LONG-TERM ENERGY OUTLOOKS: SUSTAINABLE ENERGY DEVELOPMENT OR ENERGY TRANSITION?

(ENERGY SCENARIOS COMPARATIVE ANALYSIS)

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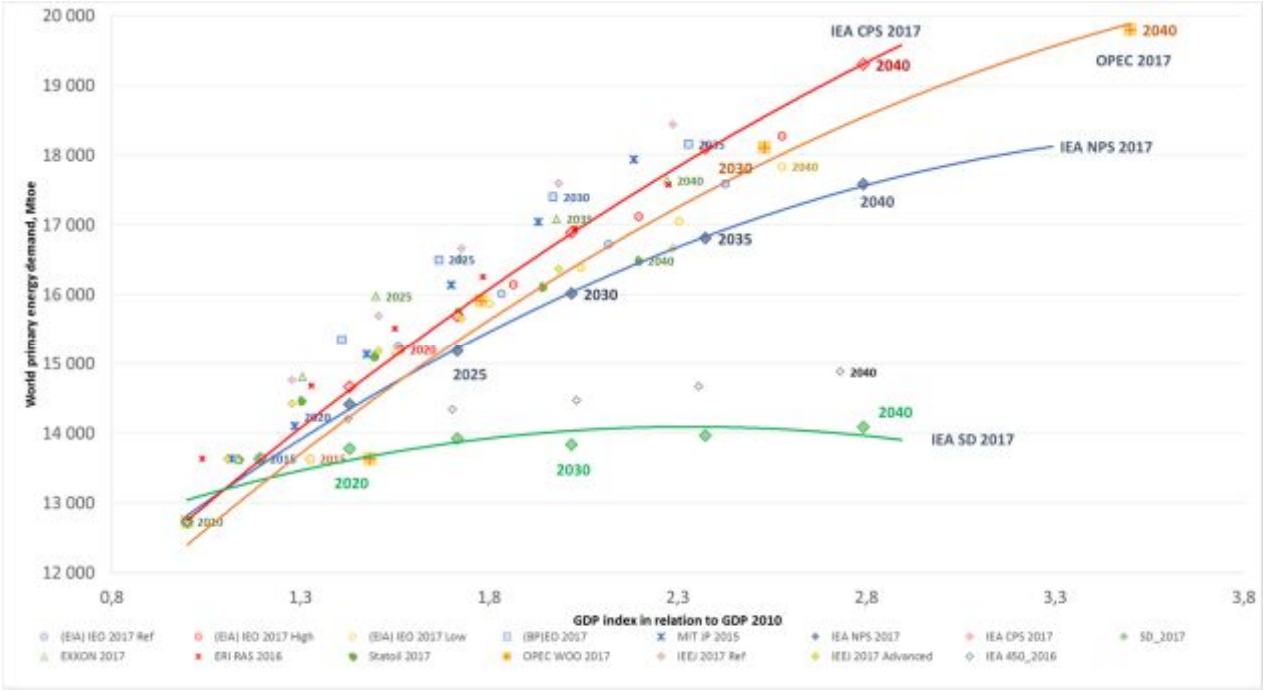
8th IEA-IEF-OPEC Symposium on Energy Outlooks
IEF Headquarters, Riyadh, 14th February 2018

The Energy Scenarios Field: How We Can Use It Today?

- Currently, the world energy landscape is on the continuous change.
- High level of uncertainty forces the situation when the number of publically available energy scenarios grows notably
- Each organization develops their scenarios based on their own views, interests and assumptions.
- The key questions to our study:
  - How all these energy scenarios combine with each other?
  - What possible conclusions on the world energy development could be made from the different energy scenarios combination?
  - Whether different energy scenarios represent ‘multiple energy futures’ or they basically represent the variants of a single one?

World Primary Energy Demand (PED): “Fading” or “Zero” Growth?

