Energy decarbonisation and primary energy in the 21st century

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Energy Decarbonisation and Primary Energy in the 21st Century

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SUMMARY

This paper emphasizes the role of primary sources of energy, primarily oil and gas in the future (so-called "energy mix") with the expected trends in the future. The changes expected by the oil and gas sector in the 21st century have been underlined due to energy decarbonisation. There are intense discussions about the oil and gas future due to the effects of climate change and the announcement that oil is in the final phase of exploitation due to the high depletion of fields around the world. How are the big oil companies responding to these challenges and what are the trends of global energy consumption? In the 21st century, it is necessary to take in account all types of energy with the growth of renewable sources. In the meantime, natural gas is imposed as a bridge between fossil and decarbonised energy, and the trends in the gas segment in the world and in the Republic of Croatia will be emphasized as well. In addition, the new Croatian energy strategy must be aligned with changes in the oil and gas sector, as well as exploration and production of hydrocarbons. Carbon-free energy is still a long way, but the low-carbon energy period has begun.

KEYWORDS

primary energy, decarbonisation, oil and gas, hydrocarbon exploration and production

1. INTRODUCTION

What are the most important trends in energy? If you follow mainstream press accounts, there are at least three:

1. The oil and gas industry will soon face radical restrictions as countries respond to climate change;
2. The rapidly growing electrical vehicle market will make oil obsolete;
3. The world is quickly moving toward 100% renewable energy.

All of these supposed trends are part of an overarching narrative that says we are in the midst of an energy transition: the world is moving quickly and inevitably away from "dirty" fossil fuels to "green" solar, wind, and batteries. Regardless of whether the "transition to renewables" narrative is true, the wholesale belief in that narrative poses a threat to oil and gas companies. One major way the industry has responded to this is to talk about the benefits of its work: about how oil and gas power our homes, cars, data centers, and hospitals, and about how the industry creates millions of jobs and billions in tax revenue [1].

All of that is true. But, by itself, it does not counter two core premises:

1. That oil and gas are easily replaceable by solar, wind, and electric vehicles, which means these benefits are not unique to oil and gas but apply to all sources of energy.
2. That oil and gas have catastrophic costs—on our health, our environment, and our climate—which means that even significant economic costs of transitioning to alternatives could be worth it.

Desire of people all over the world is greater development (expecially in India, China and Africa), therefore we should expect that the fossil fuel industry will not cease to exist but that it will be even more developed. In the first quarter of this year, a number of new discoveries of hydrocarbons (reserves) increased by as much as 30% compared to last year (offshore discoveries around Cyprus, Israel, Egypt, etc.) [2]..

2. CHANGES IN OIL AND GAS SECTOR

In September 2015, the United Nations adopted 17 Sustainable Development Goals, addressing the global challenges facing humanity, including poverty, inequality, health, education, energy, climate, the environment, and prosperity. The organization's 2030 Agenda for Sustainable Development is a continuation of its Eight Millennium Development Goals, with, among notable additions, the inclusion of energy access as a separate goal.

Energy is central to many of these goals through its linkage to the economy, education, health, the environment, and water. In 2019, nearly a billion people (more than 13% of the world population) do not have access to electricity, and 3 billion people lack access to clean cooking solutions, even within oil and gas producing/exporting countries.

Sustainable Development Goal no. 7 sets five ambitious objectives to be reached by 2030, including universal access to affordable, reliable, and modern energy services; a significant increase in the share of renewable energy in the global energy mix; and a doubling of the global rate of improvement in energy efficiency. Despite its importance in world energy supply, and its lower environmental footprint compared with coal, the oil and gas

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industry suffers from a poor public image, especially with the younger generation. Given the 2018 Intergovernmental Panel on Climate Change report that raised alarm bells about the consequences of just a small change in average global temperatures, how can the industry support the ambitious agenda of the UN's sustainability goals?

Several organizations including energy agencies, major oil and gas companies, and research and consulting groups have developed energy supply and demand outlooks based on various scenarios. These outlooks (not forecasts) show the potential evolution of energy demand in the future (generally 2040/2050/2060), and the corresponding energy mix.

