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STRATEGIC MANAGEMENT OF THE POLISH ENERGY INDUSTRY AS IT IS BEING SHAPED BY GLOBAL FACTORS

Abstract
The Polish energy sector is shaped by a combination of regulations, especially those pertaining to environmental protection, domestic and international energy resource availability, and pricing of both renewable and non-renewable resources, in addition to the economics of energy exploration, transport, refining, production, distribution, and final energy use. The article outlines the main global factors shaping the use of energy sources in Poland and in the world, and proposes that strategic management of the Polish energy industry be based on minimizing the discounted unit social cost of final energy use as the criterion for optimizing decisions on choosing energy sources and conversion technologies.

Key words:
Energy, strategic management, energy resources, renewable energy, hydrocarbons, nuclear power

Introduction
Poland's energy policy is shaped mainly by forces of supply and demand, the availability of non-renewable and renewable, domestic and foreign energy resources, existing and prospective technologies related to energy production and use, and by European Union directives and local regulations concerning the functioning of energy markets and environmental protection. These directives stipulate a reduction in primary energy use and greenhouse gas emissions, a lowering of the energy intensity of the economy, increasingly stringent regulations on the emissions of pollutants, and a requirement to increase the use of renewable energy sources.

Figure 1 shows data compiled by the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) on global primary energy consumption, sorted by fuel, and an International Energy Agency (IEA) forecast up to 2035.

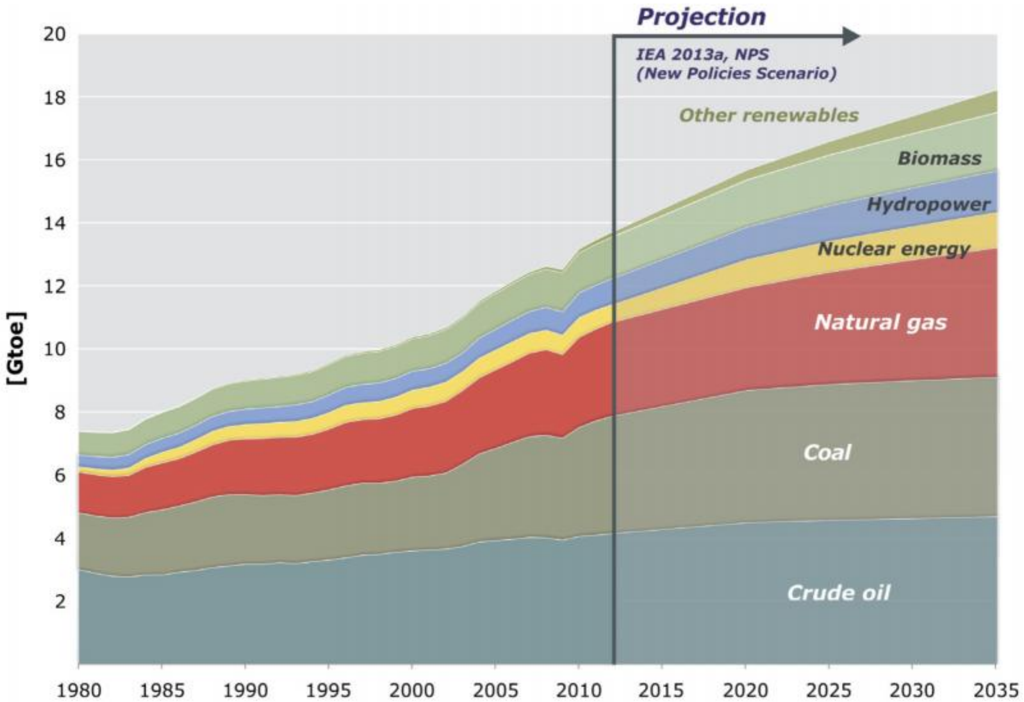

Fig. 1. Global primary energy consumption, sorted by fuel, and IEA forecast up to 2035
Source: [1]

The data shows that global consumption of all primary energy sources is rising, and is expected to continue to rise. By far the largest year-on-year growth is expected for renewable energy sources other than hydropower, i.e. mostly solar and wind power. Nevertheless, it is noteworthy that despite the rapid growth, even in 2035, renewables will still have the smallest share of all primary energy sources, whereas fossil fuels currently account for the vast majority of the global primary energy supply, and it is expected that this will remain largely unchanged in 2035, mainly due to rapid growth in fossil fuel use by developing countries.

Both historical information starting from 1965 and a BP forecast up to 2035 on the shares of primary fuels within global energy consumption developed by BP are shown in Figure 2. The most important trends are a falling share of oil, a forecast for a falling share of coal, a rise in the share of natural gas and renewables, and nuclear energy maintaining its share in the energy mix. However, it is noteworthy that looking only at the shares may be misleading. For example, despite its falling share of global primary energy consumption, coal use is not expected to decrease, due to an overall rise in global energy production. A comparison of the data in Figures 1 and 2 reveals that BP expects a stronger rise in renewables production than BGR, with the share of renewables within the total primary fuel supply surpassing nuclear energy sometime in the 2020s.

