SAFEGUARDING ENERGY SECURITY IN SOUTH-EAST EUROPE WITH INVESTMENT IN DEMAND-SIDE INFRASTRUCTURE

THE CASE FOR ENERGY EFFICIENCY IN BUILDINGS

BPIE

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EXECUTIVE SUMMARY

The security of gas supply is a political issue of considerable importance to the economies and well-being of citizens in the South-East Europe (SEE) countries[1]. Modelling published by the European Network of Transmission System Operators for Gas (ENTSO-G) and by Energy Union Choices[2] identified this region as the only one in Europe with a significant gas security issue in the event of an interruption of supply from Ukraine. The Security of Gas Supply Regulation aims to ensure deliveries of gas to protected customers (i.e. residential buildings) but its operation in a real crisis is unknown. Consumers, including business and public sector buildings not covered by the regulation, would not be able to rely on it to meet their heating needs in case of a serious supply disruption, as it has been witnessed in recent years when the supplies from Russia to Ukraine were cut.

ASSESSING THE RISK FOR BUILDINGS

In order to better understand the risks faced by gas consumers, this study explores the vulnerability of the building sector to gas supply interruptions in specific countries of the region, through the prism of the Building stock Vulnerability Indicator (BVI). The BVI takes into account the importance of the use of gas in the building sector, along with the dependence on imported gas and its import routes.

The results show that most countries of the region are at least moderately vulnerable, with **Hungary** and **Slovakia** found to be severely vulnerable.

Building Stock Vulnerability

	BVI	Vulnerability level
Albania	0	Not Applicable
Bosnia & Herzegovina	5	Moderate
Bulgaria	12	Substantial
Croatia	4	Low
FYROM	5	Moderate
Greece	3	Low
Hungary	34	Severe
Kosovo	0	Not Applicable
Montenegro	0	Not Applicable
Romania	1	Low
Serbia	7	Moderate
Slovakia	39	Severe
Slovenia	6	Moderate

Scale:	N/A	Low	Moderate	Substantial	Severe	Critical
	BVI = 0	0 < BVI < 5	5 < BVI < 10	10 < BVI < 20	20 < BVI < 40	BVI > 40

Following these assessments, Member States can then consider appropriate measures to mitigate the threat posed to their citizens.

[1] Report on European Energy Security Strategy, 18 May 2015 http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+REPORT+A8-2015-0164+0+DOC+XML+V0//EN

[2] https://europeanclimate.org/energy-union-choices-a-perspective-on-infrastructure-and-energy-security-in-the-transition/

SOLUTIONS TO THE GAS SUPPLY PROBLEM

The traditional solution to address energy security concerns is to install additional gas supply infrastructure. Such an approach would lock the region into long-term dependency on imported gas, high vulnerability to fuel price fluctuations and continued outflow of national income, and would also worsen the risk of stranded assets, should projected gas demand not materialise.

This study considers an alternative solution: demand-side measures for supply-side problems. Reducing gas demand through a dedicated building renovation programme could considerably improve energy security and drastically reduce the need for investments in the supply infrastructure. Building renovation programmes reduce energy demand, provide employment opportunities, yield a return on investments and offer multiple benefits, such as health and air quality improvement as well as fuel poverty alleviation, in addition to energy security.

Increasingly, buildings are being recognised as a key component of the energy infrastructure and can play a role in addressing energy security issues. The added benefit is that, unlike remote supply infrastructure such as pipelines, building renovation is a visible measure that enhances people's quality of life and improves business productivity. Since the region is facing a gas security issue, focus should be put on renovating buildings using gas, either directly or indirectly.

BPIE has estimated the potential impacts by modelling four scenarios that examine the evolution of a dedicated renovation programme focused on gas-consuming buildings:

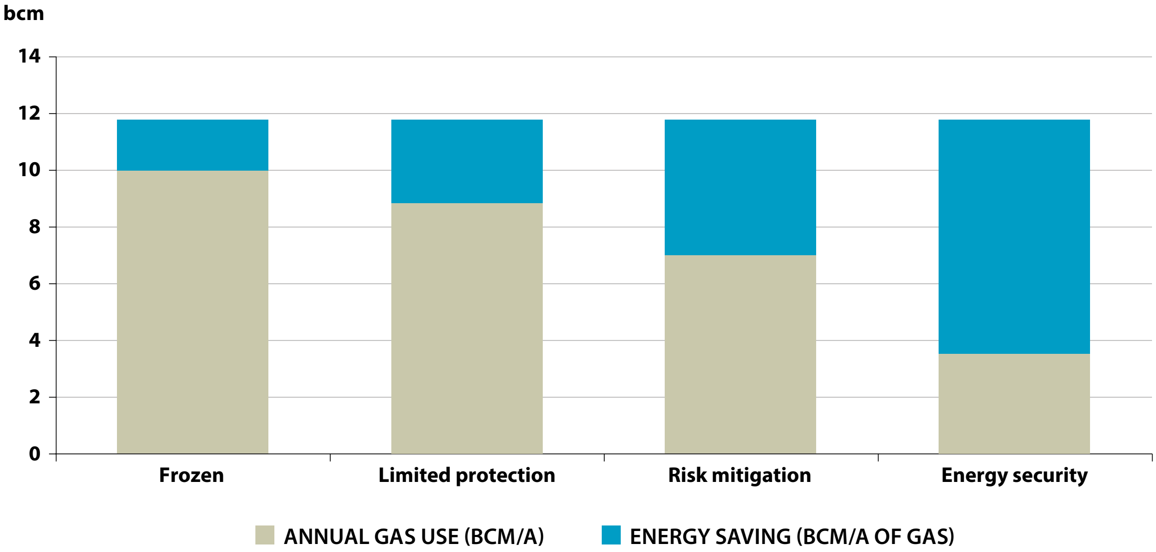
1. FROZEN – The baseline scenario with no change from prevailing levels of renovation activity;
2. LIMITED PROTECTION – a modest increase in renovation rates[3] and a general increase in the depth of renovation towards higher levels of energy savings over time. This reflects the "direction of travel" of gradual improvement and increase in the renovation activity, driven by EU directives and climate policy;
3. RISK MITIGATION – a more proactive approach with a significant push towards an increased renovation activity;
4. ENERGY SECURITY – an aggressive, dedicated approach which aims to renovate all buildings using gas to increasingly deeper levels within 20 years.

The "energy security" scenario can dramatically reduce the vulnerability to gas supply interruption. All buildings currently using gas could be renovated within 20 years, cutting gas consumption by 70%, or over 8 bcm/a[4]. Even in the event of a complete and prolonged gas supply disruption from Russia, the region would be able to meet its demand with reverse-flow pipelines from Western Europe and LNG terminals.

[3] The specific renovation rates in the target countries are not known. For the purposes of modelling, we have used 1% of floor area p.a., this generally being accepted as a reasonable indication of European building renovation activity, as derived by BPIE in "Europe's buildings under the microscope" and by the European Commission in the Inception Impact Assessment for the Review of the Energy Performance of Buildings Directive and the Heating & Cooling Strategy, COM(2016) 51 final.

[4] bcm = billion cubic metres.

Reductions in gas demand within 20 years under the four scenarios



The upfront investment required is relatively high in all scenarios but is more than offset by the avoided energy costs. The maximum investment requirement under the "energy security" scenario is €81bn, which delivers energy-cost savings of €106bn (present value costs and savings, derived over the measures lifetime). While most of the investment will almost certainly come from private sources (building owners and other private investors), public funding can initiate and support the transition, by using for example funding from the European Fund for Strategic Investment and the European Structural and Investment Funds.

COSTS AND SAVINGS € billion – Present value	Frozen	Limited protection	Risk mitigation	Energy security
Investments	22	31	47	81
Avoided energy costs	23	42	70	106

Those countries of the region that are European Member States will need to draw up Preventive Action Plans according to the requirements of the Security of Gas Supply Regulation. These Preventive Action Plans should put more emphasis on demand-side measures, such as the electrification of the district heating network with heat pumps, or the energy efficiency in buildings achieved through deep renovations. A dedicated programme for building renovation would, in addition to providing energy security, deliver multiple benefits:

- Improve the balance of payments by cutting national expenditure on fuel imports;
- Extend the lifetime of indigenous gas resources;
- Help tackling fuel poverty, a serious problem in most SEE countries;
- Increase the quality and value of the building stock;
- Improve the very poor air quality experienced in many towns and cities of the region;
- Contribute to meeting the climate policy goals by reducing GHG emissions;
- Stimulate domestic industry to supply and install the necessary energy efficiency and renewable energy technologies within the building sector, creating significant employment as well as revenues to national treasuries.

Under the requirements of Article 4 of the Energy Efficiency Directive (EED)[5], all governments need to develop national building renovation strategies. This applies to the EU Member States as well as to the non-EU Members part of the Energy Community (that adopted the EED requirements). Building renovation strategies should tackle all barriers and provide the right signals, financing framework and market confidence for a long-term transition of the existing building stock to a highly energy performing one that can withstand energy supply shocks. These issues are covered in detail for Bulgaria, one country of the region, in the BPIE report *"Accelerating the renovation of the Bulgarian building stock"*[6]. The framework and roadmap developed for the residential building sector in Bulgaria could be the basis for similar initiatives in other countries of the region.

RECOMMENDATIONS

- A dedicated renovation programme could, within 20 years, address all gas-consuming buildings in South-East Europe and reduce the building stock's gas consumption by as much as 8.2 bcm/a, or by 70% of the current consumption. The European institutions and countries in the region are therefore strongly encouraged to set energy efficiency as an infrastructure priority.
- A strategic roadmap should be developed for shifting away from traditional heating and cooling methods based on fossil fuels and local biomass, towards modern approaches based on best available low-carbon technologies. The energy efficiency of the whole energy system, including district heating, should be addressed in order to mitigate the demand for gas as well as for other energy carriers.
- Subsidies for fossil fuels need to be phased out and redirected to clean energy developments that support the combination of renewable energy technologies and energy efficiency improvements in the building sector.
- Funds from the Connecting Europe Facility, the Multiannual Financial Framework, the European Fund for Strategic Investments and the Structural and Investment Funds should be better directed for investments in deep renovations of the building stock.
- In drawing up their Preventive Action Plans under the Security of Gas Supply Regulation, participating countries need to look into demand-side measures on an equal footing with supply-side measures. "Efficiency First" should be a fundamental principle of the energy market design proposals, as identified by the European Commission in its Energy Union Strategy[7].
- Countries in the region are encouraged to take the Building Vulnerability Indicator (BVI) into account when preparing their risk assessments under the Security of Gas Supply Regulation. Thermal renovations through energy efficiency and renewable energy provide overwhelmingly positive solutions with multiple benefits, such as energy security, investments in infrastructure, promotion of the renovation market and jobs.
- Energy efficiency and demand-side response need to be taken into account in The Projects of Common Interest list for 2018.
- To ensure that local employment opportunities are maximised and that economic benefits are retained within the region, a strategic multi-country approach that sees the development of manufacturing capacity alongside the expected increase in the installation of renovation measures is required.
- The significant renewable energy potential in the region needs to be maximised, including within the building stock.

In order to ensure a successful implementation of the above demand-driven solutions, national governments in the region should adopt the strategic objective of tackling energy security, in particular in relation to gas, within the context of a drive towards low-carbon economies. Doing so will help improve the living conditions of millions of citizens, reduce air pollution and provide a significant economic stimulus. Relevant bodies, such as ACER, ENTSO-G and national regulatory authorities, should be required to work together in a co-ordinated fashion to achieve this strategic objective.

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[5] Directive 2012/27/EU, http://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive

[6] http://bpie.eu/publication/accelerating-the-renovation-of-the-bulgarian-building-stock/

[7] See more at the ECF report "Governance for Efficiency First: "Plan, Finance And Deliver" https://europeanclimate.org/wp-content uploads/2016/06/ECF_Report_Summary_v9-screen-spreads.pdf

CURRENT ENERGY SITUATION IN SOUTH-EAST EUROPE

Security of energy supply is a key strategic objective of the EU, as embodied by the recent establishment of the Energy Union. Concerns over security of supply have become more prominent since the Ukraine-Russia disputes, affecting both EU and non-EU countries of the region. Recent analysis, in a publication by Energy Union Choices[8], makes clear that, while most of Europe is resilient to a range of gas supply disruption types, this is not the case for the South-East region which is vulnerable to supply interruptions from the East, i.e. mainly from Russia. ENTSO-G, the European Network of Transmission System Operators for Gas[9], also identified that selected countries of South-East Europe would face significant economy-wide gas shortages after a 6-month gas supply disruption from Russia.

The EU is promoting a regional approach aiming at strengthening cooperation. Politically, this situation will bring significant challenges considering that Member States would have to subsume their national interests and act in solidarity in the event of a crisis. Availability of funds for gas purchases and divergence of national interests might be two scarce resources during a crisis. If, however, countries reduce their gas dependence by minimising their need for gas, then both the high costs and political conflict can be avoided.