In these models, energy demand grows between 3% and 44% from now until 2040, while the share of oil and gas in the energy mix varies between 53% today and between 50-58% in 2040. Therefore, oil and, more importantly, natural gas will be important sources in meeting the world's increasing energy demand going forward. Most of the outlooks, however, do not take into account the multiple requirements associated with the UN's sustainable development goals [3].

In 2017, the International Energy Agency (IEA) published an energy outlook that took into account universal access to energy, a reduction of emissions in line with the so-called Paris Agreement regarding climate change, and a major improvement in air quality, which is the cause of millions of premature deaths. In this "sustainable development scenario," which does not require a major increase in energy-related investment compared with the baseline case, it is projected that global energy demand will continue to increase and, that by 2040, the oil and gas share of the global energy mix will still be 50%, representing the major enabler for universal energy access. The major emission-reduction wedges for this energy transition are: energy efficiency, renewables, CO2 capture/utilization/storage, and switching from coal to natural gas.

The oil and gas industry has many opportunities to move public perception of it as being part of the sustainability problem to being part of the solution. The industry has been fueling major economic growth since World War II, enabling access to transportation and electricity to an increasingly larger share of the world's population. Major international and national oil and gas companies are participating actively in an economically and socially acceptable energy transition to the future. Several initiatives are under way, including:

- The majors' shift to natural gas and its role as a major bridge to a low-carbon future. Technological developments such as LNG-Liquified Natural gas, floating storage and regasification units, and floating LNG are contributing to larger access at the country level to natural gas. Additionally, renewables such as solar and wind, which have seen major cost decreases over the past decade and are competing with fossil fuels for power generation, suffer from their intermittency and need to be combined with costeffective energy storage solutions and/or a baseload energy supply such as natural gas.
- The Oil and Gas Climate Initiative, with a $1 billion fund over 10 years to take practical action on climate change and reduce the carbon footprint of energy value chains. The initiative was started by 10 International Oil Companies-IOCs and National Oil Companies-NOCs. Among its initiatives are to monitor and reduce methane leakage and the development of carbon capture and storage projects.
- The Clean Energy Ministerial and Mission Innovation initiatives, which involves public and private organizations (including oil companies) making progress on a range of issues, including sustainability themes as diverse as gender diversity in the energy sector, energy efficiency, and clean hydrogen.
- The Greenhouse Gas Flaring Reduction Partnership, a publicprivate initiative, led by the World Bank, to address the issue of gas flaring, which wastes resources and creates an environmental problem. The partnership disseminates best practices and helps develop country-specific gas flaring reduction programs.
- Carbon capture, utilization, and storage as a single technology, which has the potential to be the largest decarbonisation component in the energy transition. Its application expands beyond capture from natural gas to include power plants as well as industry (steel, cement, aluminium, petrochemicals). Having been a pioneer in carbon capture, and through its subsurface-related technologies, the oil industry can play a major role in making this technology meet the most stringent regulatory requirements.
- Energy efficiency and clean energy in the development and production of hydrocarbons and in the downstream sectors. Technological advances associated with technologies such as digitalization are helping the industry improve its efficiency. Collaboration through industry organizations such as International Petroleum Industry Environmental Conservation Association-IPIECA and International Association of Oil & Gas Producers-IOGP are providing participants the opportunity to benchmark their operational performance. In the refining sector (the most energy-intensive activity of the oil industry), voluntary use of benchmarks such as the Solomon Energy Intensity Index has helped participants improve performance. Novel conversion routes such as crude-to-chemicals provide further potential for efficiency. Other innovation in the upstream sector is the increased use of renewables as an energy source for enhanced recovery (e.g., solar for steam generation).
- Development of renewables and energy storage solutions. Oil companies are investing in novel third-generation biofuels such as algae. They also are providing expertise for offshore wind projects based on experience developing platforms. Reduction in the cost of energy storage and its improved reliability has also been featured in company strategies.
- Several IOCs have created technology venture arms to invest in startups associated with the energy transition.