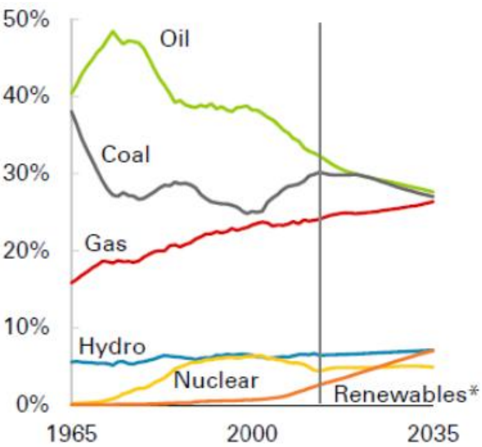

Fig. 2. Shares of primary fuels in global energy consumption

Source: [2]

Figure 3 shows that Polish energy production differs significantly from global averages. It is dominated by hard coal and lignite. Production of hard coal has fallen significantly, with Poland recently turning from a major coal exporter into a net coal importer. Lignite production and natural gas production are relatively stable. The share of renewables keeps rising, whereas domestic crude oil production is relatively small.

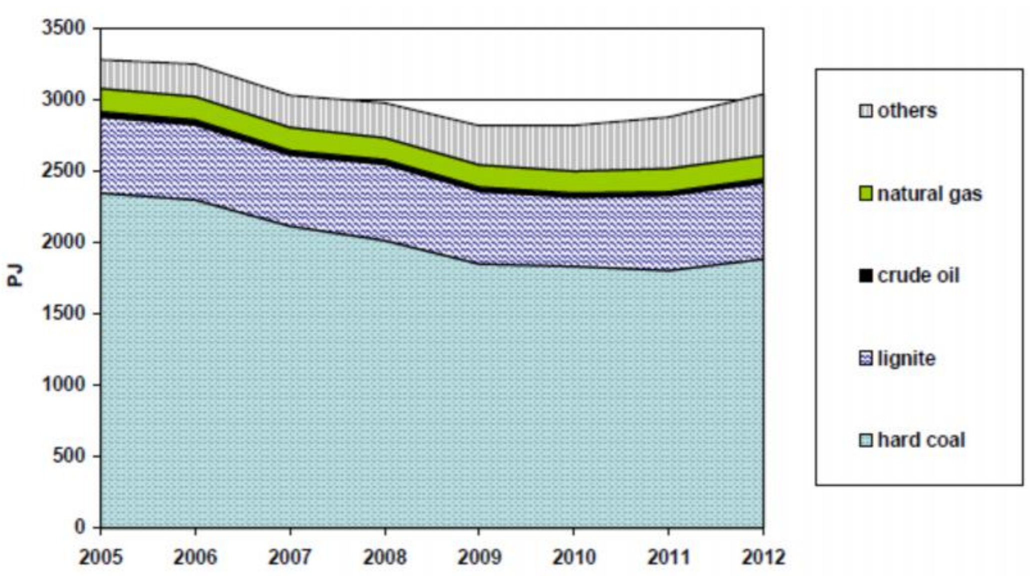

Fig. 3. Primary energy production in Poland

Source: [3]

Polish primary energy consumption, shown in Figure 4, differs from production, reflecting mostly a much larger share of oil and natural gas. Poland is highly dependent on imports from one source: Russia accounts for about 80% of natural gas imports and over 90% of oil imports.

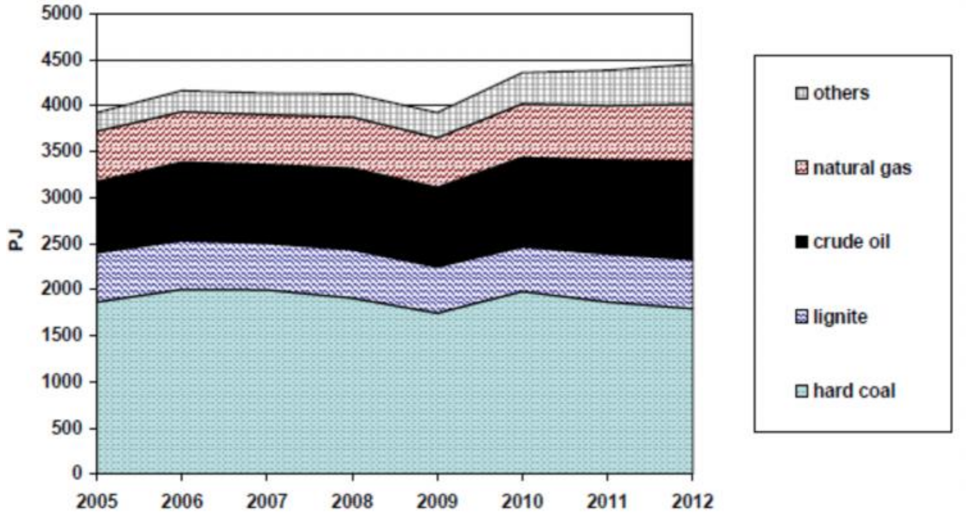

Fig. 4. Primary energy consumption in Poland
Source: [3]

The rest of the paper provides a brief overview of the ownership structure and government regulation of the energy industry, with a focus on EU regulations as those most relevant to the development of the Polish energy industry. This is followed by a discussion of investment requirements for the 2014 to 2035 time period, and a discussion of hydrocarbon, nuclear and renewable resources and prospects. Finally, criteria are proposed for the strategic management of the Polish energy industry.