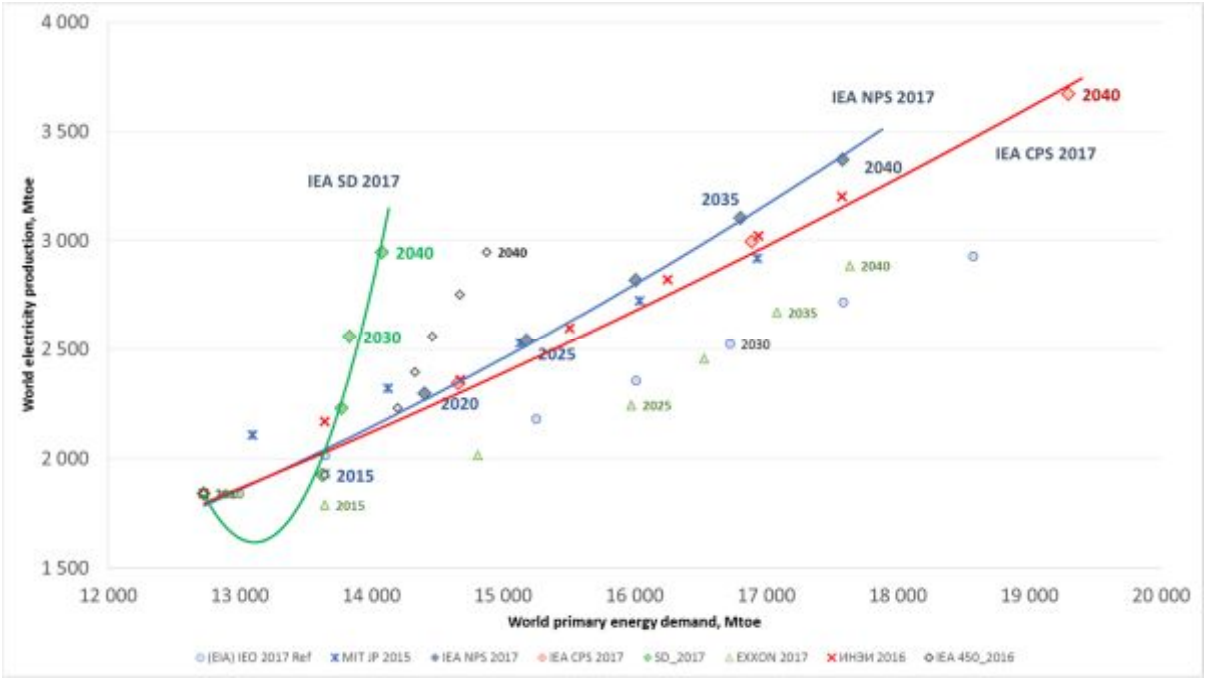


Source: FIEF plot on the basis of IEA, EIA, BP, MIT, ERI RAS, ExxonMobil, Statoil, OPEC and others data. 2016, 2017

On this slide we consider primary energy demand (PED) versus GDP index. Such a consideration allows tracing the energy demand in relation to the economy development.

- **The most of scenarios represent inertial development** without essential change of world economy structure
- In these scenarios the growth rate of PED declines (approx. from 1,4 to 1,2% p.a.) so the PED grows logarithmically with respect to GDP (PED in 2040 is projected within the range between 18 000 and 19 200 Mtoe)
- IEA SD 2017 scenario reflects the imagination of ‘green’ world with stabilization of PE consumption, first in the scenarios history. Previous (2016) ‘green’ 450 scenario has less radical plot of PED
- **There is no sufficient substantiation how such PED stabilization can be really/economically achieved**

World Electricity Production: The Boom Is Coming or Not?