Table 1 – Percentage of missing gas in February after a 6-month Russian gas-flow disruption, for an average February and a cold spell February (Source: ENTSO-G[10], via the European Commission)

	Bulgaria	Croatia	Greece	Hungary	Romania
Cooperative average	38%	0%	16%	26%	37%
Non-cooperative average	61%	0%	0%	31%	42%
Cooperative cold spell	41%	5%	32%	26%	31%
Non-cooperative cold spell	66%	12%	18%	35%	31%

While an increased diversity of supply routes and sources is an option for the region, this study explores an alternative approach to improving energy supply security. Our proposed approach, the roll-out of a major renovation programme focused on the gas-consuming building stock, resulting in its transformation into a highly-efficient, electrified and renewable-based system with a significantly reduced need for gas, represents a forward-looking political vision for the region. In addition to increased energy security, it also delivers cost-savings for building owners and occupants, improves the living conditions of millions of citizens and delivers substantial economic returns to governments by cutting expenditure on energy imports and supporting local industries and employment.

Target countries of this analysis are: **Albania, Bosnia & Herzegovina, Bulgaria, Croatia, the former Yugoslav Republic of Macedonia (FYROM), Greece, Hungary, Kosovo, Montenegro, Romania, Serbia, Slovakia** and **Slovenia**. Energy security in general, and gas dependency in particular, are significant concerns for these countries. This led to the formation of the CESEC, the Central and South-Eastern Europe Gas Connectivity High-Level Working Group[11], which was set up in 2015 in partnership with the EU, coordinating efforts to facilitate projects that diversify gas supplies to the region.

[8] https://europeanclimate.org/energy-union-choices-a-perspective-on-infrastructure-and-energy-security-in-the-transition-reports-launch/

[9] http://www.entsog.eu/

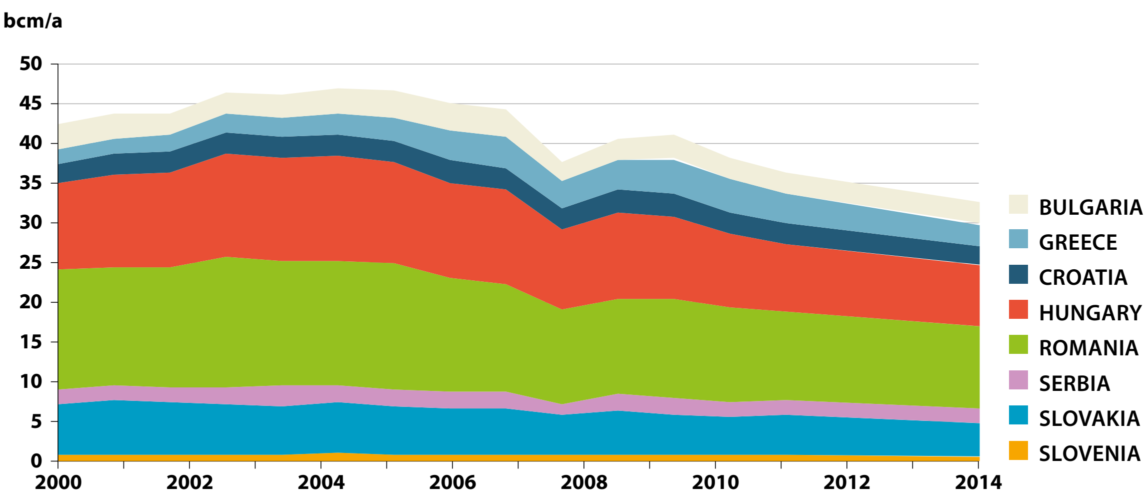
[10] SWD(2014) 326 final – Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015. https://ec.europa.eu/energy/sites/ener/files/documents/2014_energystresstests_southeasteuropeanfocusgroup.pdf

[11] Comprised of Bulgaria, Croatia, Greece, Hungary, Romania, Slovakia and Slovenia: https://ec.europa.eu/energy/en/topics/infrastructure/central-and-south-eastern-europe-gas-connectivity

Figure 1 - Map of the target countries in dark blue (Source: BPIE own analysis)

As depicted in Figure 2, the total gas consumption has declined in almost all studied countries by about 10 bcm/a, or 30% since the beginning of the century. This trend has been particularly strong since 2010.

Figure 2 - Historical regional gas consumption in the target region, top 8 countries[12]
(Source: Eurostat, 2014)

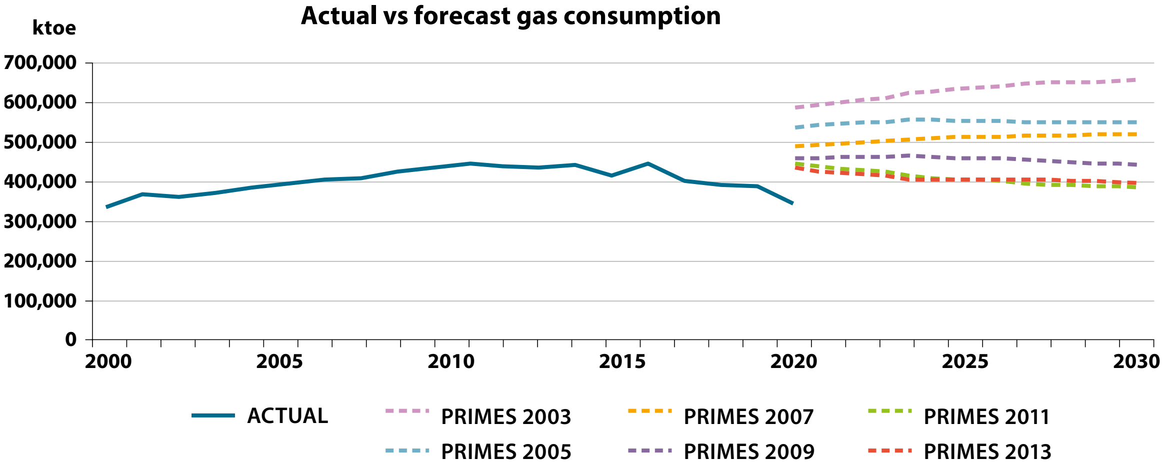


In fact, historical projections of future gas use have been consistently overestimated (Figure 3). The figure shows the results of the PRIMES model[13], used by the European Commission to forecast the energy use. It can be seen that each subsequent biennial projection has resulted in a lower forecast, yet current consumption trends are even below the latest 2013 projections. While the reasons might be related to ambitious assumptions on GDP growth, fuel switching or energy prices, the reality is that overestimated projections for gas demand have routinely fallen short of the actual consumption. Gas consumption could also fall further with warmer winters resulting from climate change, and also if gas remains a premium product that is more expensive than other alternatives. There is a significant financial risk in basing investment decisions on inaccurate forecasts. Unrealistic expectations of increasing gas demand lead to bullish investments in gas supply infrastructure, leading in turn to increased risks of stranded assets.

[12] Albania, Bosnia & Herzegovina and FYROM use very little gas, so their consumption cannot be seen at the scale of the graph. Kosovo and Montenegro are also excluded since there is no historical data on their gas consumption.

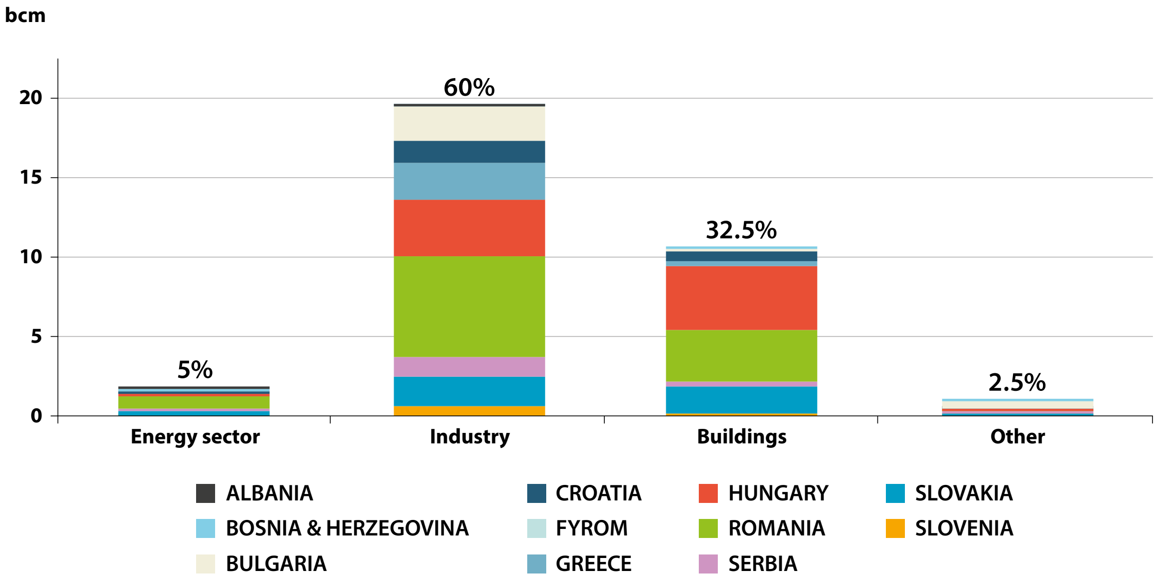
[13] PRIMES is operated by the National Technical University of Athens. More info at www.e3mlab.ntua.gr

Figure 3 - Overestimated projections of natural gas demand (Source: PRIMES, via E3G, 2016)



This report is based on the latest available Eurostat data on gas consumption (2014). The most significant consumers of gas in the region are industry, with 60% of the total gas use, and buildings, making up 32.5% of the total gas demand. Gas use in the energy-generation sector is not a significant end-use, accounting for 5% of the total. It also becomes obvious that a small number of countries dominate the regional gas use. These are **Romania, Hungary** and **Slovakia** for all sectors, while significant amounts are also used by **Bulgaria** and **Greece** in industry. Unsurprisingly, the energy sector makes very little use of gas, since most electricity generation is from indigenous coal deposits[14].

Figure 4 - Sectoral gas use in the target region (Source: Eurostat, 2014[15])

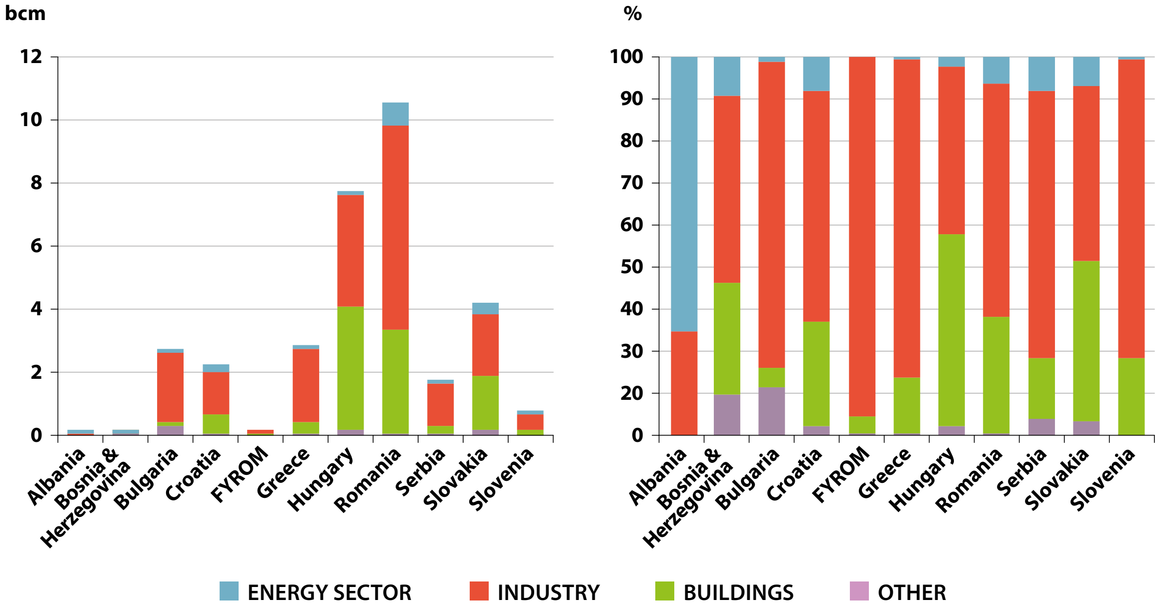


[14] See South-East Europe Sustainable Energy Policy (2016).

[15] Kosovo and Montenegro are not included in this graph as they have no gas consumption (Eurostat, 2014).

The share of gas use between industry and buildings is not the same in all countries and varies across the region. Almost all countries make more use of gas in industry by up to 80% or 90%. In **Hungary** and **Slovakia**, the 'industry' and 'buildings' sectors account for roughly equal shares of gas. In **Romania**, the biggest consumer of gas in the region, buildings make up a little over 30% of the total gas consumption. **Albania** is unique in the region, as the dominant use of gas is in the electricity production, complementing the country's high reliance on hydropower. No other country uses more than 10% of its gas in electricity generation.

Figure 5 - Gas use in economic sectors by country in absolute amounts and as shares
(Source: Eurostat, 2014[16])



[16] Albania, FYROM and Bosnia-Herzegovina are using 0.027bcm/a. 0.1232bcm/a and 0.1229bcm/a respectively.