Changes in the Oil and Gas Sector are permanent regardless of the so called low-carbon strategy as a strategy of primarily developed countries. New gas producers come from unconventional sources as well as those old on the example of Iran. Liquefied Natural Gas (LNG) is coming to Europe after the US government has approved the export. The price of LNG is reduced compared to gas transported by pipeline, which is more concise. Many shipping companies are thinking of using LNG or Gas to Liquid-GTL as fuel for launching marine engines. Further construction of transport pipelines is planned to bring gas to Europe from the Caspian region and Russian gas by pipeline Turk Stream. For many years there have been talk about peak of oil and gas production and reserves disappearance. However, production has grown most thanks to the acquisition of gas from the unconventional layers (shale and tight gas layers).

Change in energy consumption in the world where China's leadership has surrendered to India is shown by Figure 1.

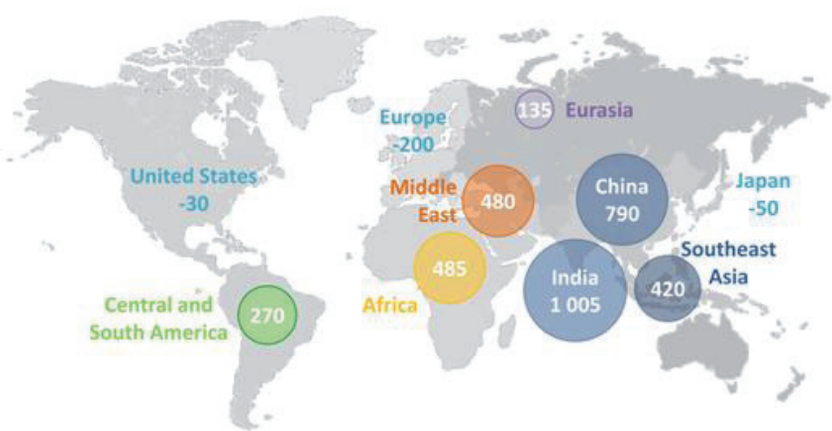

Figure 1. Change in energy demand, 2016-2040 (Mtoe) [4].

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The change in the energy consumption structure is given by Figure 2. and new energy capacities by type of production is given by Figure 3.

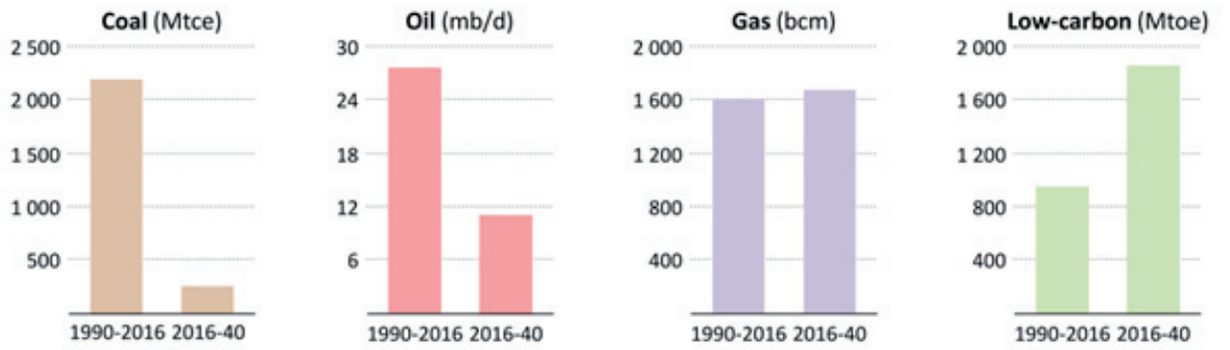

Figure 2. Change in world demand by fuel [4].

