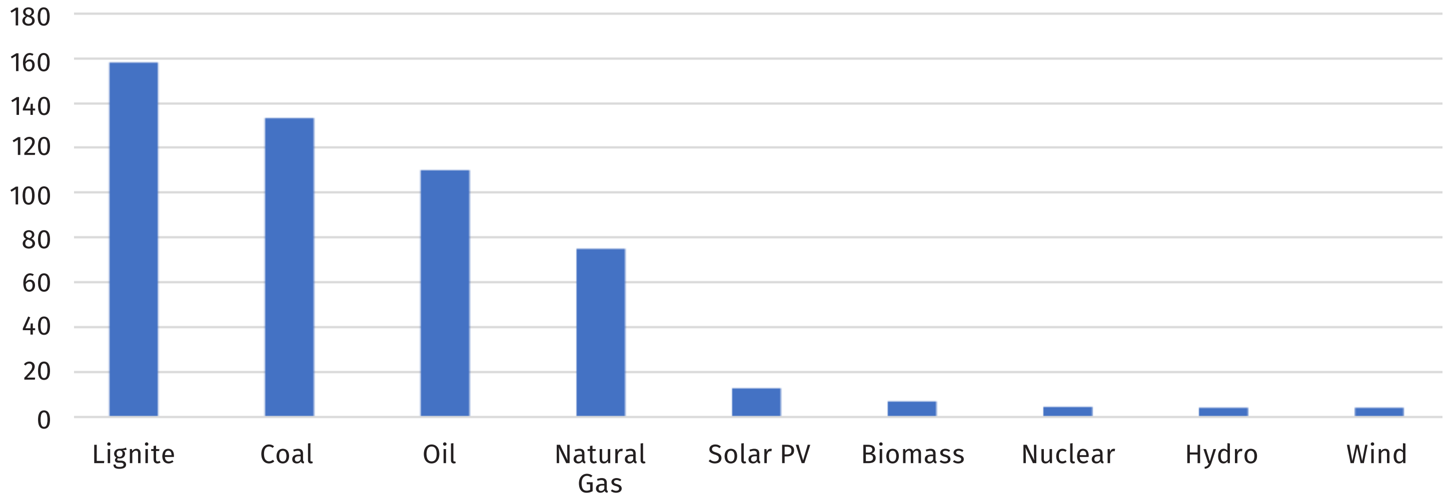
Firstly, by applying the individual capacity factors already used in this report, the requisite installed capacity for each energy type to supply the deficit electricity was calculated. Unsurprisingly, given in its low capacity factor – 13.3% – oil-fired generation would necessitate the largest capacity installation, 128,376 MW in total, followed by solar energy, requiring 83,044 MW of capacity. Nuclear power, on the other hand, could fulfil the deficit generation with the lowest installed capacity, 19,756 MW in total, before biomass-fired capacity, requiring 27,556 MW.

Required Capacity (MW)	
Biomass	*27 556*
Gas	*36 617*
Hydro	*48 321*
Nuclear	*19 756*
Oil	*128 376*
Other Renewables (incl. Geothermal)	*26 802*
Solar	*83 044*
Solids	*29 200*
Wind	*55 718*

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF 'NEW TRENDS AND POLICIES'

To continue the analysis, the expected volume of CO_2 equivalent emissions implicit in each type of electricity generation was calculated, using mean figures published by the World Nuclear Association[7] (WNA). This analysis illustrates that to meet the electricity deficit with coal-fired generation would be the most carbon-intensive strategy, leading to an additional 133 million tonnes of CO_2 emissions. Indeed, this figure should be regarded as a lower-bound estimate as southeast Europe relies heavily on the lignite rank of coal, which at the higher end of the carbon-intensity spectrum of solid fuels. As such, should lignite be used to meet the entire deficit, CO_2 emissions of up to 158 million tonnes would occur.

Electricity Deficit - CO_2 Emissions per Energy Type (million tonnes of CO_2 equivalent)



Finally, we present a brief review of technical and political considerations for each energy type.

For carbon-intensive energy sources, the principal concerns relate to energy dependence – particularly with regard to those that must be imported – as well as the likelihood of future prohibitive legislation. It should be noted that the high emission sources – coal, gas, and oil – have thus far been subject to the strictest EU-level legislation; carbon emissions are not contained by national borders and so the process of developing a pan-regional consensus on their reduction is perhaps more straightforward.