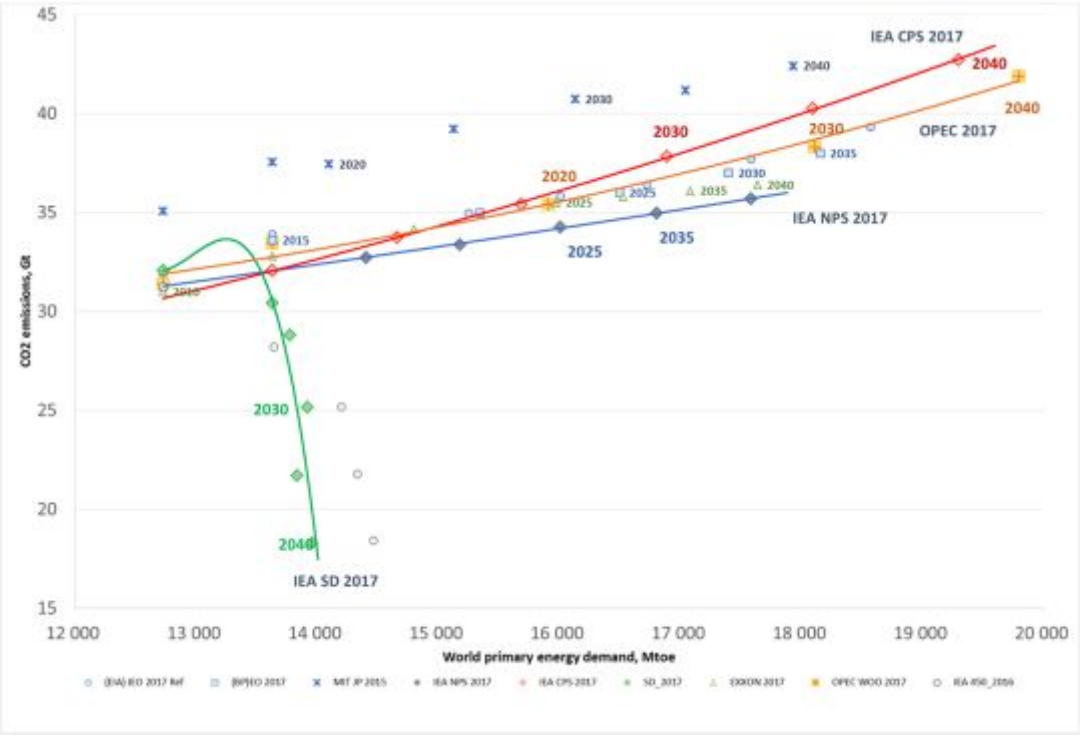


Source: FIEF plot on the basis of IEA, EIA, MIT, ERI RAS, ExxonMobil data, 2016, 2017

On this slide we consider electricity production versus primary energy demand (PED). Such a consideration allows tracing the electricity production in relation to the energy demand.

- **In all scenarios world electricity production is steadily growing.** Most of scenarios has the growth rate about 1,5% p.a. In IEA SD 2017 the growth is 1,7% p.a. up to moderate 3 bln toe, but exposed against the background of PED stabilization it looks unbelievably huge
- Moreover the electricity production ranges in 2040 approx. from 3 bln toe to 3,5 bln toe and approximate ratio of electricity and primary energy production for all scenarios (even in SD) for 2040 is close to 20%.
- **Thus the observations above indicate that projections do not anticipate 'electric world'**.
- In addition EIA & Exxon electrification projections are notably lower than that of IEA. This in a sense reflects the more bent of North America to oil and gas

World CO_2 Emissions: Moving to the "Green World"?