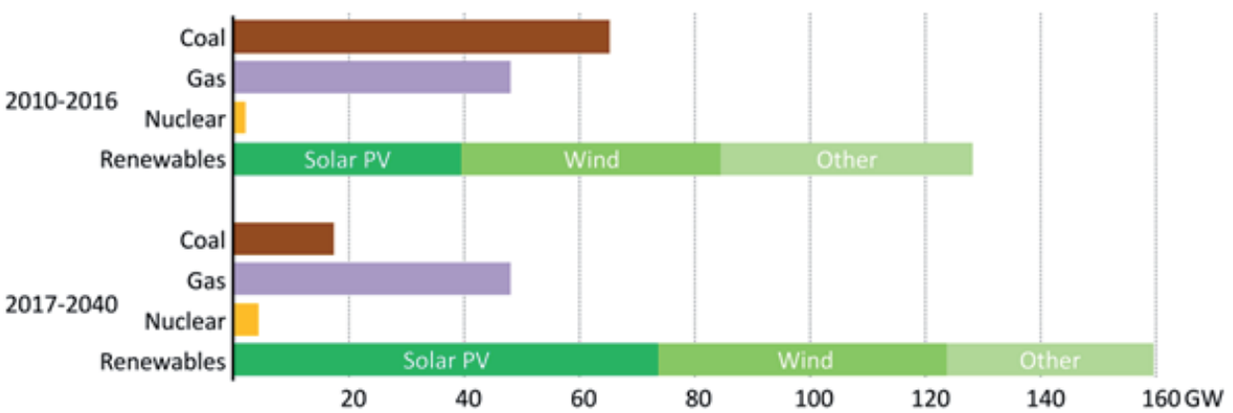

Figure 3. Global average annual net capacity additions by type [4].

Further on, according to forecasts until 2040, despite the increase in the number of electric cars, oil consumption will continue to grow, primarily due to the transport needs and the petrochemical industry (Figure 4.).

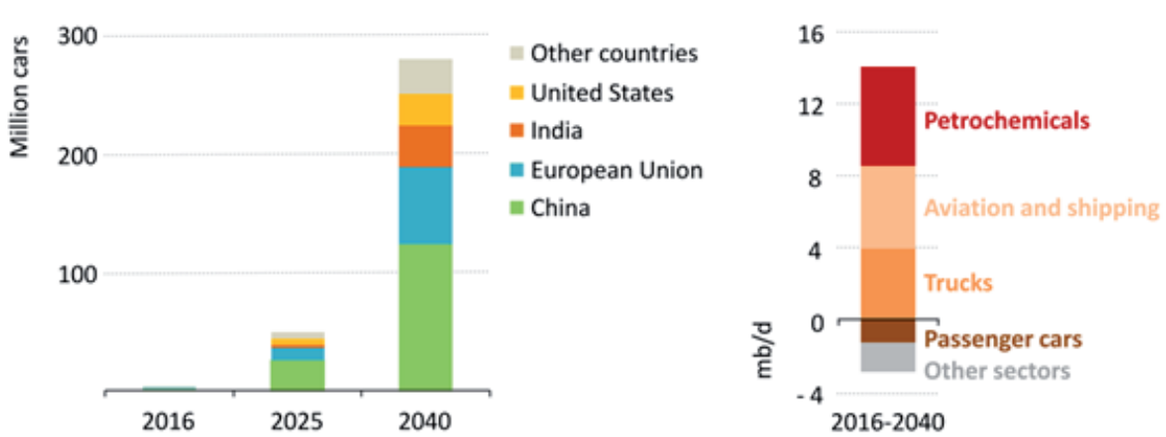

Figure 4. Electric car fleet and change in global oil demand [4].

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3. PRIMARY ENERGY IN CROATIA (OIL AND GAS) AND OPPORTUNITY FOR NEW DISCOVERIES

The main guidelines of the Croatian Energy Strategy are the growing, flexible and sustainable energy production. This means:

- Reduce dependence on energy imports by stopping the decline in domestic production;
- Invest in energy production (define the potential of the Republic of Croatia);
- Ensure an adequate energy mix with lower CO2 emissions.
- Invest in existing oil and gas fields as well as new oil and gas exploration (reserve replacement).

There are three areas in the Republic of Croatia that are important for hydrocarbons exploration and production (Figure 5.). These are the Pannonian basin (green area), the Dinarides (red area) and the Adriatic offshore (blue area).