Ownership structure and government regulation of the energy industry

Despite significant pressure to establish private ownership and market mechanisms in the energy industry, most of the industry is owned by various levels of government. Figure 5 shows the ownership structure of global oil and gas reserves, and existing power plants. According to the International Energy Agency (IEA), 71% of oil and gas reserves are owned by national oil companies (NOCs). World Bank estimates show an even higher share: NOCs control approximately 90% of the world's oil reserves and 75% of production, and similar numbers apply to gas, as well as many of the major oil and gas infrastructure systems. Furthermore, according to the World Bank, NOCs function as "gatekeepers" for exploitation by private oil companies (POCs) [4].

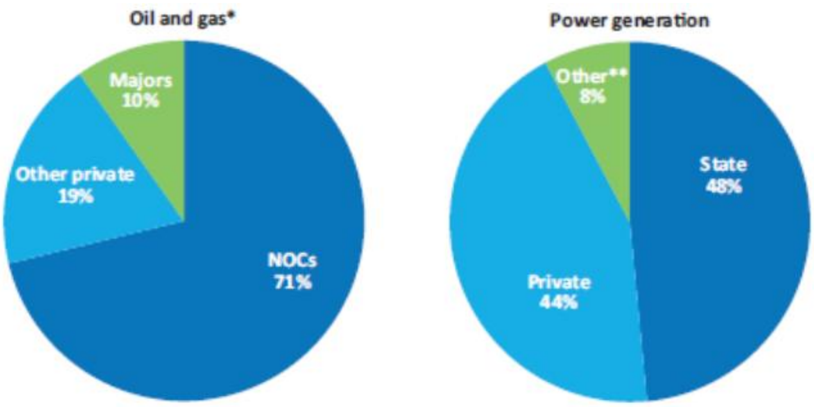

Fig. 5. Ownership structure of global oil and gas reserves and existing power plants
Note: *Oil and gas reserves include proven and probable reserves; the 7 major corporations are: BP, Chevron, ConocoPhillips, Eni, ExxonMobil, Shell and Total. ** Others include auto-producers, such as industrial plants generating their own electricity, and generation plants owned by communities and households.
Source: [5]

Seven so-called "major" energy industry corporations (namely: BP, Chevron, ConocoPhillips, Eni, ExxonMobil, Shell and Total) account for 10% of oil and gas proven and probable reserves, and other private entities own the remaining 19%. Thus, the vast majority of oil and gas reserves remain under government ownership, and to a large extent also under direct government control, although leases to private companies for energy resource exploration are also common. The case of power generation is somewhat different, with 44% private and 8% other ownership, the latter including mainly industrial auto-producers and community-owned generation. Nevertheless, 48% of power generation remains state-owned. High state ownership is not limited to developing countries. Highly developed, market-based economies, such as Canada, France, Germany and Sweden, also have high levels of state and local government ownership.

There are significant pressures to introduce market-based mechanisms, despite the aforementioned high levels of state and local government ownership. The main regulations shaping Poland's energy industry are European Union Directives. The most significant are those concerning common rules for the internal market in natural gas (Directive 2009/73/EC) and electricity (Directive 2009/72/EC), as well as those relating to the promotion of energy use from renewable energy sources (Directive 2009/28/EC). All of these are updates to previous directives, shaping the energy market together with more detailed directives on various aspects of safety, conditions for access to transmission networks, including for imports and exports, and energy efficiency (Directive 2012/27/EU). All are being implemented as part of national regulations, under the Polish Energy Law [6].

Directive 2009/73/EC defines the rules for the functioning of the internal market in natural gas, progressively implemented throughout the EU since 1999 [7]. However, obstacles to a common market in natural gas remain, since non-discriminatory network access does not yet exist in all member states. Furthermore, the directive notes that separation of networks from production and supply activities is not yet fully implemented, and much work remains to establish effective market mechanisms. At the same time as the aforementioned directive on natural gas, the EU also introduced Directive 2009/72/EC, concerning common rules for the internal market in electricity, which has likewise been progressively implemented throughout the EU since 1999. It aims to deliver a choice of supplier to all citizens and businesses. The regulation also aims to achieve efficiency gains and competitive prices, and contribute to the security of supply and sustainability [8]. In theory, a well-functioning electricity market should provide producers with appropriate incentives for investing in highly efficient and low-emission production technologies. In practice, uncertainty caused by changing regulations and market conditions, especially those relating to carbon dioxide emission pricing, has created significant investment risk. Furthermore, in many cases, generation capacity is outdated. The need for investment will be analyzed in more detail in a latter part of this paper.

The regulation with the largest impact on the Polish energy industry is Directive 2009/28/EC, on the promotion of energy from renewable sources. This directive is the main part of the so-called "20-20-20" climate and energy package that sets the following targets for the year 2020:

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- A 20% reduction in primary energy (compared with forecasts for 2020);
- A 20% share of renewable energy sources [9].

Directive 2009/28/EC makes reference to meeting the obligations agreed upon in the Kyoto Protocol. Targets are set for individual countries depending on their share of renewables in 2005, local renewable resources and the level of economic development. For example, the target for Poland is a 15% share of energy from renewable sources in the gross final consumption of energy by 2020 – up from 7.2% in 2005 [10].