On the contrary, the feasibility and viability of nuclear energy is more dependent on national sentiment, which is rather more idiosyncratic and location-specific. Moreover, in all likelihood, the installation of new nuclear capacity in the southeast European nations will entail the involvement of a foreign company, a position that could prove divisive amongst lawmakers and citizens.

[7] *http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf*

SECTION 3: ALTERNATIVE SCENARIO — THE IMPACT OF ‘NEW TRENDS AND POLICIES’

	Technical Considerations	Political Risks
Coal	• relatively abundant national reserves in southeast Europe • most carbon-intensive option	• subject to increasingly strict legislation • the price of carbon emissions in the EU will increase
Natural Gas	• further investment in regional connectivity required	• reliant on import – issue of security and dependence • concentrated supplier market • the price of carbon emissions in the EU will increase
Oil	• least efficient source of power generation (capacity factor of 13.3%)	• reliant on import – issue of security and dependence • price volatility • the price of carbon emissions in the EU will increase
Nuclear	• waste storage facilities must be installed • total project cost highly determined by cost of capital	• feasibility sensitive to national nuclear sentiment • probable involvement of foreign corporation
Hydropower	• regional capacity is approaching technical limit • cyclicality requires management	• further expansion constrained by environmental concerns
Renewable Energy Sources	• intermittent availability • investment in balance-of-system equipment • investment in storage technology	• economic viability may have to be supported by national subsidies

SECTION 4: CLOSING REMARKS

NEW SUPPLY-SIDE POLICIES POSE A SERIOUS THREAT TO ELECTRICITY GENERATION IN SOUTHEAST EUROPE...

#1

In this report, the impact of two major supply-side developments – the burgeoning legislative support for an accelerated pan-European phase-out of coal and the rising price of unit carbon emissions – on electricity generation in southeast Europe are modelled and evaluated. Ultimately, the final outcomes of these developments are identical – the withdrawal of coal from the energy mix of Europe – but the two represent different methodological approaches; the stimulus in the former is regulation while in the second it is driven by the market.

This presents southeast Europe – currently relying on coal for electric power generation – with an enormous problem. The four EU states in the region are already subject to EU environmental policy while the six non-EU states will be similarly monitored before the late-2020s, via an expansion of the remit of the Energy Community – its Western Balkans Electricity Roadmap and Sustainability Charter – and presumed eventual EU accession. Moreover, the economic viability of coal-fired generation in southeast Europe will deteriorate as reform to Phase 4 of the EU ETS causes the unit carbon emission price to rise.

With reference to both of these regulatory and economic trends, the outcome of our alternative scenario analysis makes clear the dire outlook for coal power plants. The net generation capacity of coal-fired thermal generation falls by 76% between 2020 and 2040, while actual generation – net generation capacity modified to account for a capacity factor – falls by 94% (from 107 TWh to 6 TWh) over the same period. The model further indicates that the share of electricity generation account for by coal falls from 34% in 2020 to 2% in 2040. Overall, the impact of coal's decline is to reduce actual generation by 15.5% over the forecast period.

SECTION 4: CLOSING REMARKS

… AND IMPENDING DEMAND-SIDE TRENDS WILL PUT FURTHER PRESSURE ON THE MARKET FOR ELECTRICITY.

#2

As the analysis has demonstrated, the advent of the electric vehicle revolution and the extensive diffusion of data-processing technologies will cause a positive deviation away from predicted electricity consumption. Over the forecast period, the inclusion of a technological disruption increases the electricity demand of southeast Europe by 5.03%, from an average annual demand of 312 TWh to 328 TWh (2015 to 2040).

The impact of the disruption in western Europe – forecast to occur as early as 2025 in this model – affects the regional electricity market through trade. Furthermore, one assumption of the alternative demand scenario is trade volumes between southeast Europe and its external markets remains constant at the level witnessed in 2015; this assumption may not endure a worsening of the electricity balance in these external markets, it being quicker and cheaper to expand international transmission capacity than it is to increase national generation capacity.