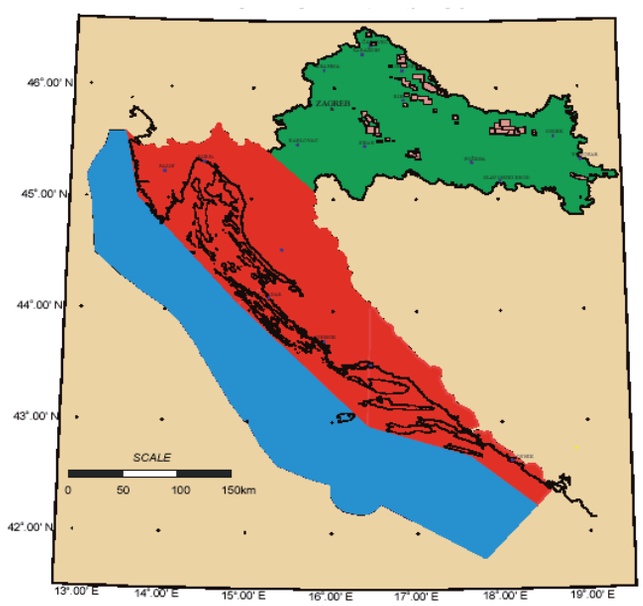

Figure 5. Oil and gas exploration areas in Croatia [5]

The Croatian part of the Pannonian Basin has reached a relatively high degree of exploration. So far most large and medium dimensions fields have been discovered, but there are still a number of »minor« ones. There is a justification for further exploration due to existing infrastructure. The quantity of hydrocarbons produced per volume unit and weight of the source rock, the amount of hydrocarbons derived from the source rock by the generation phases and the amount of hydrocarbon residue held in traps were determined [6]. In the most unfavourable scenario so far 66% of hydrocarbons have been discovered and 33% still exist for discover. In a more favourable scenario, assuming traces of the remaining 10% of the generated hydrocarbons remain, there is a potential scenario that up to now 15% has been detected and there are still 85% of the hydrocarbons to be discovered. The fact is that a small numbers of wells are deeper than 4000 m. Therefore it is necessary to record additional new generation geophysical data. Five exploration areas for which the Government of the Republic of Croatia signed the contracts in 2016 launched new investments in exploration after a long period with a continuous decline in production. In 2018, the Government of the Republic of Croatia announced new bid round for seven new exploration blocks (Figure 6.).

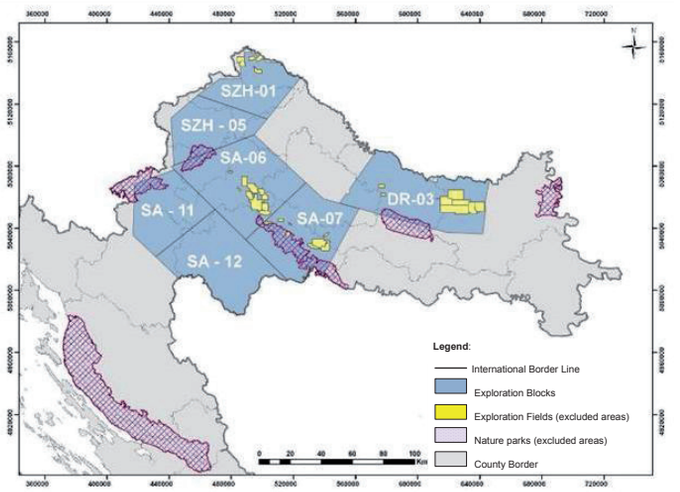

Figure 6. Map of exploration block-Pannonian basin [5]

Regarding Dinarides numerous geological studies, maps and detailed geological profiles were made, gravimetry, magnetometry and seismic (1957/58) were recorded as well. The first exploration well (RK-1) was drilled in 1959 and since then a total of 22 wells has been drilled and 17 wells were located in the coastal area. The poor quality of existing seismic data is a problem in solving complex structures. So, this year, the Government of the Republic of Croatia issued a call for 4 exploration blocks (Figure 7.).