Capital investment requirements for the global energy industry

Significant investments are needed in the energy industry. Rising GDP in many parts of the world is increasing demand for various forms of energy, especially electricity. In highly developed countries, nuclear reactors are nearing their design life cycle of 40 years, and will require significant investment to continue working, or will incur significant decommissioning costs. The investment costs are mostly associated with the need to meet strict safety regulations, whereas high decommissioning costs are a result of problems with long-term storage of radioactive waste.

Figure 6 shows investments in global energy supply in the years 2000-2014. Electricity and oil have the largest share, followed by gas. The rising investments in electricity generation are mainly caused by investments in new, relatively expensive renewable energy sources. Increasing investments in the oil sector are a result of a significant increase in the number of cars, while the effect of better fuel efficiency is insufficient to offset the rise in oil consumption. Overall, as easily accessible hydrocarbon resources are being depleted, the cost of exploiting deeper and technologically more challenging deposits, such as shale gas, result in significantly higher investment requirements.

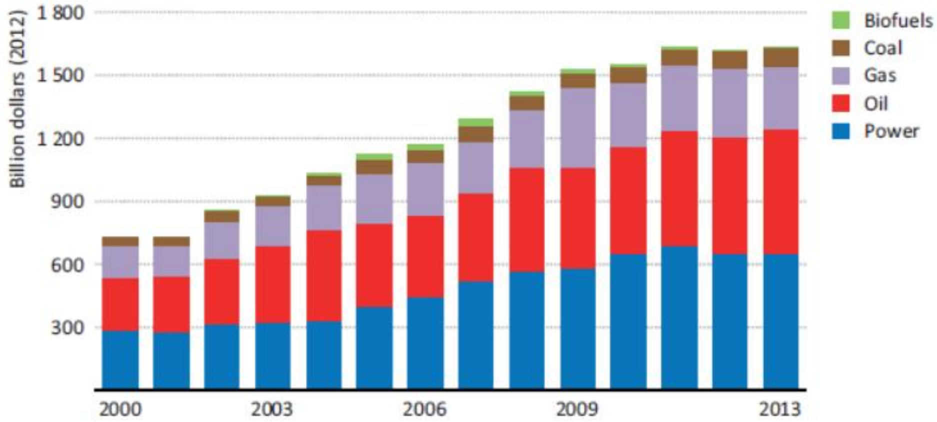

Fig. 6. Investment in global energy supply in 2000-2013
Source: [5]

Despite a rising share of renewable energy sources, especially in OECD countries, as shown in Figure 7, by far the largest share of investments in global energy supply is in conventional fossil fuels – accounting for over a trillion dollars in 2013. The investment in non-fossil fuels is only about a fifth of that, which includes both renewables and nuclear energy. Rising electricity demand in many parts of the world also necessitates steady investment in the transmission and distribution (T&D) infrastructure, which was slightly smaller than for the supply of non-fossil fuels in 2013.

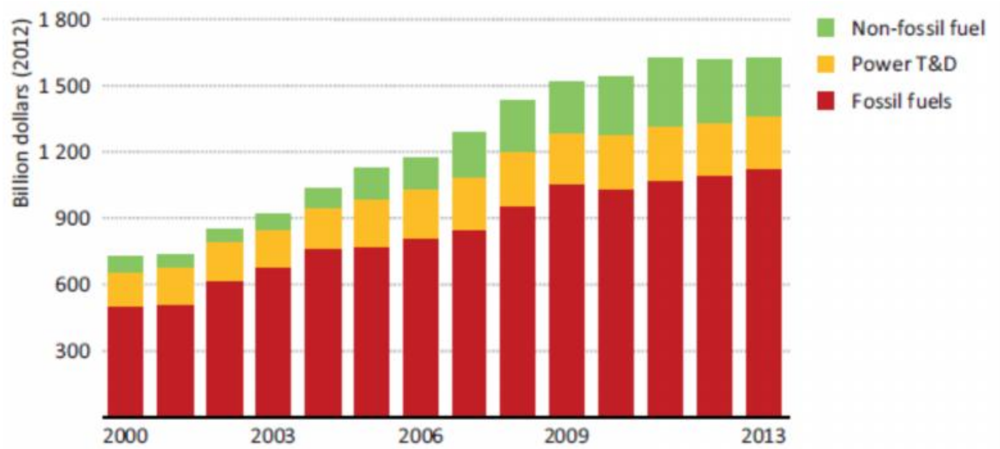

Fig. 7. Investment in global energy supply by fossil fuel, non-fossil fuel and power T&D in 2000-2013
Source: [5]

According to IEA forecasts, global cumulative investment in energy supply required in years 2014-2035 totals over 40 trillion USD. As shown in Figure 8, the largest share of this – over 16 trillion – will be in electricity generation, with a great part of this, about 1/3 – i.e. almost 6 trillion USD – going to investment in renewable energy sources. It is noteworthy that nuclear power investment equals only about 1/5 of the investment in renewables, and that the second largest part of the investment in power generation, about 5 trillion USD, will go towards building and upgrading distribution networks. Oil accounts for about 13.7 trillion USD in investment, with over 11 trillion USD going to upstream activities – mainly drilling ever-deeper wells in more challenging conditions, such as on the ocean floor in rough waters, steadily increasing investment costs as inexpensive resources, such as conventional sites in the Middle East, become increasingly depleted. Gas accounts for almost 9 trillion USD in planned investments, with the majority again going to upstream activities: searching for resources, drilling exploratory wells and finally drilling and operating wells to recover the gas. Transmission and distribution needs total almost 2 trillion USD for natural gas, excluding LNG, which, as an increasingly important way of trading gas, adds another 736 billion USD. Coal has a relatively minor cost of 1 trillion USD, with most of this going to mining and to biofuels, which account for 320 billion USD in investment.