It should be emphasised at this stage that the supply-side effect is much more significant – in terms of absolute size – than the that projected for the demand-side. However, the precise arrival date of the electricity demand deviation may play an important role in determining the exact year in which the electricity market begins to experience internal shortfalls. While the timing of the data-processing shock will be governed by local economic conditions – the adoption of a new technology is contingent upon the capacity of an economy to invest significant volumes of capital, for example – the actual onset of the electric vehicle revolution will be considerably influenced by national and EU-level environmental and climate policy.

SECTION 4: CLOSING REMARKS

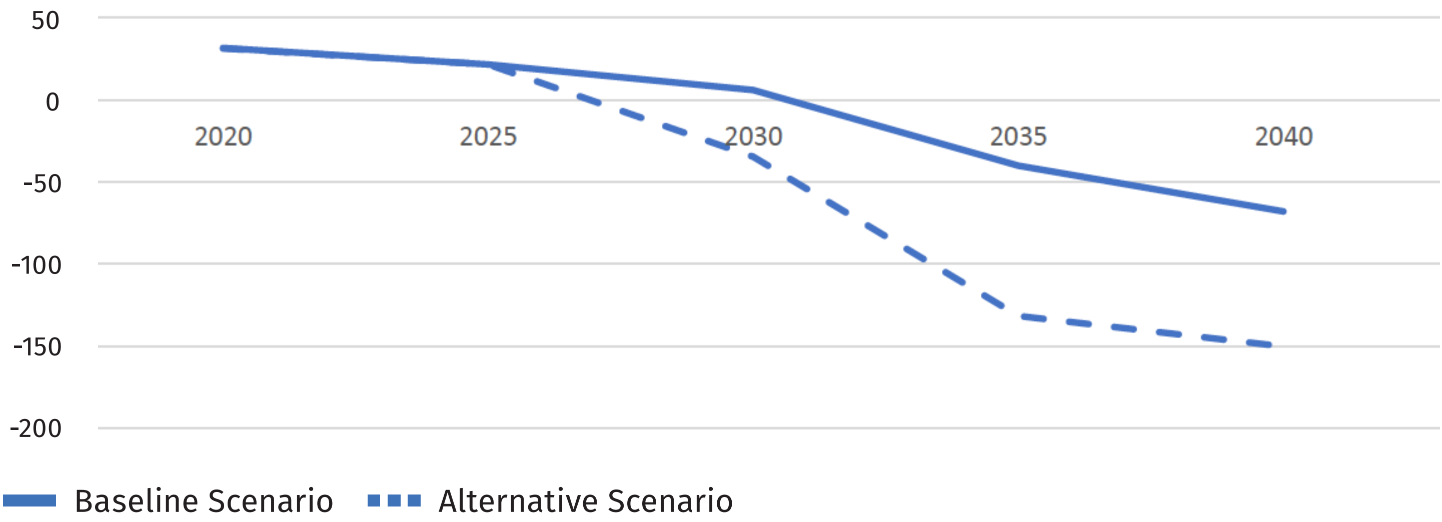
#3

AS A RESULT, THIS REPORT PROJECTS AN ELECTRICITY GENERATION DEFICIT AS EARLY AS 2027...

The conclusion of our alternative – 'New Trends and Policies' – scenario is that southeast Europe will experience annual electricity generation deficits from 2027 onwards; the onset of annual deficits is delayed until 2031 in the baseline analysis.

The market balance of the alternative forecast worsens over the duration of the forecast period. After falling into deficit in 2027, the shortfall then reaches 35 TWh in 2030, 132 TWh in 2035, and 150 TWh in 2040. The projected deficit at the end of the forecast is marked, 150 TWh is only slightly less than half of the actual generation forecast for 2020 (310 TWh).

Market Balance (TWh) — Scenario Comparison



SECTION 4: CLOSING REMARKS

...MAKING SIGNIFICANT INVESTMENT IN LOW-CARBON, DISPATCHABLE BASELOAD CAPACITY AN URGENT REGIONAL PRIORITY.

#4

The immediate consequence of an electricity generation deficit is simple: electricity will have to be imported to southeast Europe and so unit prices will increase, eroding living standards and dampening business activity. In the long-term, a sustained period of high electricity prices will inhibit the economic and social development of the region. It may also provoke popular unrest, which could perversely make the situation worse as long-term investment decisions are postponed in favour of stabilisation efforts.