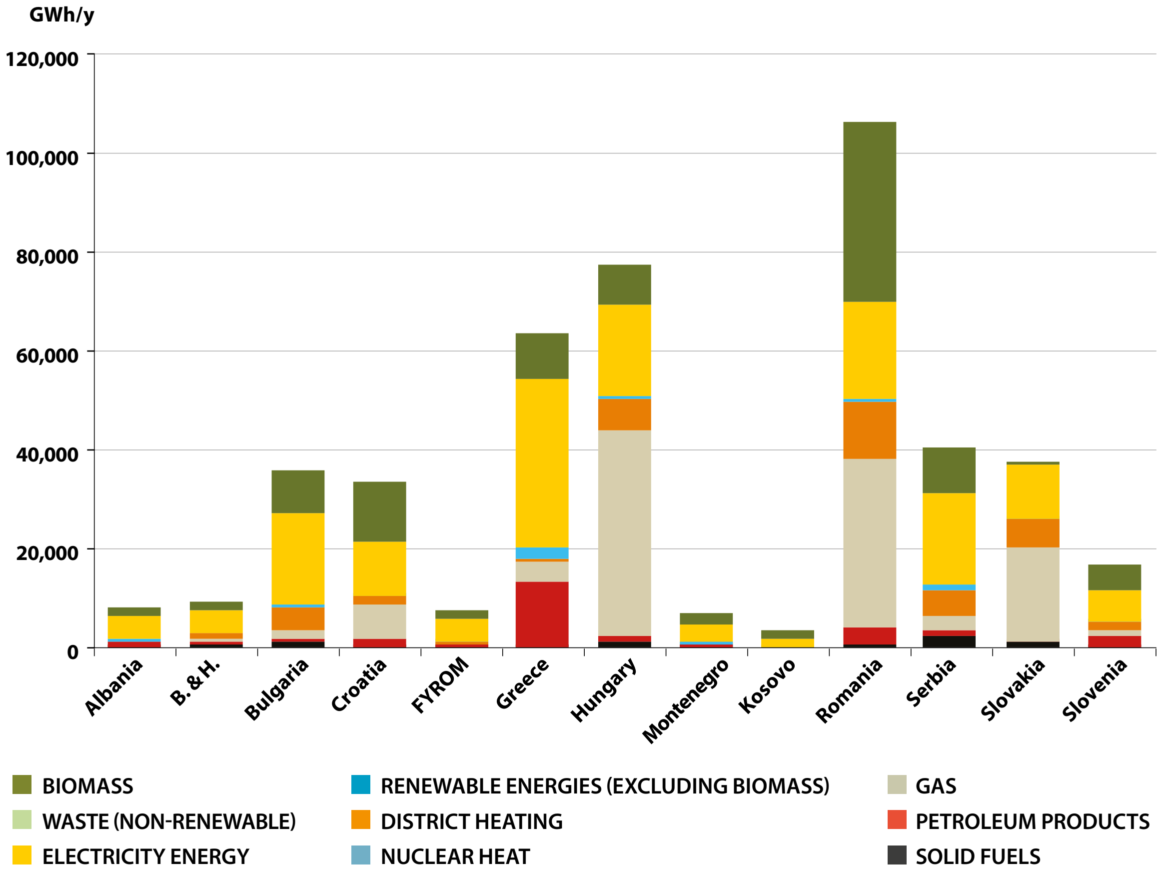
ENERGY USE IN BUILDINGS

Understanding the energy demand of buildings and insights into the trends of buildings' energy use are essential for planning adequate infrastructure. The building sector, with its important need for heating and cooling, is one of the major consumers of energy in the region. The energy carriers for the building stock in the targeted countries are:

Electricity	35% or 157.6 TWh/y
Gas	25% or 111.5 TWh/y
Biomass	22% or 99.0 TWh/y
District Heating[17]	9% or 38.5 TWh/y
Petroleum Products/Oil	6% or 28.5 TWh/y
Solid Fuels/Coal	2% or 9.0 TWh/y
Other Renewables	1.5% or 6.7 TWh/y

The detailed breakdown per country is presented in the following figure.

Figure 6 - Energy sources meeting buildings' demand (Source: Eurostat, 2014)



[17] Gas is 77% of the input in district heating plants and 8% in electricity generation.

Gas is not the dominant heating fuel for buildings in most countries, but it represents a significant share in three countries, namely **Hungary, Romania** and **Slovakia**.

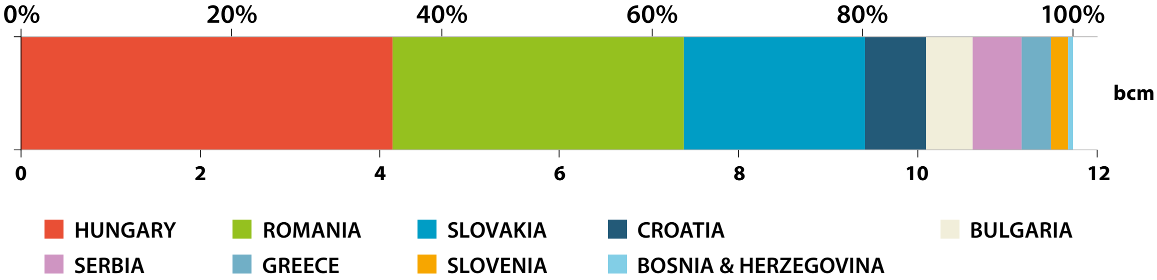
Hungary and **Slovakia** are reliant on gas for over half of their buildings' energy requirements, thereby putting themselves in a vulnerable situation in case of a gas supply interruption. Romanian buildings are also heavily reliant on gas, but the country depends almost exclusively on indigenous supplies. These three countries account for over 80% of the gas consumption in the region's buildings, representing 28% of the total gas consumption. District heating is, to a large degree, supplied by gas[18], thereby a risk for countries like **Bulgaria** and **Serbia**, making little direct use of gas in buildings, but having extensive district heating networks. Other countries of the region, especially the southern Balkans, such as **Albania, Bosnia & Herzegovina, FYROM, Kosovo, Montenegro** and **Greece** rely to a significant extent on electricity to heat their homes, followed by biomass and heating oil.

As for biomass use, it is likely that it could be underrepresented in Eurostat figures. Since traditional biomass, as used in stoves, is frequently sourced from private grounds or local woods rather than centralised distribution channels, there is a high probability that there exists a significant amount of unaccounted biomass that contributes to the energy needs of residential properties. For example, it was suggested that biomass may be contributing up to 90% to the heating of residential buildings in **Montenegro**[19].

Direct and Indirect gas use

Gas is used to meet essential requirements, namely heating and hot water demand in buildings, either directly in gas boilers or indirectly by generating electricity and district heating, which are in turn used for heating and hot water production. BPIE made use of Eurostat data and modelling on heating and cooling by Fraunhofer ISI (2016), to derive the amount of gas that is directly and indirectly used to meet heating and hot water demands of (residential and tertiary) buildings in South-East Europe. This analysis confirms that three countries are consuming 80% of gas in the region's buildings: **Hungary, Romania** and **Slovakia**. The remaining 20% of gas demand is spread between **Croatia, Bulgaria, Serbia, Greece, Slovenia and Bosnia & Herzegovina**.

Figure 7 - Share of direct and indirect[20] gas use by buildings in absolute and relative figures, for space heating and hot water (bcm) (Source: Eurostat, 2014)



In comparison with Figure 2, where the overall gas use in the economies of South-East Europe declined by about 30% in the past 14 years, direct gas use in buildings has also declined by 2bcm, or 15%. While gas consumption increased somewhat in **Greece**, **Bulgaria** and **Romania**, it has been more than offset by the decrease observed in **Hungary** and **Slovakia**.

[18] More details in Annex 1.

[19] Support for Low-Emission Development in South-Eastern Europe (SLED) (2015).

[20] Direct use of gas is gas which is delivered directly to buildings. Indirect use of gas is gas consumption caused by demand for electricity (taking into account the share of gas used to generate electricity and for district heating (again, taking into account the share of gas used for district heating). See the methodology box and Annex 1 for an explanation of indirect gas use.

Figure 8 - Historical gas consumption in buildings of the target region (Source: Eurostat, 2014)

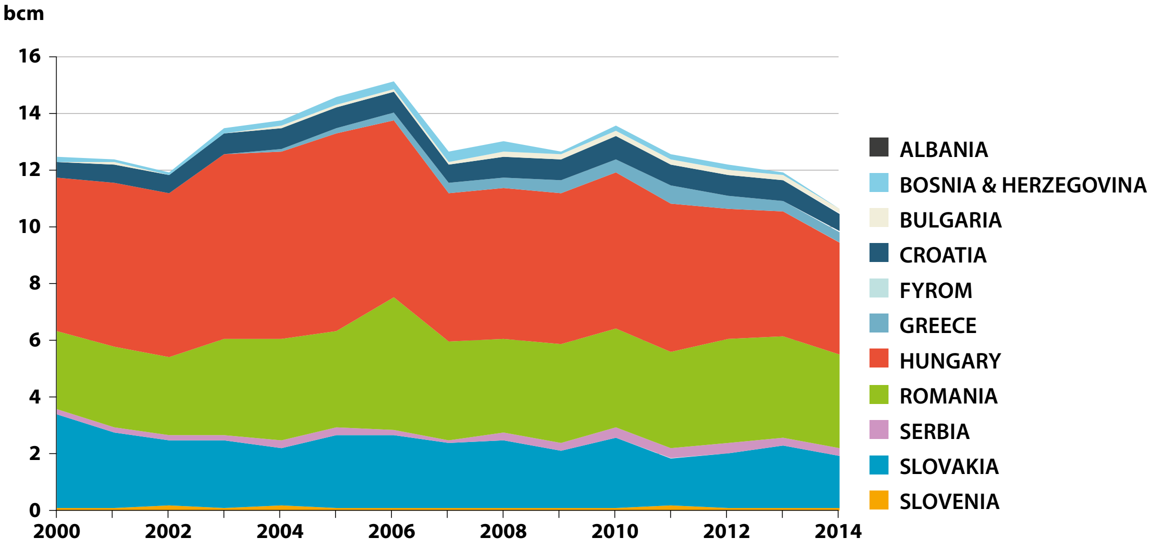


Table 2 - Gas use by country (in bcm/a and as a share of gross inland consumption) in 2014 for space heating and domestic hot water (Source: Eurostat, 2014[21])

Albania	Bosnia & H.	Bulgaria	Croatia	FYROM	Greece	Hungary	Romania	Serbia	Slovakia	Slovenia	Total
0.00	0.06	0.52	0.66	0.05	0.33	4.13	3.26	0.54	2.02	0.20	**11.77**
0%	48%	20%	30%	39%	12%	53%	31%	30%	48%	29%	**36%**

Countries in South-East Europe exhibit relatively high annual energy consumption due to very low levels of energy efficiency in their building stock. Various EU efforts seek to address this issue, including:

- EU's climate policies, aimed at reducing CO_2 emissions, increasing the deployment of renewable energy and improving energy efficiency;
- Increased funding availability from EU Structural Funds and other sources;
- The Energy Performance of Buildings Directive (EPBD)[22] and the national renovation strategies prepared under the Energy Efficiency Directive (EED);
- The mandatory upgrade of all new construction to nearly Zero-Energy Building standards, however defined (from 2018 in the public sector; and 2020 for all buildings), is likely to have a positive spill-over effect on the renovation of existing buildings, via the experiential training of the labour force and the development of technical solutions.

[21] Kosovo and Montenegro do not consume gas in buildings. For a more detailed analysis of gas consumption by end use, please see Annex 1.

[22] Directive 2010/31/EU, https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings

While the Energy Community countries have likewise adopted the relevant EU directives, albeit with some time-rescheduling and amendments in details, many still have some way to go to realise the full potential of the legislation. These policy developments are likely to continue the downward trend in the gas use of buildings, thereby helping improve energy resilience to some degree. They also place a growing risk on traditional large supply-side investments, becoming stranded or under-used assets as the region moves towards a low-carbon economy. The emergence of new technologies on demand-side response flexibility, energy storage and decentralised energy production are also contributing to a decrease in the energy use.

Notwithstanding the above, gas will remain an important fuel in the building sector for some time to come, so the issue of import dependency will have a role to play in the energy security situation for the foreseeable future. As presented in the table below, most countries in the region are heavily reliant on imported gas for over 70% of their needs. Exceptions are **Albania**, which is not exposed to supply disruptions because it has no imports and **Romania** and **Croatia**, which source most of their gas needs indigenously. However, **Romania**, with only 5% gas imports, will, in the future, be increasingly reliant on external suppliers, due to declining indigenous production.

Table 3 - Proportion of national gas use that is imported (Source: Eurostat, 2014[23])

Gas import dependency										
Albania	**Bosnia & H.**	**Bulgaria**	**Croatia**	**FYROM**	**Greece**	**Hungary**	**Romania**	**Serbia**	**Slovakia**	**Slovenia**
0 %	100%	99%	29%	100%	100%	83%	5%	71%	98%	100%

While the amount of gas import is of importance when analysing energy security, the source and diversity of sources is equally relevant. The table below presents the most important gas interconnections. Full data and a map indicating the gas supply routes are provided in Annex 4.

Table 4 - From where do countries in the region import their gas? (ENTSO-G, 2016)

Gas import interconnections and their total capacity										
	Bosnia & H.	**Bulgaria**	**Croatia**	**FYROM**	**Greece**	**Hungary**	**Romania**	**Serbia**	**Slovakia**	**Slovenia**
Import capacity in bcm/a from	Serbia (0.49)	Romania (26.22)	Hungary (2.64) Slovenia (1.84)	Bulgaria (0.93)	LNG (5.21) Turkey (1.69) Bulgaria (3.75)	Ukraine (20.84) Romania (4.50) Austria (0.09)	Ukraine (26.25) Hungary (1.78)	Hungary (4.88)	Ukraine (79.53) Hungary (1.77) Czech R. (24.21) Austria (8.60)	Italy (0.97) Austria (3.91)%
Total	0.49	26.22	4.48	0.93	10.66	25.45	28.03	4.88	114.11	4.88

[23] Does not take into account fuels in International Maritime Bunkers.