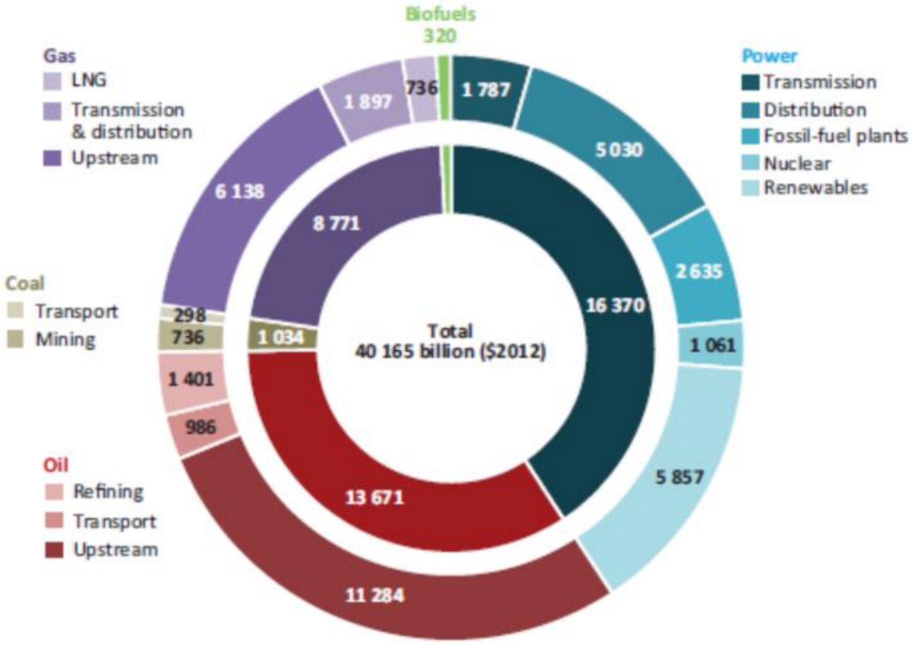

Fig. 8. IEA cumulative global energy supply investment forecast for 2014-2035
Source: [5]

Investment in energy efficiency is becoming both a supplement and a substitute for investment in energy supply. Figure 9 shows a forecast of cumulative global efficiency investment by the end-use sector for the years 2014-2035. The grand total is 8 trillion USD – about 1/5 of the investment forecast for the global energy supply. Investment in transport, totaling almost 5 trillion USD, accounts for over 60% of cumulative investment in energy efficiency. The remaining 3 billion USD are split into about 2.3 trillion USD for improving the energy efficiency of buildings, accounting for the largest share of global energy use, and over 700 billion USD for efficiency gains in both non-energy intensive (455 billion USD) and energy intensive (284 billion USD) industries.

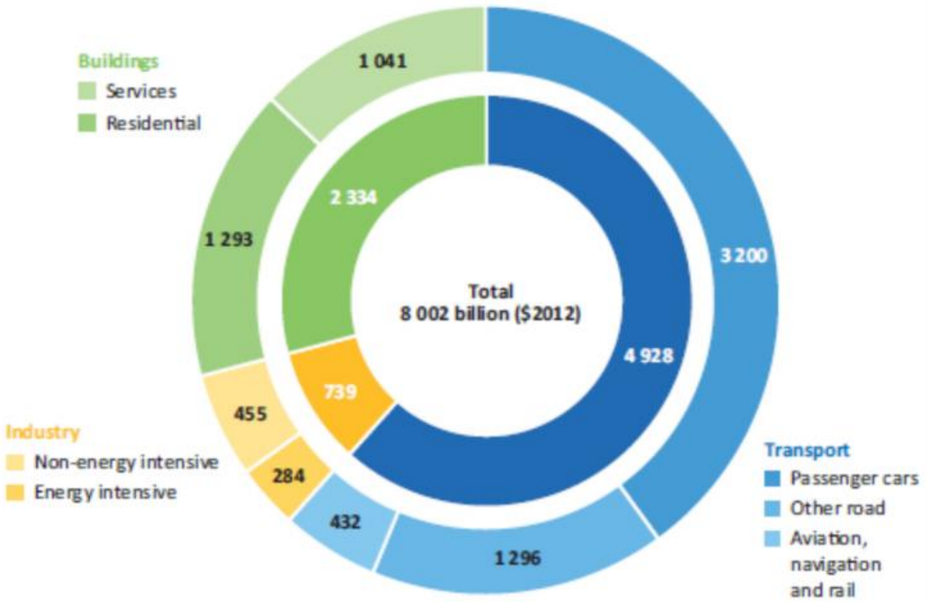

Fig. 9. IEA cumulative global energy efficiency investment by end-use sector forecast 2014-2035
Source: [5]

In Poland, investment needs are also very high. For example, over 40% of the generating capacity is more than 30 years old, and over 70% is more than 20 years old [11]. Domestic energy companies cite regulatory uncertainty as the main source of risk that results in insufficient investment.