It is clear, therefore, that efforts to prevent an electricity shortfall from occurring must be made. However, if the only consideration made is of meeting the deficit – by whatever means possible – the notions of sustainability and resilience will be sacrificed. To ensure that the generation system is fit for purpose in the future is must be based on a low-carbon energy source; new environmental regulation in tandem with rising emission cost will erode – eventually eradicating – the economic rationale of carbon-intensive power generation and so make such projects impractical.

The value of dispatchable generation must also be reiterated. One result of the alternative scenario supply-side analysis is that the share of generation provided by dispatchable sources – thermal and nuclear plants – falls by 21% to 48% of system generation. This trend – decreasing the share of electricity sources that power grid operators are able to control – and the concomitant increase in the share of generation from intermittent energy sources reduce the stability of the electricity system. Of course, as energy storage technology has improved, the indeterminacy of renewable energy sources such as wind and solar power has been lessened, but the supplementary costs of storage and balance-of-system infrastructure remain partially elevated.

It should be kept in mind that the projected deficit first happens in 2027, less than a decade from 2018. This should clarify the urgency of a policy response, articulating a cohesive, forward-looking strategy and committing to substantial investment in the immediate future.

SECTION 4: CLOSING REMARKS

THEREFORE, THE OPTIMAL RESPONSE IS TO COMMIT TO THE EXPANSION OF NUCLEAR CAPACITY IN SOUTHEAST EUROPE.

#5

With this requirement in mind, the benefits of expanding nuclear capacity are evident, offering, as it does, a low-carbon, dispatchable source of electricity generation that would enable the nations of southeast Europe to strengthen the security of their future energy supply.

Therefore, the installation of new nuclear facilities – operational between 2025 and 2030 – ought to be regarded as an energy policy priority and a favourable means of averting future energy instability and uncertainty. This position – an inherently low-carbon one – has the further benefit of insulating the nations of southeast Europe from the risks associated with increasingly stringent environmental and climate policy at the EU level.

However, this strategy is not without obstacle. New nuclear build projects are capital-intensive and require a significant amount of upfront investment. As such, the availability of capital and the cost of finance are strong determinants of the economic viability of new projects, perhaps more acutely in southeast Europe than in Europe as a whole, given the political and monetary risks of the region. This being the case, it seems improbable that a privately financed project – at the required scale – would be able to deliver electricity at a reasonable final cost.

At present, there is considerable debate about the structure and form of the new nuclear funding model. In the UK, for example, the widespread criticism levied at the financing of Hinkley Point – entire construction cost met by EDF and its Chinese partner CGN – has prompted a debate on the merits of public involvement. While consensus on a new model has not yet been reached, the availability of capital at a sovereign rate – or sovereign plus premium – would reduce the final consumer electricity price.

Given the urgency with which low-carbon, dispatchable electricity generation is required in southeast Europe, it seems clear that innovative funding models should be identified, analysed, and seriously considered.

SECTION 5: APPENDIX

METHODOLOGY

DEMAND:

#1

Electricity Demand Forecast

Prior to the definition of the demand-side regression, a number of economic variable were assessed for their correlation and causal link to electricity use. In addition to the theoretical considerations of the regression itself, the availability and quality of relevant statistical data was also examined.

This process led to the identification of two available, explanatory variables:

!!!

• economic growth (measured in terms of the annual growth of per capita national output);
• and, urbanisation (measured by the percentage of the total population who inhabit urban agglomerations).

Datasets were used from the following sources:

!!!

• GDP per Capita – the World Bank DataBank;
• Urbanisation – the Department of Economic and Social Affairs of the United Nations (World Urbanisation Prospects).

The initial analysis and subsequent regressions were performed on data for the OECD aggregate.

This was done for two reasons:

!!!

• the availability of long-term historical data (from 1960 onwards);
• and, that, while there is evidence to suggest that the relationship between the two independent variables and electricity consumption weakens at high levels of national output, the coefficients of this period would apply to the southeast Europe region due to its lagged development in relation to the OECD.

SECTION 5: APPENDIX

The final electricity consumption forecast is built upon two separate regressions, defined thusly:

$$Total\ Energy\ Use_{i,t} = \beta_{GDP\ per\ Capita} * GDP\ per\ Capita_{i,t} + \beta_{Urbanisation} * Urbanisation_{i,t}$$

$$Electricity\ Share\ of\ Total\ Energy\ Use_{i,t} = \beta_{GDP\ per\ Capita} * GDP\ per\ Capita_{i,t} + \beta_{i,t} * Urbanisation_{i,t}$$

The products of the two regressions, for a given location and a given time period, constitutes the electricity demand forecast.