ENERGY POVERTY AS A SIGNIFICANT REGIONAL ISSUE

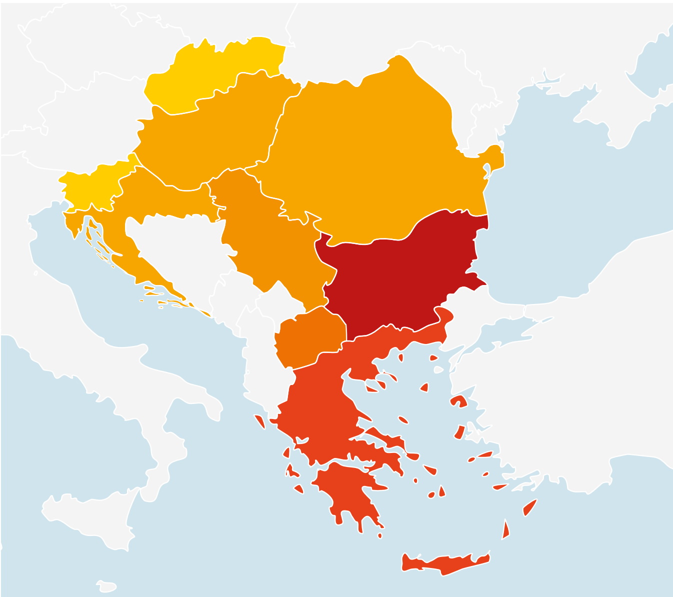
Heating is the largest energy demand of households, putting a considerable strain on the residents and the countries in question. Eurostat estimates that nearly one third (30%) of the overall population in target countries cannot pay their bills on time, while 20% live in very low quality dwellings with serious defects, such as leaking roofs, damp walls and rotting floors. As a consequence, these residents experience higher incidences of poor health and damp-induced illnesses and diseases. These energy poverty indicators are among the highest in Europe, and provide a further dimension to the case for added focus on improving the energy performance and quality of the building stock in South-East Europe.

Table 5 - Indicators of fuel poverty offered as a share of the total population
(Source: Eurostat, 2014[24])

Country	Inability to keep home adequately warm	Arrears on utility bills	Living in a dwelling with a leaking roof and damp or rotten walls and floors
Bulgaria	40.5	32.9	13.2
Serbia	17.1	41.4	26.2
Greece	32.9	37.3	13.7
FYROM	26.1	38.8	15.2
Hungary	11.6	22.3	26.9
Slovenia	5.6	20.3	29.9
Croatia	9.7	29.1	11.7
Romania	12.3	21.1	12.7
Slovakia	6.1	6.1	7.0

Scale: Percentage of population						
0%-8%	8%-17%	17%-25%	25%-33%	32%-42%	42%-50%	> 50%

Figure 9 - Inability to keep home adequately warm [Colour-coded after Table 5] (Source: BPIE own analysis)



[24] Albania is missing from the datasets of Eurostat.

BUILDING SECTOR'S CONTRIBUTION TO AIR POLLUTION

In addition to the generally poor quality of the building stock, the poor air quality is a serious problem in many parts of the region. When considering particulate matter (PM), the four towns/cities within Europe with the highest PM10 emissions are all within the countries covered by this study. In total, 17 out of 50 European towns/cities with the highest atmospheric concentrations of PM10 are in the region, as well as 13 out of 50 for the smaller and more damaging to health PM2.5 particles[25]. All exceed the World Health Organization guidelines for particulate emissions by a factor of at least 2, and in some cases as much as 5-6.

According to the European Commission's Joint Research Centre, within the Central and Eastern European region, domestic fuel burning is the main source of the pollutants PM10 and PM2.5, the former accounting for close to half of the total[26]. Further details are provided in Annex 6. Measures to reduce energy demand will also have a positive impact on the air quality of the region.

Protected customers in the Security of Gas Supply Regulation

Through the proposed Security of Gas Supply Regulation[27], an obligation is set on neighbouring Member States that, in the event of severe energy shortages, should ensure gas deliveries to a specifically identified group of 'protected customers', including at minimum all households. This 'solidarity principle', which requires countries to make their gas available to neighbouring countries' protected customers, is the last resort after the market has been unable to satisfy demand and after Emergency Plans have been triggered.

Despite the regulation's good intentions, it could place an unacceptable strain on neighbourhood relations in times of crisis. The burden to supply protected customers could grow unbearable as the definition of protected customers can be expanded from just residential buildings to include all buildings and district heating plans, while the protection may last for up to 30 days or even for the total length of the disruption.

What is significant in the context of this study is that the Regulation invites Member States to act pre-emptively to avoid future conflicts by reducing their gas dependence through their Preventive Action Plans.

[25] World Health Organization (WHO) "Global Urban Ambient Air Pollution Database" (update 2016). http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

[26] https://ec.europa.eu/jrc/en/news/what-are-main-sources-urban-air-pollution

[27] See Security of Gas Supply proposed regulation and Impact Assessment (SWD (2016) 25/2).

ASSESSING THE RISK OF GAS SUPPLY DISRUPTION

The importance of gas for the present state of the economy and for meeting society's needs cannot be understated. Despite all its benefits, gas comes with a number of adverse risks, including dependence on a single energy carrier. Once buildings are dependent on gas to meet their heating needs, a possible disruption can have devastating social and economic impacts. **Bulgaria's** GDP decreased by 9% in the 14-day disruption period during the 2009 Ukraine-Russia dispute[28]. It is clear that national sovereignty is under threat in the absence of energy security. However, energy security cannot be guaranteed with increased gas dependence, even when coming from a more diversified range of sources.

The EU is taking some steps with the Security of Gas Supply Regulation and is calling on Member States to guarantee gas deliveries to a number of 'protected customers' comprising at least all households, and is requiring them to draw up Preventive Action Plans and Risk Assessments. The present section contributes to these risk assessments by examining the vulnerability of the building stock.

BUILDING STOCK VULNERABILITY INDICATOR – BVI

The threat of gas disruption needs to be assessed as to the severity of its potential impact on residents and businesses. For this purpose, BPIE has developed a Building stock Vulnerability Indicator (BVI), to conduct a risk assessment of the building stock and rank countries according to defined vulnerability levels. The following table presents the classification of building stock vulnerability levels.

Table 6 - Levels of building stock vulnerability to gas supply disruptions (Source: BPIE own analysis)

Building stock vulnerability level		Appropriate response	
Critical	Gas users are extremely vulnerable	EXCEPTIONAL	Maximum energy security measures to minimise vulnerability and risk
Severe	Gas users are highly vulnerable		
Substantial	Gas users have significant exposure to supply disruption	HEIGHTENED	Additional energy security measures reflecting specific consumer vulnerabilities and judgements on acceptable risk
Moderate	Gas users have some exposure to supply disruption		
Low	Gas users are broadly secure	NORMAL	Routine energy security measures
N/A	Gas users are not exposed		

The Building stock Vulnerability Indicator (BVI) ranks countries according to the vulnerability of their buildings to a disruption in gas supply. In broad terms, the vulnerability (and BVI score) increases according to:

- The importance of gas as a source of heating fuel in buildings;
- The level of gas import dependency.

[28] Christie et al. (2011)

Conversely, the BVI decreases with increasing levels of gas supply diversification, also taking into account the original source of the gas.

THE BUILDING STOCK VULNERABILITY INDICATOR $$BVI = \frac{Bg}{Bt} * EDg * IRF * 100$$

Where:

Bg is the absolute amount of gas use in buildings;
Bt is the total absolute amount of energy consumption of buildings;
EDg is the Energy Dependence for gas defined as the net imports of gas divided by the sum of gross inland energy consumption;
IRF is the Interconnection Risk Factor, defined by the formula:

IRF = CountryA*IRFa + CountryB*IRFb + … + CountryN*IRFn
Where, each country "N" has its corresponding Interconnection Risk Factor "n", taking values from 0 to 1 according to the following logic:

- IRF= 0.8 for imports from Ukraine, 0.6 from Turkey, 0.5 from Austria, Czech R. and Italy
- IRF= 0.4 for LNG,
- IRF= 0 for no interconnection

A low BVI score means that buildings are resilient to gas-supply shocks. This could be for example either because they are covered by domestic production to a significant extent, or because the sector does not use a lot of gas, or because a country is not dependent on just one supplier. **A high BVI score indicates high vulnerability.** An example would be a country that heats a large proportion of the building stock with imported gas from just one source. In the following map, the colour gradation from green to red indicates increasingly higher vulnerability.

Table 7 - BVI results and corresponding map (Source: BPIE own analysis)

Building Stock Vulnerability

	BVI	Vulnerability level
Albania	0	Not applicable
Bosnia & Herzegovina	5	Moderate
Bulgaria	12	Substantial
Croatia	4	Low
FYROM	5	Moderate
Greece	3	Low
Hungary	34	Severe
Kosovo	0	Not applicable
Montenegro	0	Not applicable
Romania	1	Low
Serbia	7	Moderate
Slovakia	39	Severe
Slovenia	6	Moderate

Scale:	N/A	Low	Moderate	Substantial	Severe	Critical
	BVI = 0	0 < BVI < 5	5 < BVI < 10	10 < BVI < 20	20 < BVI < 40	BVI > 40

The BVI paints an important picture of the gas security situation in the region. Whilst potential provisions under the Security of Gas Supply Regulation have not been reflected in the BVI, one can assume that non-EU countries in the region will face increased risks compared to their neighbouring EU countries that should act in solidarity.

Table 8 discusses the position of each country regarding its vulnerability score.

Table 8 - Building stock vulnerability level by country (Source: BPIE own analysis)

Building stock vulnerability level	Description
N/A *(countries either do not use or do not import gas)*	**Kosovo** and **Montenegro** do not use gas to heat their buildings and are thus not vulnerable to gas supply shocks. **Albania** does not import gas, so it is not vulnerable to external supply interruptions.
Low	**Romania** has little import dependency as it largely covers its significant gas demand from indigenous production. However, due to its limited interconnectivity, it could face some problems in the future, where production from national resources could be compromised. **Croatia** uses a significant amount of gas in buildings, but has a large indigenous share of gas, so it lowers its risk level. **Greece** has a low BVI due to its diversity of supply routes, in particular its import capacity from LNG infrastructure.
Moderate	**Bosnia & Herzegovina** and **FYROM** have relatively little reliance on gas as a heating fuel for their building stocks but their complete import dependency brings moderate risk. Also, as non-EU members, they may be exposed to a relatively higher additional risk as they are not covered by the provisions of the EU Security of Gas Supply Regulation. **Slovenia** is characterised as moderately vulnerable considering its combination of moderate gas demand in buildings, and its 100% import dependency. **Serbia** has an import dependency of 71% and imports gas from just one country. It also faces an additional risk as it does not currently benefit from the provisions on protected customers of the EU Security of Gas Supply Regulation.
Substantial	**Bulgaria** is substantially vulnerable due to a relatively high share of gas use in buildings and its 100% import dependency. Its vulnerability became obvious in 2009 when there was a disruption in gas imports.
Severe	Buildings and their inhabitants in **Hungary** and **Slovakia** are severely vulnerable in case of a gas supply disruption. In both countries, gas demand in buildings is half of the total demand for gas. They are also connected to Ukraine, which is at the epicentre of geopolitical issues at present and whose gas supply, as a transit country from Russia, has been interrupted in recent years. Pipelines from Ukraine make up 70% of Slovakia's import capacity and 82% of Hungary's.
Critical	No countries have been assessed as having a critical BVI.

In conclusion, it can be seen that most countries in the region have some degree of building stock vulnerability to gas supply interruptions. Their vulnerability would not be perceived immediately following a gas supply disruption, since some countries, namely **Bulgaria, Croatia, Hungary, Romania, Serbia** and **Slovakia**, have built gas storage facilities. These facilities are between 60% and 75% full and able to cover 10% to 45% of inland gas consumption for a limited period of time, until their supplies become scarce. Two countries in particular, which are most dependent on gas and which together account for over half of the region's building gas usage, are at severe rating on the BVI index. **Hungary** and **Slovakia** should therefore be at the forefront of efforts to reduce their risk, though **all countries** would benefit from co-ordinated action. As we argue in this paper, the only medium- to long-term sustainable solution, which significantly improves energy security and the countries balance of payments while at the same time reducing fuel poverty, improving air quality and generating local jobs, is a concerted programme of building renovation to a high energy performance level.

MITIGATION OF GAS DEPENDENCY THROUGH BUILDING RENOVATION

The traditional approach of addressing energy security calls for additional supply infrastructure and expansion of sources. While doing so provides some increase in gas security, the long-term impact is actually increased dependence on imported gas. This approach also carries financial risk in the form of stranded assets, should gas consumption fall short of predicted levels. While some additional gas infrastructure is warranted (such as reverse-flow pipelines), the need for it can be greatly reduced by cutting gas usage, reducing investment requirements and avoiding the risk of stranded assets.