Regional distribution and structure of global energy resources

As shown in Figure 10, world energy resources are plentiful, but distributed unevenly among the continents. Upstream and transportation costs define whether it is economically feasible to recover a given resource type at a specific location.

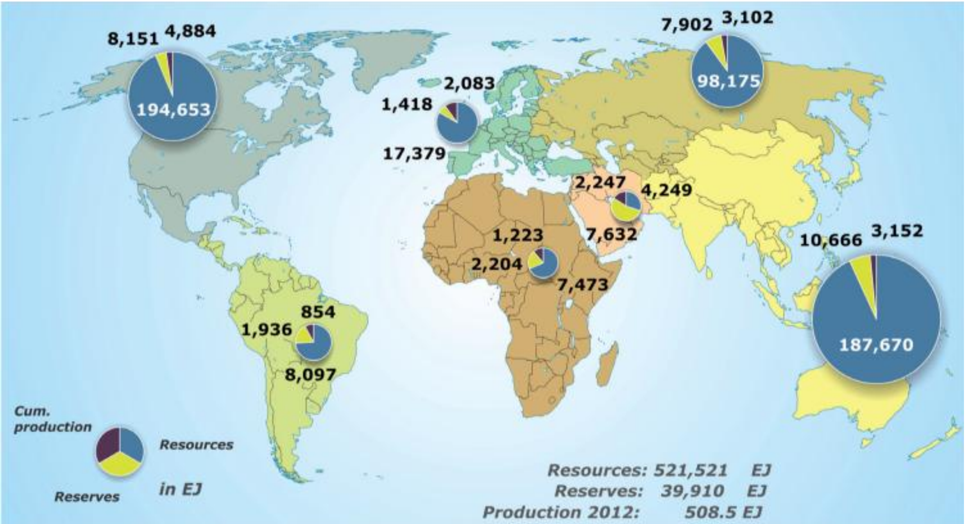

Fig. 10. Distribution of total global potential energy resources

Source: [1]

Figure 11 provides a summary of global energy consumption, production, reserves, and resources by type. Fossil fuels dominate both energy consumption and production – they account for approximately 87% of energy consumption and 94% of production. At current production rates, reserves[1] would last for 78 years, whereas total resources would last over 1000 years.

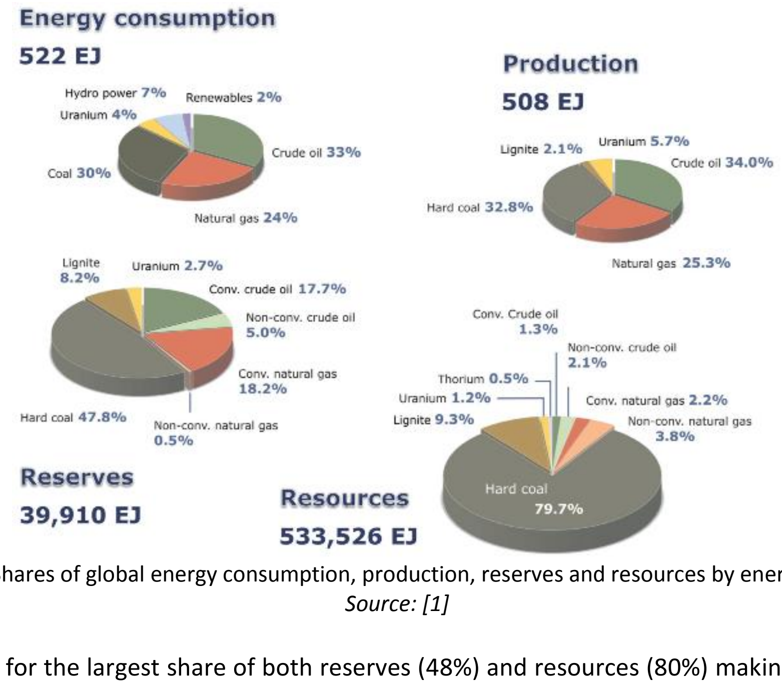

Fig. 11. Shares of global energy consumption, production, reserves and resources by energy source

Source: [1]

Hard coal accounts for the largest share of both reserves (48%) and resources (80%) making it an inexhaustible source of energy for the foreseeable future. Nevertheless, coal use is being limited in some advanced econo-

[1] Reserves are proven volumes of energy commodities that are economically exploitable at today's prices.

mies, including those of EU member states, since it is characterised by the highest level of greenhouse gas emissions – about double the amount for natural gas.

Despite continuous exploitation, and thus depletion, of world energy resources, the amount of documented resources is growing, not diminishing, with time, as a result of advances in exploration and mining technologies. Figure 12 shows that between 2000 and 2012, estimates of global resources have increased by over 20% for oil and lignite, by over 35% for natural gas, by 97% for hard coal and by 66% for lignite.