The regression statistics are now presented:

SUMMARY OUTPUT - Total Energy Use

Regression Statistics	
Multiple R	0.994579394
R Square	0.98918817
Adjusted R Square	0.965121222
Standard Error	50.8699689
Observations	44

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	9943790.275	4971895.137	1921.316958	3.03867E-41
Residual	42	108685.6569	2587.753736		
Total	44	10052475.93			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GDP/Capita	0.078333659	0.017510753	4.473460417	5.76537E-05	0.04299553	0.113671789	0.04299553	0.113671789
Urban Population (%)	1308.003863	47.460172	27.56003208	1.60142E-28	1212.225358	1403.782367	1212.225358	1403.782367

SUMMARY OUTPUT Electricity Share

Regression Statistics	
Multiple R	0.99833837
R Square	0.9966795
Adjusted R Square	0.977748925
Standard Error	0.007456383
Observations	55

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.88447253	0.442236265	7954.226686	2.17226E-65
Residual	53	0.002946675	5.55976E-05		
Total	55	0.887419205			

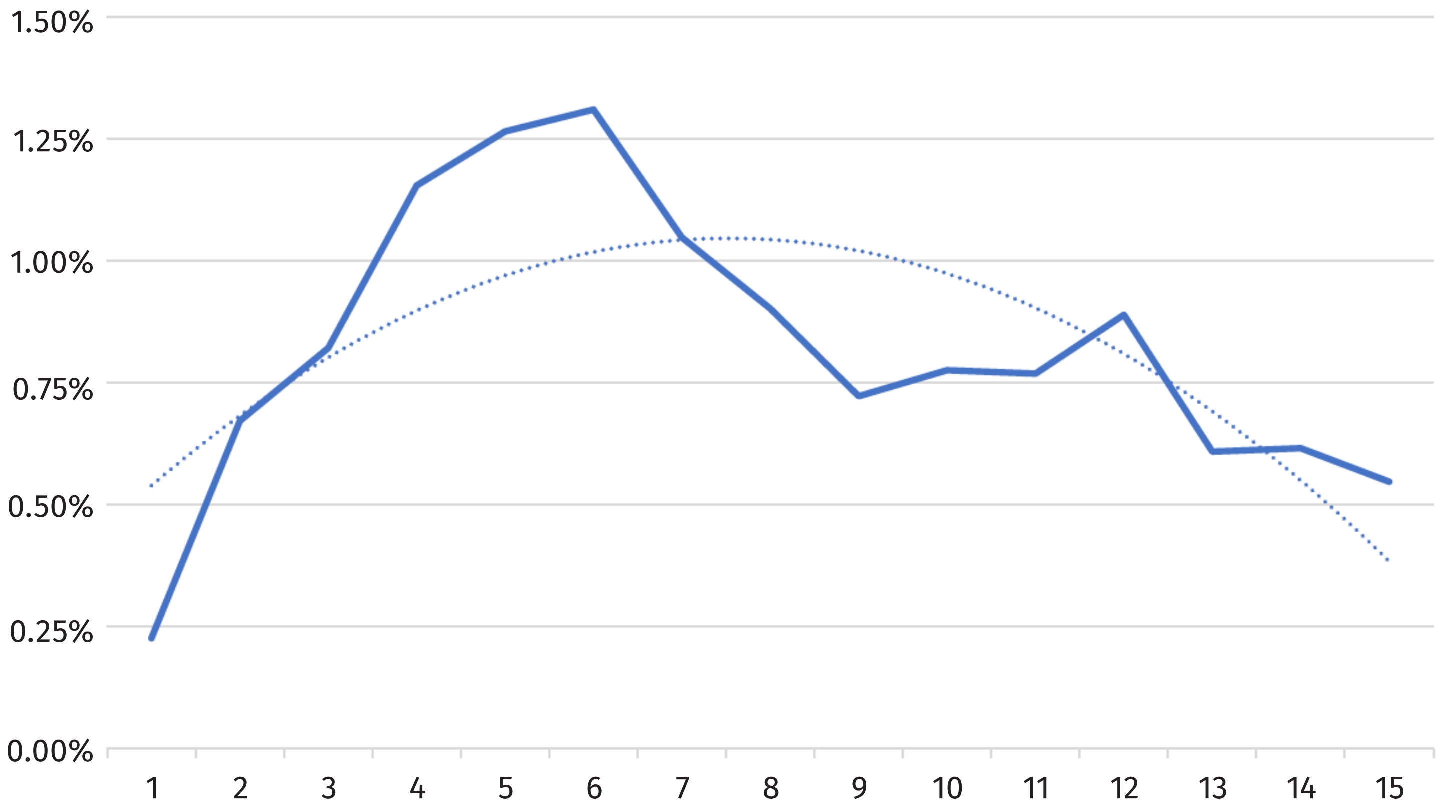
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
GDP per Capita	1.7724E-06	8.87345E-08	19.97414679	2.49339E-26	1.59442E-06	1.95037E-06	1.59442E-06	1.95037E-06
Urbanisation (%)	0.132317448	0.002473182	53.5008889	8.32948E-48	0.127356872	0.137278023	0.127356872	0.137278023