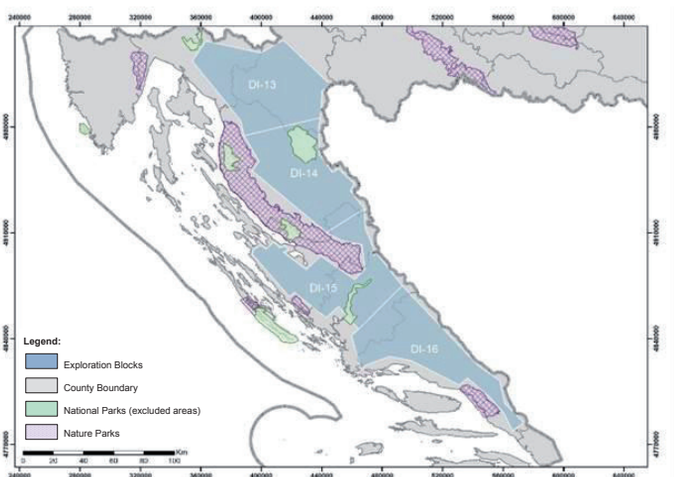

Figure 7. Map of exploration block-Dinaridi [5]

The offshore hydrocarbon potential is not considered in this paper. Gas production from the North Adriatic Sea has been started in 1999. INA PLc. is planning to drill new wells next year.

4. OIL AND GAS PRODUCTION AND RESERVES IN CROATIA

In the period from 1952 to present, 45 oil and 30 gas fields were put in production. More than 100 million tons of oil, 10 million tons of condensate and 80 billion cubic meters of natural gas were produced. Close to 4 500 exploration and development wells were drilled, out of which 1 200 are production oil wells and 200 are gas wells. Oil and condensate production forecast up to 2050 is shown by Figure 8. and Gas production forecast is shown by Figure 9.

Author's opinion of this text is that the current production forecast needs to be changed because it does not show a realistic picture, especially with regard to offshore production.

If there is no additional investment in reserve recovery, and considering the high level depletion of existing production fields, it is to be expected that very soon after 2030 the recoverable amounts of oil will become insufficient for profitable production.

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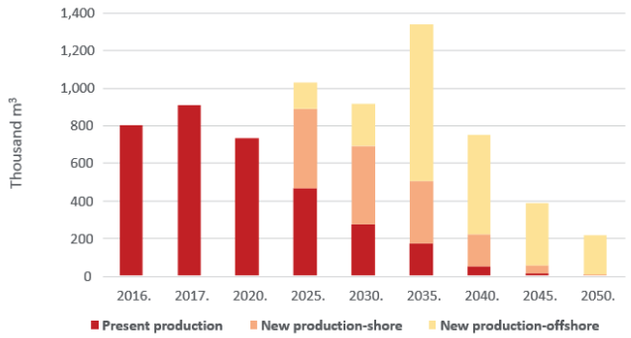


Figure 8. Oil and condensate production forecast to 2050 [7]

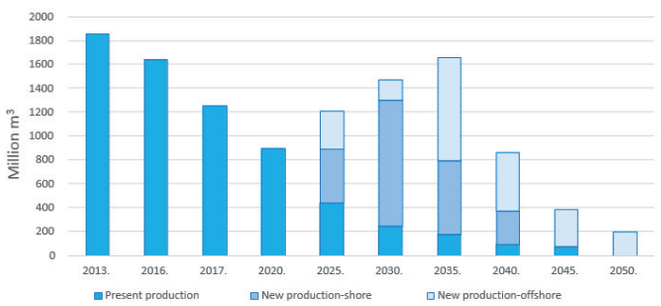


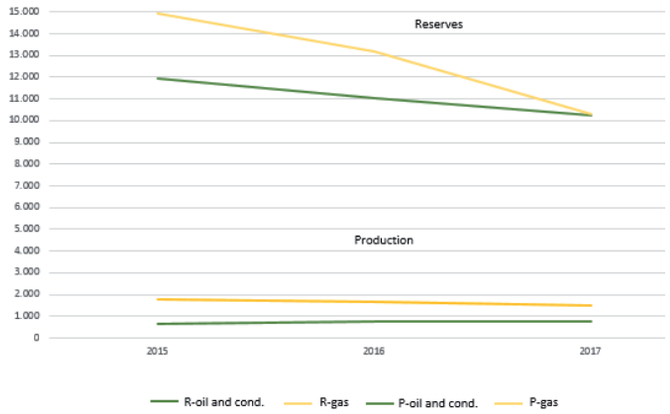
Figure 9. Natural gas production forecast to 2050 [7].