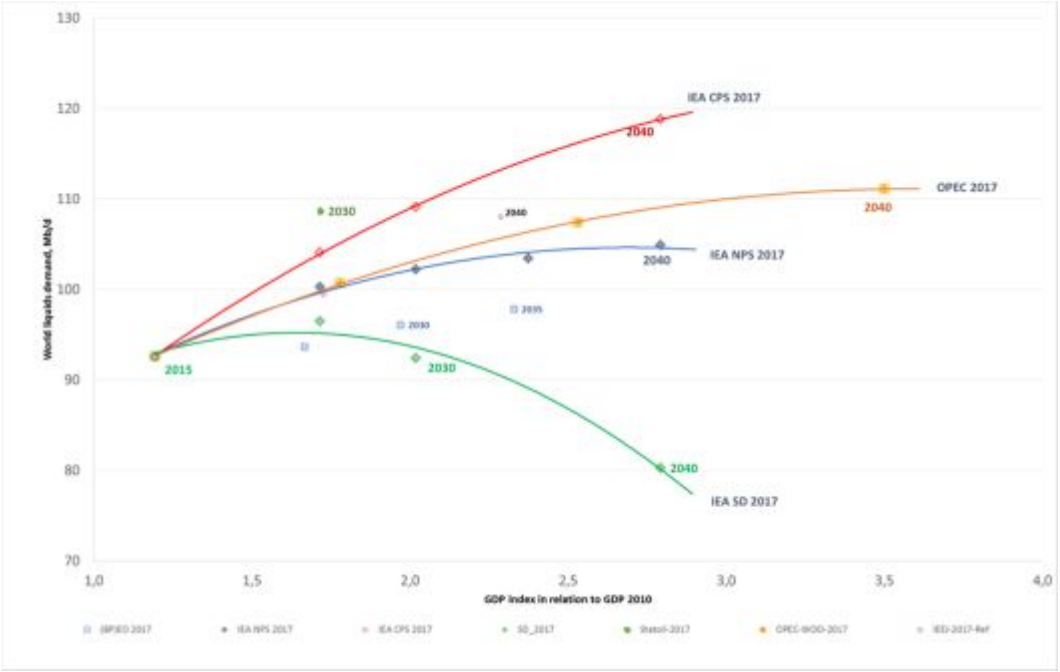


- **In the most scenarios world emission is steadily growing** (the range of growth rate is within the 0,4-1,15% p.a.)
- The exception is 'ecological' scenarios of IEA (SD 2017 and 450 2016), where emissions drop by 2,21% p.a. But according to available data and narratives **there hardly exists more or less reliable description of concrete fulfillment way of such scenarios**
- Regulative measures (NPS and CPS scenarios) can only slow down the emission growth but not even stabilize
- **Thus no real scenario depicts the 'green' world.** It seems that such world is up to now only some 'desired goal'

Source: FIEF plot on the basis of IEA, EIA, MIT, BP, MIT, OPEC, ExxonMobil data, 2016, 2017

On these slide we consider carbon emissions versus primary energy demand (PED) . Such a consideration allows tracing the CO2 emissions in relation to the energy demand.

World Consumption of Liquids: the End of Golden Age of Oil?