Provisions under the Security of Gas Supply Regulation can mitigate the vulnerability of EU Member States if appropriate Preventive Action Plans are enacted. Accordingly, this section presents the case for a lasting solution to building's vulnerability to gas supply disruptions through demand-side measures.

THE BENEFITS OF ENERGY EFFICIENCY INFRASTRUCTURE FOR ENERGY SECURITY

The deployment of a publicly-supported programme of building renovation has the potential to cut gas demand significantly. Reducing gas demand means reducing the vulnerability for residential and commercial buildings, and, by extension, for the South-East Europe region as a whole.

This section presents the results of a BPIE modelling of the impact of energy efficiency infrastructure upgrades to the building stock of the region[29]. BPIE's model estimates the macroeconomic benefits arising from the upgrade of buildings via energy performance improvement measures. To set things in context, our goal in this analysis is to improve the energy security by minimising the use of gas, by improving the building stock heat retention properties and by increasing the resilience to gas supply interruptions[30]. The demand-led approach provides numerous co-benefits and delivers across a range of national and regional strategic priorities. Our analysis shows that addressing supply-side problems with demand-side measures is an effective solution that offers many additional benefits and addresses long-term energy concerns and climate issues when compared with a "supply infrastructure only" driven approach.

[29] Albania and FYROM were not covered in the analysis because data on their building stock is lacking and because their gas use in buildings is non-existent according to Eurostat .

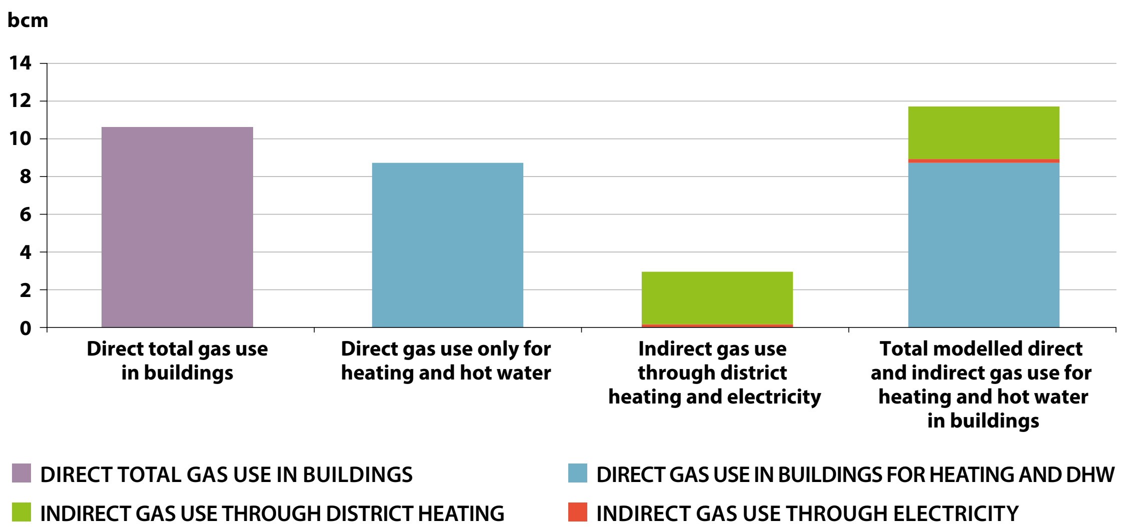
[30] See a similar approach from the Towards 2030 Dialogue project: http://towards2030.eu, Issue Paper No. 1.

Scope of the renovation modelling methodology[31]

Energy performance improvements are focused on the "regulated" end-uses covered by the Energy performance of Buildings Directive, namely heating, cooling, ventilation & air conditioning (collectively, "HVAC") domestic hot water, fixed lighting (mainly in non-residential buildings), passive solar systems and solar protection. Cooking[32] and appliances such as televisions and refrigerators are not covered by the EPBD requirements. Therefore, for modelling purposes, we focus on the share of energy carriers for heating and hot water (i.e. electric or gas boilers for hot water, electric space heaters, wood stoves, district heating supply, etc).

The indirect use of gas by buildings through their use of electricity generated by gas, as well as the use of gas in district heating systems, is also taken into account. Gas is part of the fuel mix generating electricity and heat and thus a significant reduction in the energy demand of buildings would decrease the demand for gas in power plants. An overview of the modelled gas use in buildings is visualised in Figure 10 and is presented in details in Annex 1. Direct gas demand by buildings for heating and hot water is 8.7 bcm/a, compared to 2.9 bcm/a for indirect gas use (through use in generation of electricity and district heating).

Figure 10 - Direct and indirect gas use of buildings in South-East Europe in 2014 (annual demand in bcm) (Source: BPIE own analysis)



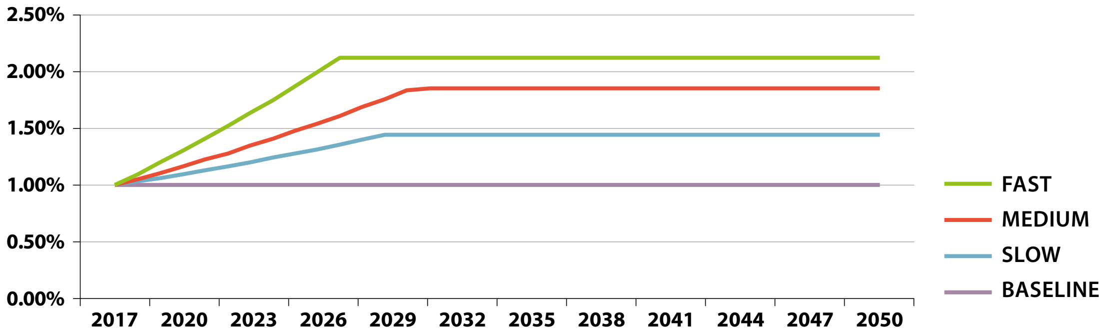
As a starting point, we take the latest available gas consumption data from 2014. From this, we forecast gas demand through a series of scenarios. The four scenarios described below represent progressively more ambitious views of the future development of the building renovation market, focused around two key drivers:

- **Renovation rates**, that reflect the expansion of the renovation market, following support from enabling policies, such as national renovation strategies. They are defined as the percentage of useful floor area of annually renovated buildings divided by the total useful floor area of the entire building stock.

[31] Data on the building stock is provided by various sources, including BPIE's Data Hub, http://www.buildingsdata.eu, while data on energy use has been sourced primarily from Eurostat.

[32] Additional gas savings could be achieved from switching away from gas fired appliances, though this has not been included within the scope of the analysis.

Figure 11 - Renovation rates for the whole building stock (Source: BPIE own analysis)



- **Renovation depths**, that indicate the energy savings achieved by the choice of renovation standards.

Table 9 - Energy savings compared to initial state of the building and associated renovation costs (Source: BPIE own analysis)

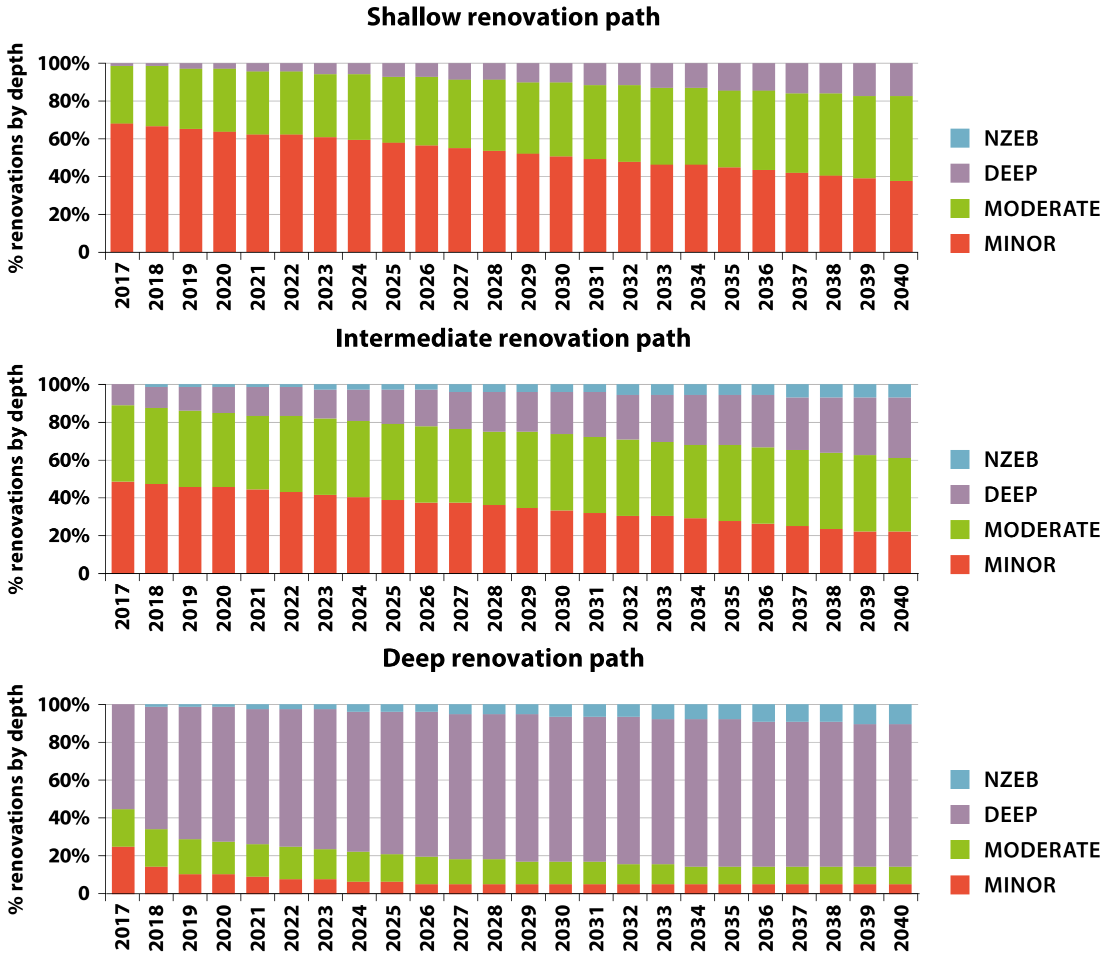
Minor renovation depth	**15%** energy savings	**75 €**/m²
Moderate renovation depth	**45%** energy savings	**120 €**/m²
Deep renovation depth	**75%** energy savings	**225 €**/m²
nZEB[33] renovation depth	**95%** energy savings	**400 €**/m²

Both the renovation rate and the renovation depth are dynamic[34]. Figure 11 shows how renovation rates could grow over time, eventually reaching a plateau. For renovation depths, we model three **renovation paths**, which are assumptions on the market share of each renovation depth and its evolution over time. Progressively deeper renovations take on a larger share of the market. This is because building codes and other policy drivers will result in higher energy performance requirements, and because economies of scale decrease the renovation costs, thus bringing deeper renovations within reach. The pathways are presented in the following graphs.

[33] Nearly Zero-Energy Buildings.

[34] The "frozen" scenario is an exception. In it, renovation rates and depths stay constant at today's levels.

Figure 12 - Renovation pathway assumptions on the share of renovation depths (Source: BPIE own analysis)



The four scenarios are created by the relevant combination of renovation rate and renovation pathway, as summarised in the table below.

Table 10 – Renovation scenarios linked to the rate and depth (Source: BPIE own analysis)

Scenarios	Frozen	Limited protection	Risk mitigation	Energy security
Renovation rate	Baseline rate	Slow rate	Medium rate	Fast rate
Renovation pathway	Baseline renovation (frozen at starting year)	Shallow renovation path	Intermediate renovation path	Deep renovation path

Future gas demand has been a challenge to estimate, as seen from the routinely overestimated PRIMES forecasts in Figure 3. There is no logical reason in the foreseeable future for gas demand to increase significantly in the buildings of these countries, at least not enough so that additional import capacity may be needed. It has to be noted that, currently, the gas import capacity, while not uniformly or ideally distributed from a gas security perspective, is severely under-used. We have therefore decided to keep gas demand steady at current levels for the scope of this analysis.

Unfocused renovation of the building stock

Following the above-mentioned methodology, in a 20-year period the effect of renovations in mitigating gas demand and its macroeconomic implications. The results show that an untargeted programme open to all buildings would lead to moderate gas savings and would only have a limited impact on reducing gas supply vulnerability. *Direct* and *indirect* (through district heating and electricity generation) gas use account for 25% and 7% respectively of the energy demand in the region's buildings, equalling 0.5 bcm/a to 1.92 bcm/a of total direct and indirect gas savings depending on the scenario, which shows that energy security benefits are not maximised.