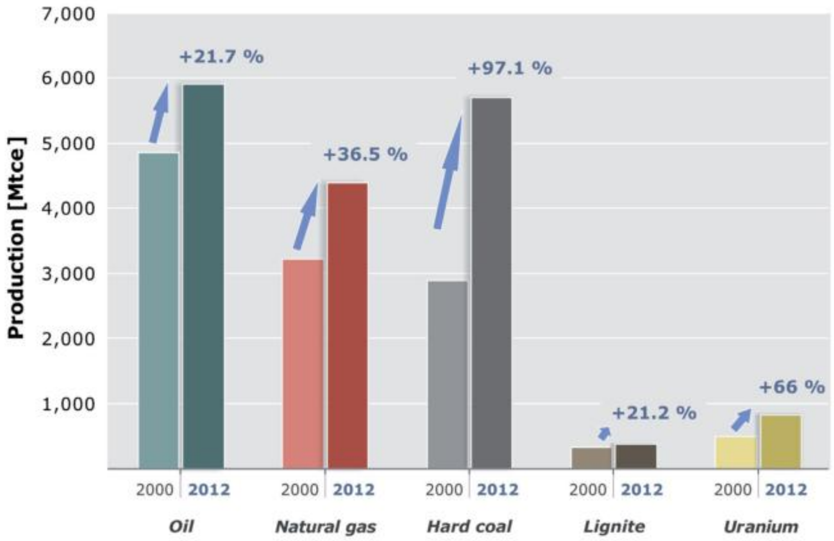

Fig. 12. Comparison of global hydrocarbon and uranium resources estimates in 2000 and in 2012
Source: [1]

Therefore, it is reasonable to assume that energy resources are not at risk of running out in the foreseeable future. However, their relative prices, and thus consumption structure, are likely to change as a result of technological advances in upstream and downstream processes, as well as final consumption and changes to regulations with respect to environmental protection. This is especially true for the most abundant fossil fuel, coal, where world consumption continues to rise, but share of world primary energy supply is falling, and expected to keep falling, as shown in figure 13.

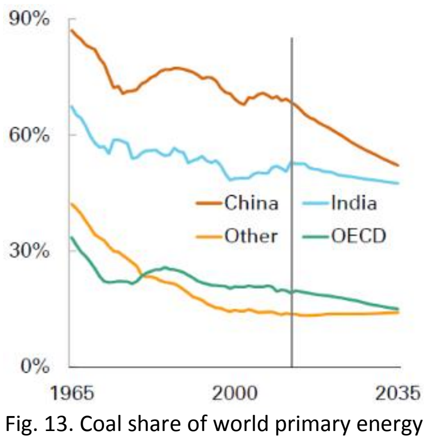

Fig. 13. Coal share of world primary energy
Source: [2]

According to forecasts, fossil fuels will remain the dominant sources of energy in the foreseeable future. However, the share of renewables is increasing and there is also a focus on energy use efficiency and reducing the energy intensity of the economy.

Focus on increasing energy use efficiency and reducing the energy intensity of the economy
Gross domestic product (GDP) growth is dependent on sufficient energy supply, yet as shown in figure 14, on a global scale the relationship is not linear. GDP grows much faster than energy use, and according to forecasts this is expected to continue well into the foreseeable future.

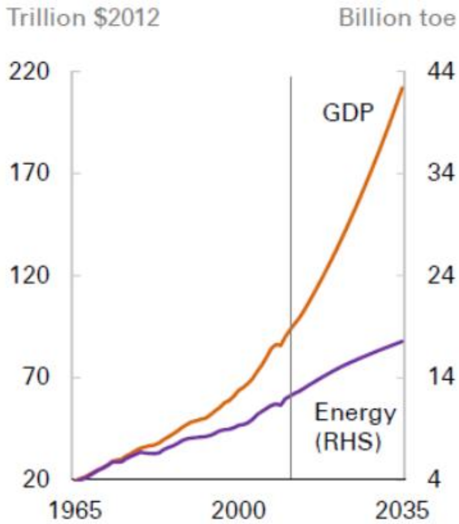

Fig. 14. Global GDP and energy use in 1965-2035
Source: [2]

The reason for the discrepancy is the falling energy intensity, expressed as energy use per unit of global GDP. A larger role of the service sector and a move towards a more information-based economy in highly developed countries result in lower energy consumption, and also lower carbon intensity, i.e. CO_2 emissions, as a result of better energy conversion efficiency of new technologies. This is usually accompanied by lower harmful emissions of pollutants.

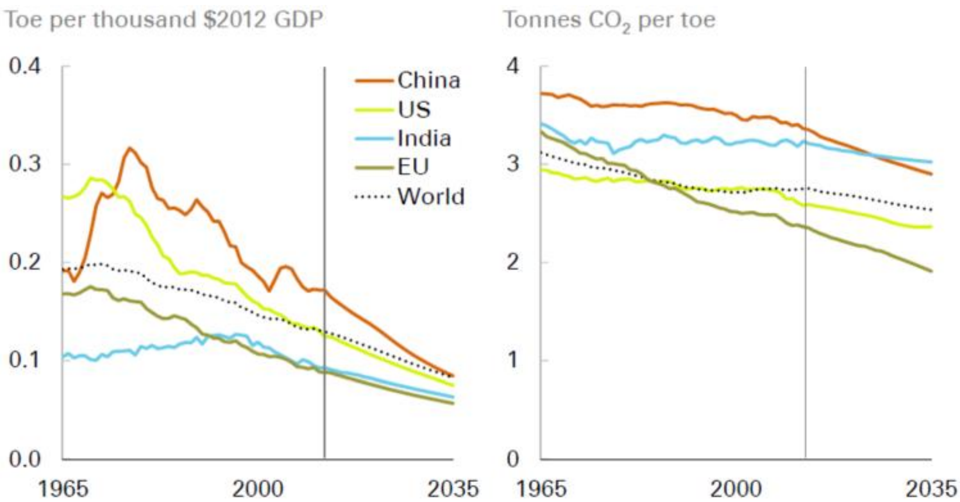

Fig. 15. Global energy and carbon intensity in 1965-2035
Source: [2]

As shown in Figure 16, there is a correlation between rising world GDP and total primary energy demand (TPED). The correlation is stronger in non-OECD countries, since in OECD countries it is partially offset by the decreasing energy intensity of advanced economies.