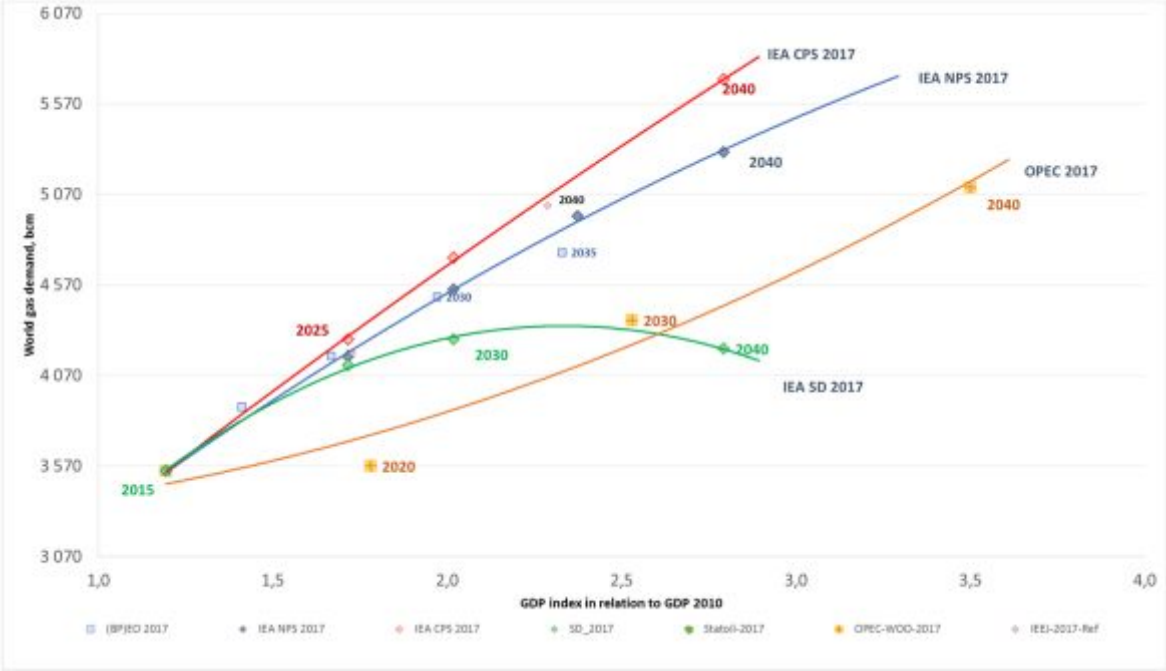


Source: FIEF plot on the basis of IEA, IEEJ, BP, OPEC, Statoil, 2017

- The scenarios, except 'ecological' ones, **clearly shows the stabilization trend for liquids demand**. The stabilization occurs around 2040 in the demand range 100 – 120 Mb/d
- The stabilization of liquids demand is smooth and without shocks. **The most of projections do not show the 'world without oil'**
- But the 'date' of the peak oil demand is very uncertain and depends on many assumptions
- Moreover, the peak oil demand is not expected to trigger a sharp fall in demand

On these slide we consider liquids demand versus GDP index. Such a consideration allows tracing the liquids demand in relation to the economy development.

World Gas Consumption: “Bridge Fuel” Is Come Back?

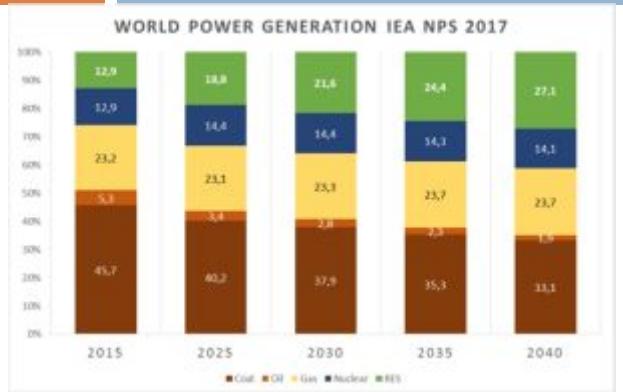


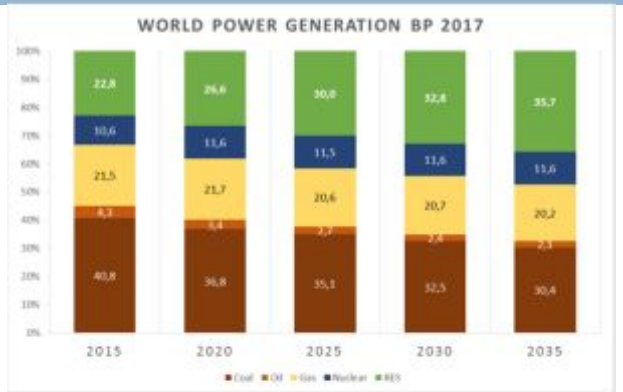
Source: FIEF plot on the basis of IEA, IEEJ, BP, OPEC, Statoil, 2017