Table 11 – Estimations of energy savings in the four scenarios for a 20-year unfocused renovation programme (Source: BPIE own analysis)

20-year unfocused renovation programme	Frozen	Limited protection	Risk mitigation	Energy security
Energy savings (bcm/a) of…				
Direct gas use in boilers	0.40	0.62	0.98	1.51
Gas for district heating	0.10	0.16	0.25	0.39
Gas for electricity	0.002	0.003	0.006	0.009

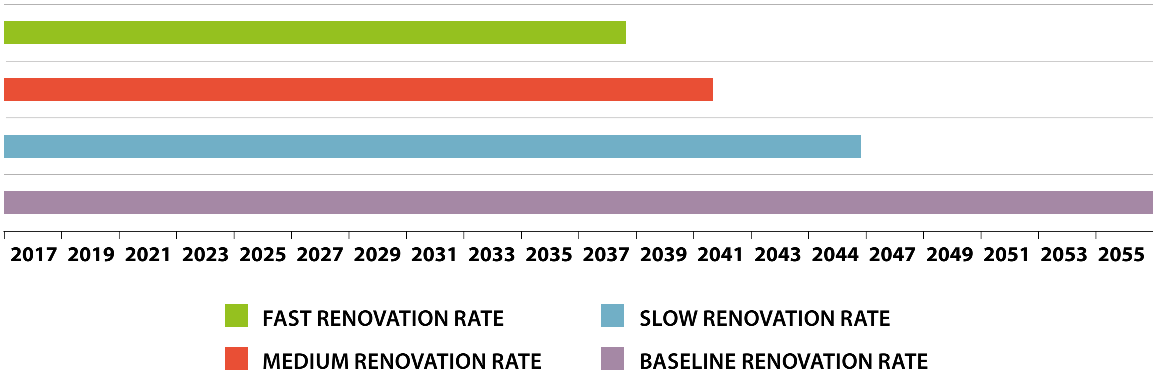
Renovation focused on buildings using gas

Untargeted renovations, while providing overall benefits to recipients, do not go far enough in decreasing the vulnerability of the building stock to gas supply disruption. A renovation programme focusing on gas-using buildings – and potentially also district heating plants – would be more effective in mitigating risks. The subsequent analysis demonstrates the impact if all the renovation efforts were directed towards those buildings heated by gas.

The outcomes of a renovation programme targeting gas-using buildings are presented in the following pages. Our methodology estimates the intensity of renovations (in square metres per year) for the total building stock, and then focuses and applies all efforts to gas-consuming buildings (both directly and to those supplied by district heating).

Applying the new 'gas-only' renovation rates, it is possible to estimate the year when all gas-using buildings will be renovated. Based on the renovation rates assumed in the methodology, the whole gas-using building stock would be renovated by 2055 at current renovation rates, as seen in the "frozen" scenario. Under the "limited protection" scenario, that date is brought forward ten years to 2045, while a further five years (2040) will be shaved off under the "risk mitigation" scenario. At the fastest renovation rate assumed in the "energy security" scenario, all gas-consuming buildings could be renovated within 20 years (by 2037).

Figure 13 - Years when all gas-using buildings are renovated (Source: BPIE own analysis)



Accordingly, our modelling has been set to span a 20-year period, to 2037. In this timeframe, all gas-using buildings are renovated under the "energy security" scenario, and thus we can observe the potential of a complete renovation programme. Under the "risk mitigation", "limited protection" and "frozen" scenarios, the targeted renovation programme at the end of the 20-year cycle would be respectively 88%, 72% and 54% complete. The following figure shows the proportion of the total building stock that will be renovated under each scenario.

Figure 14 - Share of the total building stock that can be renovated (Source: BPIE own analysis)

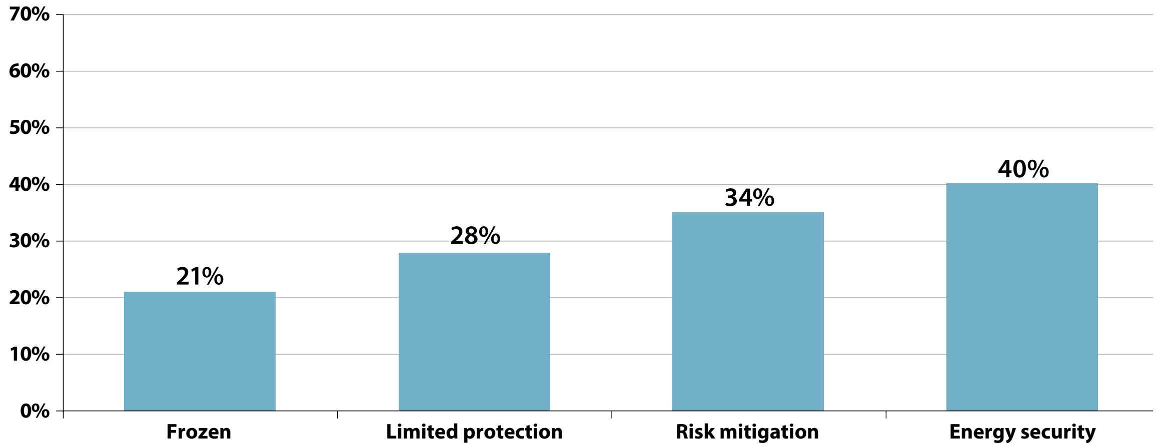
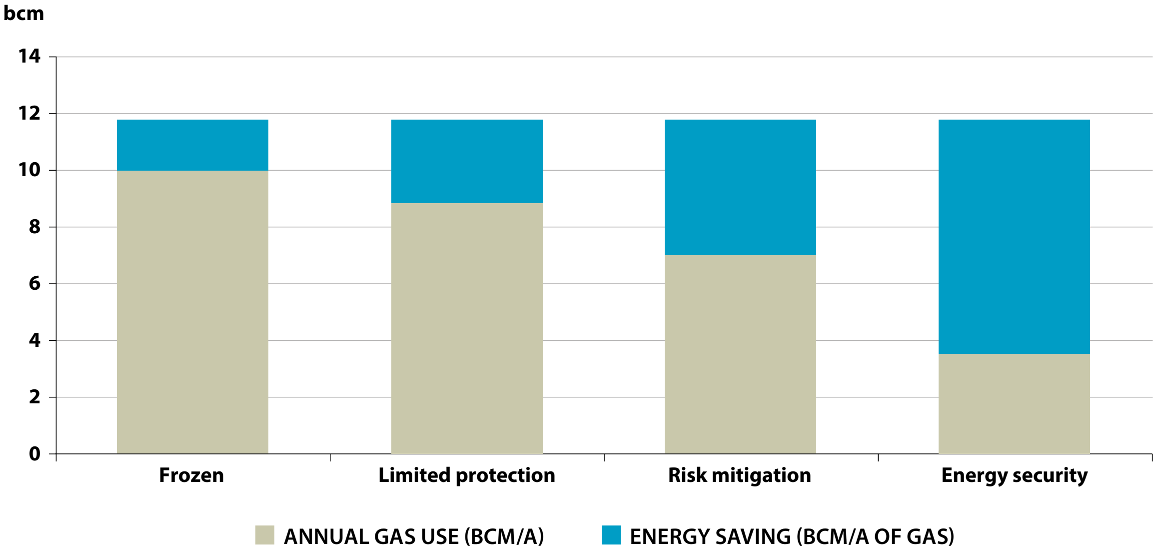


Table 12 – Achievable levels of gas demand reduction at the end of the 20-year period under the four scenarios (Source: BPIE own analysis)

Resilience benefits of a 20-year targeted renovation programme	Frozen	Limited protection	Risk mitigation	Energy security
Demand reduction through renovation (bcm/a)	1.7	2.8	4.7	8.2
Residual gas use (bcm/a)	10.1	8.9	7.0	3.5
Gas demand reduction (%)	**14%**	**24%**	**40%**	**70%**

Figure 15 - Gas demand in buildings reduced through energy efficiency measures (Source: BPIE own analysis)



Under the "energy security" scenario, gas demand is reduced by 70%, thereby substantially reducing the threat posed by gas-supply disruptions to society and economy. The residual low demand for gas in the region, of 3.5 bcm/a, could readily be covered through reverse-flow pipelines and imports through LNG terminals in neighbouring countries, including Greece.

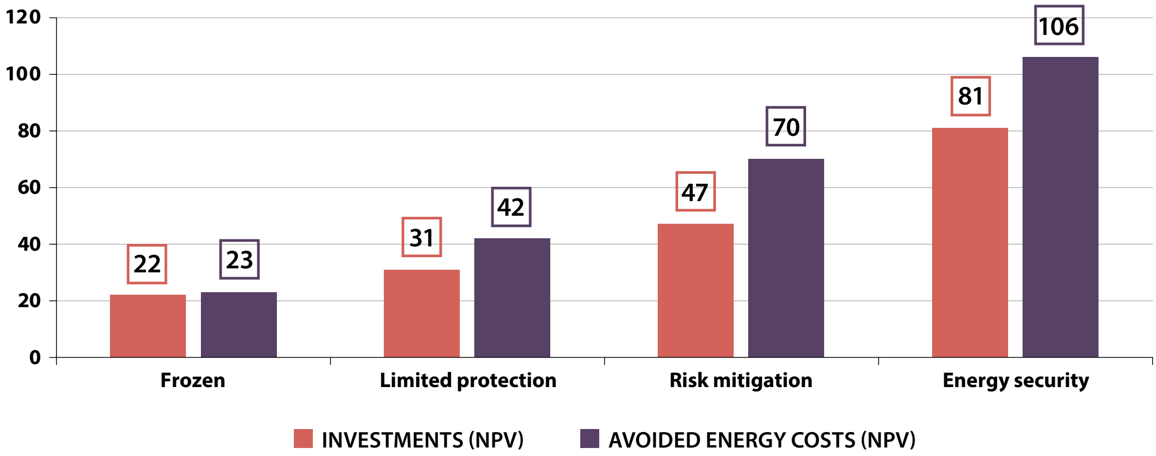
The "risk mitigation" scenario, having renovated 88% of the gas-using building stock by 2037, can make a significant contribution to reducing supply vulnerability. With 40% less demand compared to current levels, affected countries would be able to withstand a supply disruption for a considerable period of time.

Under the "limited protection" and "frozen" scenarios, however, the reduction of gas demand by 24% and 14% respectively will do little to guard countries in the region against a supply disruption. In case the interruption exceeds the monthly limit currently proposed as the minimum coverage of protected customers, the economic and social implications could be worse than Bulgaria's in 2009. It should be remembered that Bulgaria only suffered a 14-day gas-supply interruption.

Financial implications

As with any infrastructure programme, renovating a large proportion of the total building stock over a 20-year period requires a significant investment. Investments could be as much as €81bn in total under the most ambitious "energy security" scenario, but would result in €106bn in energy cost-savings over the lifetime of the measures, more than offsetting the investment (all figures are present value).

Figure 16 - Estimated investment costs for deployment of energy efficiency and the corresponding avoided energy costs in €Billion (Source: BPIE own analysis)



While governmental and EU sources of financing such as the European Fund for Strategic Investment and the European Structural and Investment Funds can and should be used to boost the renovation market, ultimately it is building owners that are likely to be the principal funders. As many citizens, public authorities and businesses lack the financial resources to make the upfront investment, despite it being economically attractive over the measures lifetime. Suitably-designed financing schemes will need to be developed to overcome the initial capital investment barrier. Likewise, governments will need to develop other non-financial forms of support, including training, awareness raising, and regulatory measures which remove barriers and provide the right signals to consumers when undertaking work on their properties.

In short, governments in the region need to develop national building renovation strategies that tackle all barriers and provide the right signals, financing framework and market confidence for a long-term transition of the existing building stock to a high energy performance level. These issues are covered in detail in the case of one country in the region, Bulgaria, in BPIE's report *"Accelerating the renovation of the Bulgarian building stock"*[35]. The framework and roadmap developed for the residential building sector in Bulgaria can be the basis for similar initiatives in other countries of the region.

[35] http://bpie.eu/publication/accelerating-the-renovation-of-the-bulgarian-building-stock/

CONCLUSIONS AND POLICY RECOMMENDATIONS

Risk assessment

South-East Europe has been identified as the only region vulnerable to gas-supply disruptions, with its building stock consuming 38% of gas imports.

The vulnerability of the building stock to gas supply disruptions is explored with the BPIE's Building stock Vulnerability Indicator (BVI). The BVI takes into consideration three factors: the importance of gas as a fuel in buildings, the degree of gas-import dependency, and the diversity of supply routes.

The analysis concludes that:

- **Less than 4 countries** in the region have low or moderate vulnerability;
- **Bulgaria** has a substantial vulnerability;
- **Hungary** and **Slovakia** are severely vulnerable.

Countries in the region are encouraged to take the BVI into account when preparing their Risk Assessments under the Security of Gas Supply Regulation.

Preventive measures

Gas dependency cannot be solved with more gas-supply options, which would only lead to increased dependency, but it can be significantly mitigated with demand-side measures in the form of a comprehensive and deep renovation of buildings. A dedicated renovation programme could, within 20 years, address all gas-consuming buildings in SE Europe and reduce the building stock's gas consumption by as much as 8.2 bcm/a, or 70% of the current consumption.

A renovation programme targeting gas-using buildings would require a significant investment of €81bn over 20 years from all countries in the region collectively. This investment would lead to financial returns in the form of reduced energy bills amounting to €106bn, more than offsetting the investment[36]. Furthermore, a dedicated programme of building renovation would deliver a number of additional benefits:

- Extending the lifetime of indigenous gas resources;
- Helping to tackle fuel poverty, a serious problem in most SEE countries;
- Increasing the quality and value of the building stock;
- Improving the very poor air quality experienced in many towns and cities of the region;
- Improving the balance of payments by cutting national expenditure on fuel imports;
- Stimulating a domestic industry to supply and install the necessary energy efficiency and renewable energy technologies within the building sector, creating significant employment as well as revenues to national treasuries;
- Contributing significantly to climate policy goals by dramatically reducing GHG emissions.