The Reserve Replacement Ratio (RRR) ratio is the ratio of added reserves of oil and gas over a period of time and amounts recovered. According to the SPE / WPC definition, inventories represent that amount of oil or gas which is based on the existing technological achievements and profitably to deliver to the market. The negative recovery coefficient means that the reserves decline is greater than the total produced one over a given period of time.

Remaining oil and condensate reserves were 10 million m^3 at the end of 2017, while the gas reserves were 13 billion m^3 [8].

Rapid gas production and reserves are very concerned and at the moment Croatia for the first time has much imported gas then production from own fields. Further production will not provide enough accumulation of funds for a new exploration.

Figure 10 shows the oil, condensate and gas production and reserves from 2015 to 2017.



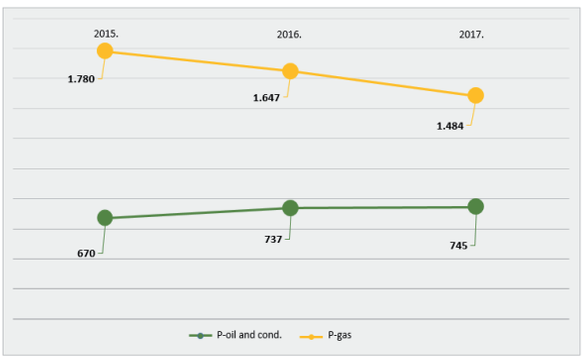


Figure 10. Reserves and production overview: 2015-2017
(oil and condensate - 103 m3 , gas - 106 m3)

Oil and gas stocks reserves be replacement by exploration that could be resulted by discovery, exploration, and hydrocarbons production. This can be realized over a long period and carries geological and technical risk. Reserves can be also increased by expanding of existing fields, implementing new technology and operations to increase oil recovery (Improved Oil Recovery-IOR and/or Enhanced Oil Recovery-EOR). In a shorter period, reserves can be increased by buying new fields in operation.

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5. CONCLUSION

In the end, it is necessary to return to the three mentioned trends.

The “transition” narrative with the “expansion” narrative by making the superiority of its product part of every energy discussion. For example:

- Will we impose radical restrictions on fossil fuels, such as a carbon tax high enough to stop people from using oil and gas? Unlikely. Given fossil fuels’ enormous superiority, the tax would have to be far higher than those passed already—and which have already led to opposition in places.
- Will electric vehicles make oil obsolete? Unlikely. Given oil’s superiority as a source of portable power, even the 2% market share that electric vehicles currently have depends on massive subsidies and mandates. In addition, the majority of oil is not used for personal vehicles, but for even harder-to-replace uses such as shipping and air travel.
- Is the world going 100% renewable? Unlikely. Wind and solar are currently inferior, intermittent sources of electricity and cannot supply reliable power—not without backup from reliable forms of energy such as fossil fuels or cost-prohibitive storage.

Further decline of hydrocarbon reserves and hydrocarbon production in the Republic of Croatia would lead to the disappearing of petroleum engineering and huge increase of energy import. Therefore, it is necessary to slow down hydrocarbons production. The best option is a more intensive exploration activity.

Exploration and production of hydrocarbons has substantial benefits, creates new jobs and stimulates the sustainable development of domestic industry.

Further hydrocarbon exploration and production will provide both a direct and multiplier effect stimulus to all Croatian industries - from shipbuilding to agriculture to transportation.

Increased hydrocarbon exploration and production will also support the establishment of new industries, services and products not yet existing in Croatia and will stimulate new exports of products and services. Ultimately, this will lead to job creation in all sectors.

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