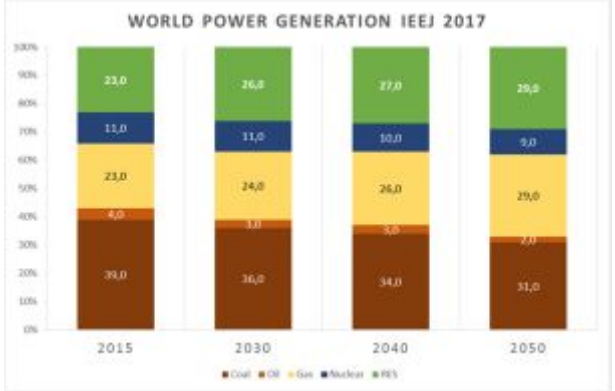
On these slide we consider gas demand versus GDP index. Such a consideration allows tracing the gas demand in relation to the economy development.

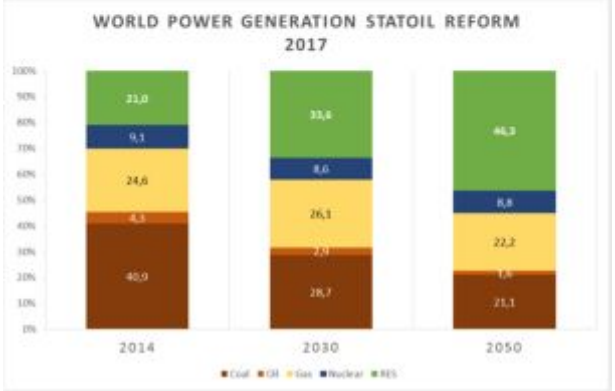
- All projections, except ‘ecological’ one, predict constant growth of gas consumption up to 5070 – 5704 Bcm in 2040
- The growth rate is within 1,5 – 1,9% p.a. range
- Thus it seems that **gas will play the role of ‘bridge fuel’** with firm share in energy balance
- Renewables would be the real game changer for future of gas as a ‘bridge fuel’ if their economic reliability would have been supplemented by their real contribution to the sustainability of energy systems

World Power Generation: RES vs Hydrocarbons









Source: FIEF plot on the basis of IEA, IEEJ, BP, Statoil, 2017

- In all scenarios we observe the **ultimate degradation of coal and the grows of RES** but this can happen in different ways
- In general **the share of gas in the energy mix is mostly stable**, the oil share decreases and in fact negligible
- The role of nuclear generation is uncertain but do not drop essentially below 9%
- The main difference in electricity generation structure lies in the RES development. The estimates give approx. 30-50% RES share near 2050.
- **Power generation sector seems on the way of energy source revolution**

Conclusions: What We Need to Do

- Continuously changing landscape of world energy requires further development of scenarios creating instruments, which can reflect high level of uncertainty and the necessity to have firm support for the decisions making.
- To achieve this target, it is necessary:
  - to provide the energy scenarios with more transparency in terms on underlying mechanisms and assumptions
  - to enlarge the energy scenarios field because it's already impossible to properly represent viable options for energy future by only 2 or 3 scenario projections
  - to provide more comparability of different energy scenarios on the basis of integrated modeling environment
  - to built the integrated energy perspective based on energy scenarios field cross-analyze

Conclusions: From Scenarios to Pathways

- We propose to launch an **open international project ‘Energy Initiatives**’ based on professional discussion about the factors, assumptions, possible issues and opportunities of energy scenarios projections for short-, mid- and long-term prospective
- The main goal of this project is not only to discuss the above issues on ‘Chatham House rules’ but **to produce the public result** of such analytical work
- We aim to improve the international cooperation by joint realizing some **‘digital’ initiatives** (e.g. Oil&Gas Big Data Project proposed by OPEC and Ministry of Energy of the UAE) **to create a kind of global field of energy data and open modeling instruments of their analyze**
- Our approach for that are partly presented in the working paper **‘About Scenario Assessment and Strategic Modeling of the Sustainable Energy Development’**