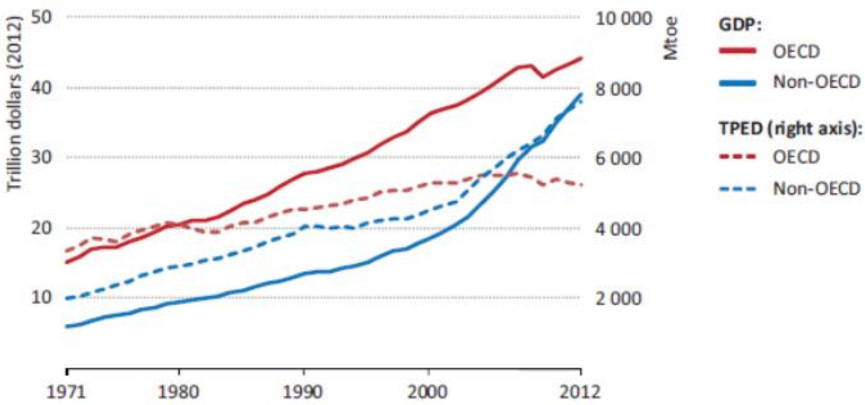

Fig. 16. World primary energy demand and GDP in 1971-2012
Source: [12]

Proposed criteria for strategic management of the Polish energy industry
Investments in the energy industry may be analyzed using various approaches, although simple methods such as payback period, rate of return or net present value often fail to capture the complexities of the energy industry, especially those related to externalities [13, 14]. Table 1 proposes criteria for the assessment and strategic management of the Polish energy industry.

Table 1. Criteria and data requirements for assessing the Polish energy industry

Criteria	Description	Data requirements	Data availability
1. Total financial expenditure per unit of energy	Value of financial capital involved in exploration processes	1. Value of *factors of production* involved in the exploration of resources expressed in terms of: ▪ Initial value of capital assets ▪ Value of resources, materials, fuels and energy ▪ Employment costs. 2. Value of factors of production inventory to assure continuous operations. 3. Value of natural resources involved in the process. 4. Value of current assets involved in the process. 5. Relevant transportation costs.	Incomplete
2. Private cost per unit of energy	Value of unavoidable expenditure on factors of production	The same as above, in unavoidable quantities.	Incomplete
3. External cost per unit of energy	Value of unavoidable expenditure on processes to eliminate negative effects associated with exploration	1. Value of factors of production used, in unavoidable quantities, on processes to restore and liquidate damages to natural resources taking into account: ▪ Amortization of capital assets ▪ Value of used resources, materials, fuels, energy ▪ Employment costs ▪ Insurance costs. 2. Cost of financing inventories of production factors required to sustain the elimination of negative effects.	Incomplete
4. Wasted expenditures per unit of energy	Value of wasted expenditure on factors of production, unnecessary resources and unrestored parts of the natural environment	1. Value of unnecessary usage of factors of production. 2. Value of unnecessary resources that were used. 3. Value of unrestored parts of the natural environment (i.e. full expenditures required to eliminate the damage to the natural environment) used during the process.	Incomplete

Criteria	Description	Data requirements	Data availability
5. Social cost per unit of energy	Value of unavoidable expenditures on factors of production and external costs of exploration	1. Value of factors of production used, in unavoidable quantities, in exploration processes taking into account: ▪ Amortization of capital assets ▪ Value of used resources, materials, fuels, energy ▪ Employment costs, including training ▪ Insurance costs. 2. Cost of financing inventories of production factors required to sustain production. 3. External costs.	Incomplete

As shown in Table 1, the criteria for the assessment and strategic management of the Polish energy industry may be divided into five groups. The author proposes that social costs be defined in this context as the sum of private and external costs per unit of energy, excluding wasted expenditures. These social costs should then be used to rank and select the best investment. The data on total and wasted financial expenditures may be used to improve the economic efficiency of exploration processes. It should be noted that data on this is largely unavailable, since expenditures on unnecessary or unrelated items are often grouped together as expenditures, which makes it difficult to assess and rank competing energy sources and energy conversion technologies.

Conclusion

Fossil fuels currently have the largest share of both the Polish and the global primary energy supply. Yet the share of renewables is rising, in part due to EU regulatory requirements. Technological progress is leading to discoveries and exploration of hitherto undiscovered or uneconomical, especially unconventional energy sources. As exploration costs keep rising and there is potential for greater environmental damage, social costs, as defined in this paper, should be used by corporations to assess and rank alternative energy sources. As national and international laws, such as EU regulation of the energy sector, push for internalization of external costs, minimizing social costs per unit of energy will also lead to long-term profit maximization.

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