[36] All costs and savings are present value.

In drawing up their Preventive Action Plans under the Security of Gas Supply Regulation, Member States are encouraged to look into preventive demand-side measures. Thermal renovations through energy efficiency and renewable energy in the building stock provide overwhelmingly positive solutions with multiple benefits such as energy security, investments in infrastructure and promotion of the renovation market and jobs. To ensure that local employment opportunities are maximised and that economic benefits are retained within the region, a strategic cross-country approach that sees the development of a manufacturing capacity alongside the expected increase in the installation of renovation measures is required.

Member States are allowed to comply with the obligation laid down in the proposed Security of Gas Supply Regulation by replacing gas with a different source of energy to the extent that the same level of protection is achieved. Building on the principle of "Energy Efficiency as the First Fuel", the European institutions are encouraged to treat energy efficiency as a reliable and clean source of energy.

EU level policies and definitions

The Projects of Common Interest list for 2018 will include combined modelling between ENTSO-G and ENTSO-E. It is proposed that energy efficiency and demand-side response developments are taken into account when modelling future energy demand.

Renovations are faced with the barrier of high upfront costs and the fact that they are not usually considered as infrastructure. The European institutions and the target countries of this analysis are strongly encouraged to set energy efficiency as an infrastructure priority. In parallel, funds from the Connecting Europe Facility, the Multiannual Financial Framework the European Fund for Strategic Investments and the Structural and Investment Funds should be better directed for investments in deep renovations of the building stock. State Aid rules will need to accommodate the new definitions of energy efficiency.

Energy efficiency of the wider energy system also needs to be addressed. District heating, for example, meets the heating needs of a significant share of customers, especially in **Bulgaria, Serbia** and **Romania**. It would be beneficial to replace gas or coal-fired district heating with those based on heat pump technology.

Heating and cooling planning

A roadmap based on fossil fuels and local biomass has to be drawn to shift away from traditional heating and cooling methods towards modern approaches based on the best available low-carbon technologies. The considered options should include, but not be limited to, the electrification of heat via heat pumps, the expansion of district heating networks to exploit industrial waste heat, and the installation of demand-response systems and energy storage to accommodate varying renewable energy generation.

A stepwise approach is warranted, whereby strict and ambitious regulations are enacted in agreed time periods. While this process is linked to local circumstances, it is suggested that, initially, only the most efficient fossil fuel boilers will be permitted in the market, while, after few years, hybrid systems that meet minimum efficiencies should be introduced. This long-term planning should lead to system-wide approaches where, for example, district heating systems will be based on heat pumps powered by renewable energy.

Finally, subsidies for fossil fuels need to be phased out and redirected to clean energy developments that support the combination of renewable energy technologies with energy efficiency improvements in the building sector.

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ANNEXES

ANNEX 1 - GAS USE IN BUILDINGS BY COUNTRY

	Albania	Bosnia & Herzegovina	Bulgaria	Croatia	FYROM	Greece	Hungary	Kosovo	Montenegro	Romania	Serbia	Slovakia	Slovenia	Total
Direct Gas demand (BCM)														
Residential buildings	-	0.04	0.05	0.48	-	0.26	2.57	-	-	2.41	0.16	1.15	0.10	7.2
Services buildings	-	-	0.09	0.15	0.01	0.14	1.38	-	-	0.86	0.13	0.63	0.04	3.4
Gas use for space heating and DHW in residential as a share of buildings gas demand	0%	89%	87%	86%	86%	78%	95%	0%	0%	75%	86%	89%	94%	
Gas use for space heating and DHW in services as a share of buildings gas demand	0%	90%	51%	60%	63%	21%	82%	0%	0%	70%	63%	90%	67%	
Gas demand for space heating and DHW in residential	-	0.03	0.04	0.41	-	0.20	2.44	-	-	1.81	0.14	1.02	0.09	6.2
Gas demand for space heating and DHW in services	-	-	0.05	0.09	0.00	0.03	1.13	-	-	0.60	0.08	0.57	0.03	2.6
Gas demand through electricity (BCM)														
Share of Gas in electricity production	0%	6%	5%	7%	4%	13%	14%	0%	0%	12%	1%	6%	2%	
Electricity consumption of residential	0.33	0.47	1.01	0.54	0.29	1.63	0.99	0.24	0.11	1.13	1.31	0.47	0.30	
Electricity consumption of services	0.13	0.59	0.75	0.54	0.14	1.60	0.73	0.07	0.06	0.78	0.43	0.59	0.30	
Electricity used for space heating and DHW in residential as a share of buildings electricity demand	16%	13%	22%	13%	16%	29%	8%	16%	16%	2%	14%	13%	11%	
Electricity used for space heating and DHW in services as a share of buildings electricity demand	21%	10%	28%	23%	21%	17%	15%	21%	21%	19%	20%	10%	27%	
Gas-generated electricity consumption for space heating and DHW in residential	-	0.00	0.01	0.01	0.00	0.06	0.01	-	-	0.00	0.00	0.00	0.00	0.1
Gas-generated electricity consumption for space heating and DHW in services	-	-	0.01	0.01	0.00	0.04	0.02	-	-	0.02	0.00	0.00	0.00	0.1
Gas demand through district heating (BCM)														
Share of gas in district heating	0%	79%	90%	91%	100%	0%	86%	0%	0%	76%	68%	79%	67%	
Gas-generated derived heat in residential	-	0.03	0.31	0.12	0.03	-	0.41	-	-	0.68	0.27	0.37	0.05	2.3
Gas-generated derived heat in services	-	-	0.10	0.03	0.01	-	0.13	-	-	0.16	0.05	0.05	0.03	0.6
Total gas use for space heating (BCM)														
Residential	-	0.06	0.36	0.53	0.03	0.26	2.87	-	-	2.48	0.41	1.40	0.14	8.5
Services	-	-	0.16	0.13	0.02	0.06	1.27	-	-	0.78	0.13	0.62	0.06	3.2
Total gas use for space heating and DHW in buildings	-	0.06	0.52	0.66	0.05	0.33	4.13	-	-	3.26	0.54	2.02	0.20	11.8

ANNEX 2 - CALCULATING THE BUILDING STOCK VULNERABILITY INDICATOR

BVI	Building Stock Vulnerability Indicator		Albania	Bosnia & Herzegovina	Bulgaria	Croatia	FYROM	Greece	Hungary	Kosovo	Montenegro	Romania	Serbia	Slovakia	Slovenia
Bg/Bt	Direct and indirect gas use in buildings as a share of total energy use in buildings		0%	6%	15%	21%	7%	5%	56%	0%	0%	32%	14%	56%	12%
EDg	Gas Import Dependency (Imports / Consumption)		0%	100%	99%	29%	100%	100%	83%	0%	0%	5%	71%	98%	100%
	Gas import capacity shares			Romania	Serbia	Slovenia Hungary	Bulgaria	LNG Turkey Bulgaria	Ukraine Romania Austria			Ukraine Hungary	Hungary	Ukraine Hungary Czech R. Austria	Italy Austria
		IRF													
	Bulgaria	0.80					100%	35%							
	Romania	0.80			100%				0.3%						
	Slovenia	0.50				41%									
	Serbia	0.74		100%											
	Hungary	0.74				59%						6%	100%	2%	
	Turkey	0.60						16%							
	LNG	0.40						49%							
	Ukraine	0.80							82%			94%		70%	
	Austria	0.50							18%					8%	80%
	Czech Republic	0.50												21%	
	Italy	0.50													20%
	No connection	0.0	100%							100%	100%				
IRF	Interconnection risk factor		0	0.7	0.8	0.6	0.8	0.6	0.7	0	0	0.8	0.7	0.7	0.5
BVI	Building Stock Vulnerability Indicator		0	5	12	4	5	3	34	0	0	1	7	39	6

Building Stock Vulnerability levels	Not Applicable BVI = 0	Low 0 < BVI < 5	Moderate 5 < BVI < 10	Substantial 10 < BVI < 20	Severe 20 < BVI < 40	Critical BVI > 40

Gas use in buildings (direct and indirect) as a share of total energy use in buildings (Bg/Bt) and **import dependency** (EDg) have been calculated using Eurostat figures of 2014

IRF: Interconnection Risk factors taking values from 0 to 1 according to the formula: IRF = CountryA*IRFa + CountryB*IRFb + … + CountryN*IRFn

Where, each country "N" has its corresponding Interconnection Risk Factor "n", making use of initial assumption values according to the following approach:

- IRF= 0 For no interconnection,
- IRF= 0.4 for LNG,
- Assumptions on countries' Interconnection risk Factors
  - Ukraine's IRF is 0.8 [Due to historical presidents of risky deliveries]
  - Turkey's IRF is 0.6 [It is closer to European interests but there are risk concerns]
  - Austria's IRF is 0.5 [Its import capacity is 24% from Germany, 8% from Italy and 68% from Slovakia]
  - Czech Republic's IRF is 0.5 [Its import capacity is 70% from Germany and 30% from Slovakia]
  - Italy's IRF is 0.5 [Its import capacity is 16% from LNG, 37% from north Africa, 1% from Slovenia, 16% from Switzerland and 30% from Austria]

BVI: The Building Stock Vulnerability Indicator is calculated according to the following formula: BVI = Bg/Bt * EDg * IRF * 100

ANNEX 3- GAS TRANSMISSION CAPACITY IN SOUTH-EAST EUROPE

Gas transmission capacity 2015 (Source: ENTSO-G)

Point	Arc	Technical physical capacity (GWh/d)	From operator	From CC	From BZ	To operator	To CC	To BZ	Available flow directions		Min GCV	Max GCV
Murfeld (AT) / Ceršak (SI)	AT>SI	**112.5**	Gas Connect Austria	AT	Austria	Plinovodi	SI	Slovenia	Y	B	11.170	11.170
Gorizia (IT) /Šempeter (SI)	IT>SI	**28.0**	Snam Rete Gas	IT	Italy	Plinovodi	SI	Slovenia	B	B	10.700	11.280
Rogatec	SI>HR	**53.0**	Plinovodi	SI	Slovenia	Plinacro Ltd	HR	Croatia	Y	Y	11.170	11.170
Lanžhot	CZ>SK	**696.5**	NET4GAS	CZ	Czech	eustream	SK	Slovakia	B	B	11.160	11.160
Baumgarten	AT>SK	**247.5**	TAG	AT	Austria	eustream	SK	Slovakia	Y	B	11.160	11.190
			Gas Connect Austria	AT	Austria	eustream	SK	Slovakia	Y	B	11.160	11.160
			Gas Connect Austria	AT	Austria	eustream	SK	Slovakia	B	B	11.160	11.160
			Gas Connect Austria	AT	Austria	eustream	SK	Slovakia	N	B	11.160	11.190
Mosonmagyarovar	AT>HU	**129.5**	Gas Connect Austria	AT	Austria	FGSZ	HU	Hungary	Y	Y	11.230	11.450
Kulata (BG) / Sidirokastron (GR)	BGg/BGT>GR	**108.0**	Bulgartransgaz	BG	GTNTT-BG	DESFA	GR	Greece	B	B	11.260	11.460
Negru Voda I (RO) / Kardam (BG)[37]	RO/TBP>BGn	**151.4**	Transgaz	RO	RO_DTS	Bulgartransgaz	BG	NGTN-BG	N	N	11.290	11.480
Negru Voda II, III (RO) / Kardam (BG)[38]	RO/TBP>BGg/BGT	**603.0**	Transgaz	RO	RO_DTS	Bulgartransgaz	BG	GTNTT-BG	N	N	11.180	11.460
			Transgaz	RO	RO_DTS	Bulgartransgaz	BG	GTNTT-BG	N	N	11.320	11.460
Csanadpalota	HU>RO	**51.1**	FGSZ	HU	Hungary	Transgaz	RO	RO_NTS	B	B	11.340	11.485
	RO>HU	**2.5**	Transgaz	RO	RO_NTS	FGSZ	HU	Hungary	B	B	11.120	12.060
Dravaszerdahely	HU>HR	**76.0**	FGSZ	HU	Hungary	Plinacro Ltd	HR	Croatia	B	Y	11.220	11.469
Balassagyarmat (HU) / Velké Zlievce (SK)	HUi>SK	**50.8**	MGT	HU		eustream	SK	Slovakia	B	B	11.160	11.160
Uzhgorod (UA) - Velké Kapušany (SK)	UA>SK	**2,288.0**	Ukrtransgaz	UA		eustream	SK	Slovakia	N	N	11.160	11.160
			Ukrtransgaz	UA		eustream	SK	Slovakia	N	N	11.160	11.160
			Ukrtransgaz	UA		eustream	SK	Slovakia	N	N	11.160	11.160
			Ukrtransgaz	UA		eustream	SK	Slovakia	N	N	11.160	11.160
Beregdaróc 1400 (HU) - Beregovo (UA) (UA>HU)	UA>HU	**600.3**	Ukrtransgaz	UA		FGSZ	HU	Hungary	N	N	11.346	11.472
Isaccea (RO) - Orlovka (UA) I	UA>RO/TBP	**755.3**	Ukrtransgaz	UA		Transgaz	RO	RO_DTS	N	N	11.310	11.310
Kipi (TR) / Kipi (GR)	TRi>GR	**48.6**	Botas	TR		DESFA	GR	Greece	N	N	11.330	11.330
Revythoussa	LNG_Tk_GR>GR	**150.0**				DESFA	GR	Greece	-	N	12.050	12.050

[37] No data is published by the Romanian TSO in the BG>RO direction.