SECTION 5: APPENDIX

Exogenous Shocks

The effect of an exogenous technological shock on final electricity demand was modelled through its impact on the electricity share in total energy use. The residuals from the second regression were collected and ordered chronologically. Then periods of technological disruption – such as the development of the Internet and the World Wide Web in the 1990s – were overlaid onto the results. As theorised, periods characterised by the mass adoption of and adaption to new technologies is associated with positive deviations in the electricity share from values predicted by the regression analysis. The profile of one such period of disruption is shown below; the shape – a transitory increase followed by a return to trend – illustrates that at the outset energy systems are not prepared for the impact of the new technology but that adaption and reallocation of energy resources occurs as time passes.

Technological Disruption - Pattern of Residuals



SECTION 5: APPENDIX

CARBON EMISSIONS

#2

Energy Source	Mean	Low	High
	Tonnes of CO_2 Emissions per GWh		
Nuclear	29	2	130
Thermal (Coal)	888	756	1 310
Thermal (Gas)	499	362	891
Thermal (Other)	733	547	935
Hydropower	26	2	237
Wind	26	6	124
Solar	85	13	731
Other Renewables	45	10	101

Source: *World Nuclear Association, Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources*

SECTION 5: APPENDIX

CAPACITY FACTORS

#3

Energy Source	EIA	EURS16	Average
Nuclear	*92.3%*	*81.0%*	*86.7%*
Solids	*55.3%*	*64.0%*	*58.6%*
Oil	*11.5%*	*15.2%*	*13.3%*
Gas	*55.5%*	*38.0%*	*46.8%*
Biomass	*62.7%*	*61.1%*	*62.1%*
Hydro	*38.2%*	*32.7%*	*35.4%*
Wind	*34.5%*	*27.0%*	*30.7%*
Solar	*23.7%*	*14.6%*	*20.6%*
Other Renewables (incl. Geothermal)	*73.9%*	*53.9%*	*63.9%*

Source: *Electric Power Monthly, EIA (December 2017); European Reference Scenario 2016, European Commission (July 2016)*

ABBREVIATION LIST

BAS	*Bulgarian Academy of Science*
BTU	*British Termal Unit*
CAGR	*Compounded Annual Growth Rate*
CIS	*Commonwealth of Independent States*
CPS	*Carbon Price Support*
EIA	*U.S. Energy Information Administration*
ECPD	*European Coal Plant Database*
ETS	*Emissions Trading Scheme*
EUA	*European Union Allowance*
EURS16	*EU Reference Scenario 2016*
ENTSO-E	*European Network of Transmission System Operators for Electricity*
FYROM	*Foremer Yugoslav Republic of Macedonia*
GDP	*Gross Domestic Product*
HDI	*Human Development Index*
IEA	*International Energy Association*
IoT	*Internet of Things*
ITU	*International Telecommunication Union*
MSR	*Market Stability Reserve*
MENR	*Ministry of Energy and Natural Resources*
OECD	*Organisation of Economic Co-operation and Development*
UN	*United Nations*
WFP	*World Food Programme*
WNA	*World Nuclear Association*
WUP	*World Urbanisation Prospects*

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