[38] For Bulgaria, there is only one physical point – Negru Voda 2, 3 (RO) /Kardam (BG). For Romania, there are two separate points - Negru Voda II and Negru Voda III. No data is published by the Romanian TSO in the BG>RO direction.

ANNEX 4 – REGIONAL MAP BY ENTSO-G

KEYS

- Trading Points / Market Areas
- Cross-border interconnection point within Europe
- Cross-border interconnection point with third country (import/export)
- LNG Terminals' entry point intro transmission system
- LNG Export Terminal
- Small scale LNG liquefaction plant
- Intra-country or intra balancing zone points
- Third country cross-border interconnection point
- Cross-border Europe *Under construction or Planned*
- Cross-border third country import/export *Under construction or Planned*
- LNG Import Terminal *Under construction or Planned*
- LNG Export Terminal *Under construction or Planned*
- Small scale LNG liquefaction plant *Under construction or Planned*

Transport by pipeline

- under 24"
- 24" to 36"
- 36" and over
- project

Transport by tanker

- LNG route
- LNG route project

Gas Reserve areas

- drilling platform
- gas field

Gas storage facilities

- LNG Peak Shaving
- Acquifer
- Salt cavity - cavern
- Depleted (Gas) field on shore / offshore
- Other type
- Unknown
- Gas storage *project*

Countries

- ENTSOG Member Countries
- ENTSOG Associated Partner
- ENTSOG Observers
- Other Countries

Nr	Location	System Operators : logos
043	Waidhaus	Open Grid Europe The Gas Wheel; GRTgaz Deutschland (CZ-DE)

System Operators		Capacity	Flow		GCV Min	GCV Max
NET4GAS	GRTgaz Deutschland	903,7	B	Y	11,20	11,20
NET4GAS	Open Grid Europe		B	Y	11,20	11,20

Capacity 903,7 — Max. technical physical capacity in GWh/d

Where different Maximum Technical Capacities are defined by the neighbouring TSOs for the same Interconnection Point, the lesser rule is applied.

If capacity information is available only on one side of the border due to confidentiality reasons, the available figure is selected for publication.

Interconnections shown on map only when firm technical capacity is existing.

Flow

B	Y
B	N

Available flow direction for each TSO

B : Point physically bi-directional: TSO can offer firm capacity in both directions
Y : TSO offers firm capacity in one direction, and virtual backhaul capacity in the other
N : TSO offers firm capacity in one direction

refers to the 2nd TSO on the row
refers to the 1st TSO on the row

GCV 11,20 (Min.) 11,20 (Max.)

Assumed GCV for conversion in Mio Nm³ /d (kWh/Nm³, reference combustion temperature 25C)

000 Virtual point

- : Not applicable

Summer Capacity : indicated in case extra capacity is available during summer months

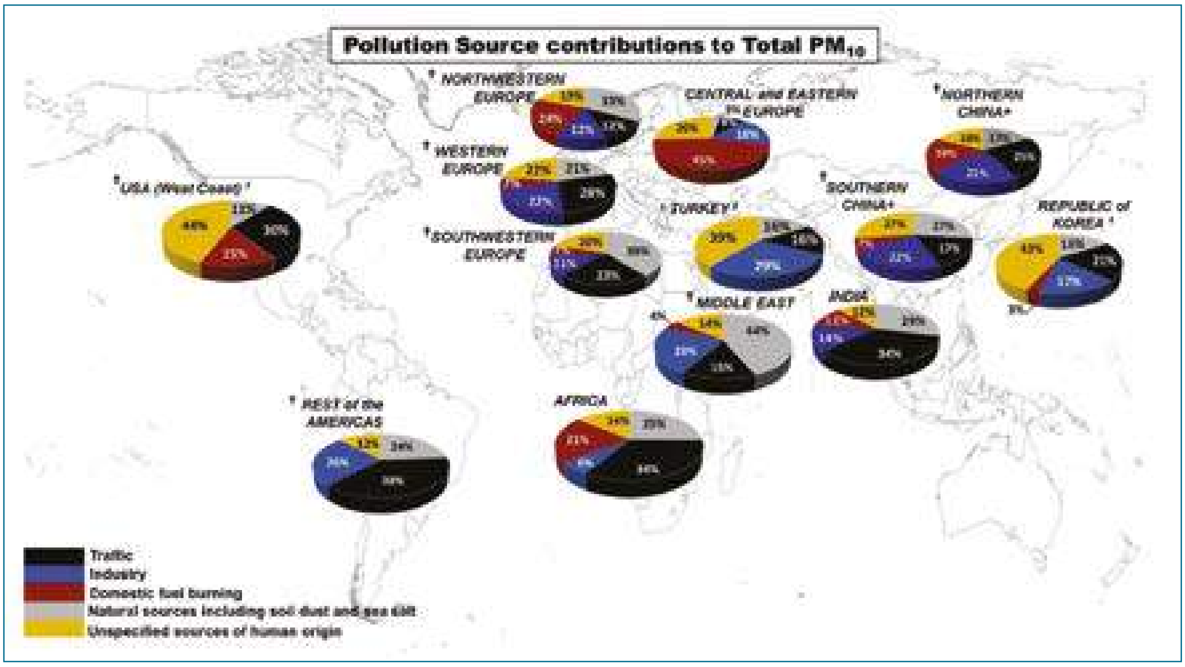
ENTSOG currently comprises 44 TSO members,
3 Associated Partners and 4 Observers

Capacity data based on Capacity data based on TYNDP 2015-2035
data collection related to the situation on 1 January 2015
Current capacity data can be found at https://transparency.entsog.eu

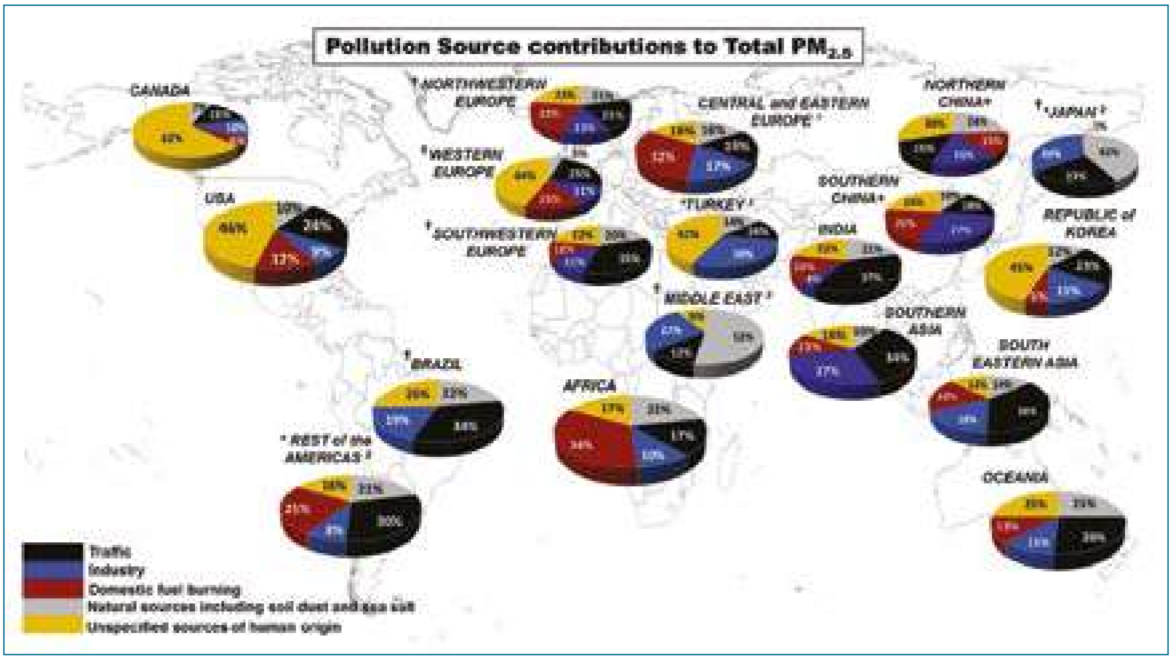
polaris graphik_technik — scale = 1 : 8.000.000 — Map version : May 2015

ANNEX 5 - SOURCES OF AIR POLLUTION IN DIFFERENT WORLD REGION[39]

PM10



PM2.5



[39] "Urban air pollution – what are the main sources across the world?", https://ec.europa.eu/jrc/en/news/what-are-main-sources-urban-air-pollution.

ANNEX 6 - RANKING OF EUROPEAN TOWNS/CITIES ACCORDING TO ANNUAL MEAN EMISSIONS OF PM2.5 AND PM10[40]

NOTE – all towns/cities in the top 50 significantly exceed WHO guidelines[41]:

Guidelines

$PM_{2.5}$: 10µg/m³ annual mean 25 µg/m³ 24-hour mean

PM_{10}: 20µg/m³ annual mean 50 µg/m³ 24-hour mean

	PM2.5			PM10		
Rank	Country	City/Town	Annual mean, µg/m³	Country	City/Town	Annual mean, µg/m³
1	**F.Y.R.O.M**	Tetovo	81	**F.Y.R.O.M**	Tetovo	140
2	**Bosnia and Herzegovina**	Tuzla	65	**Bosnia and Herzegovina**	Tuzla	106
3	**F.Y.R.O.M**	Skopje	45	**Montenegro**	Pljevlja	77
4	Poland	Zywiec	43	**F.Y.R.O.M**	Skopje	74
5	Poland	Pszczyna	43	**F.Y.R.O.M**	Bitola	69
6	**Bulgaria**	Dimitrovgad	42	**Bulgaria**	Dimitrovgad	59
7	**Montenegro**	Pljevlja	42	**Bulgaria**	Plovdiv	59
8	**F.Y.R.O.M**	Bitola	40	Poland	Zywiec	58
9	Poland	Rybnik	40	Poland	Pszczyna	58
10	Poland	Wodzislaw Slaski	39	**Bulgaria**	Dolny Voden	54
11	Poland	Opoczno	39	Poland	Rybnik	53
12	Poland	Sucha Beskidzka	39	Poland	Wodzislaw Slaski	53
13	Poland	Godow	38	Poland	Opoczno	53
14	**Bulgaria**	Dolny Voden	38	Poland	Sucha Beskidzka	53
15	**Bulgaria**	Montana	37	**Bulgaria**	Montana	52
16	Poland	Krakow	37	**F.Y.R.O.M**	Veles	51
17	Poland	Skawina	37	Poland	Krakow	51
18	**Bulgaria**	Varna	36	Bulgaria	Varna	51
19	Poland	Nowy Sacz	36	Poland	Godow	51
20	Poland	Niepolomice	36	**Bosnia and Herzegovina**	Sarajevo	50
21	Poland	Tuchow	36	Poland	Skawina	50
22	Poland	Knurow	36	Poland	Niepolomice	48
23	Poland	Zabrze	35	Poland	Tuchow	48
24	Poland	Katowice	35	Poland	Knurow	48
25	Poland	Wadowice	35	Poland	Zabrze	47
26	Poland	Nowa Ruda	35	Cyprus	Nicosia	47
27	Poland	Gliwice	35	Poland	Wadowice	47
28	**Bulgaria**	Plovdiv	34	Italy	Ceccano	47
29	Italy	Soresina	34	Poland	Nowa Ruda	47
30	Poland	Proszowice	34	**Bulgaria**	Ruse	47
31	Poland	Brzeziny	34	**Bulgaria**	Pernik	47
32	Poland	Bielsko Biala	34	**Bulgaria**	Haskovo	46
33	**Bulgaria**	Ruse	33	Poland	Proszowice	46
34	Poland	Zdunska Wola	33	Italy	Benevento	46
35	Czech Republic	Havirov	33	Poland	Brzeziny	46
36	Czech Republic	Cesky Tesin	33	**Bulgaria**	Pazarjik	46
37	**Bulgaria**	Haskovo	33	Poland	Gliwice	46
38	Poland	Kedzierzyn-Kozle	33	Poland	Nowy Sacz	45
39	Poland	Rawa Mazowiecka	33	Poland	Katowice	45
40	Poland	Sosnowiec	33	Poland	Zdunska Wola	45
41	Czech Republic	Orlova	33	Czech Republic	Havirov	45
42	**Bulgaria**	Pazarjik	33	Italy	Salerno	45
43	Italy	Settimo Torinese	33	Poland	Zory	45
44	Poland	Naklo	32	Czech Republic	Cesky Tesin	45
45	Czech Republic	Karvina	32	**Romania**	Iasi	44
46	Poland	Kalisz	32	Poland	Rawa Mazowiecka	44
47	Czech Republic	Ostrava	32	Poland	Sosnowiec	44
48	Poland	Dabrowa Gornicza	32	Czech Republic	Orlova	44
49	Poland	Tychy	32	Poland	Naklo	44
50	Poland	Zakopane	32	Poland	Dabrowa Gornicza	43

[40] Derived by BPIE from WHO Global Urban Ambient Air Pollution Database (update 2016) http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

[41] WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide, 2006 (page 10) http://apps.who.int/iris/bitstream/10665/69477/1/WHO_SDE_PHE_OEH_06.02_eng.pdf.

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