

The Next 100 Years of Global Energy: Part III

Outlook: 2120 – Global Petroleum Resources and Transportation Fuel Options*

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Summary and Key Messages

Energy Demand

- A wide range of models exist, tied to population growth, GDP/economy, technology, energy efficiency and policy
- Subjective “Cool Factor”

Transportation

- Cleaner (electric, biofueled) cars
- More efficient transportation (ride/car sharing, autonomous vehicles, mass transport)
- Fuel efficiency (increased miles/gallon)
- Flight: personal vehicles, air taxis
- ...Viability and Impact of teleportation

Energy Resources

- Growth in clean fuels such as renewables and hydroelectric
- “Peak” for oil/gas/coal timing uncertain
- Net zero carbon

Fossil Fuels

- Cleaner gas replacing coal
- Technology for zero emissions (including mineralization, carbon capture and storage)
- Wide range of potential non-combustible uses
- ... Aviation fuel may remain petroleum-based

Selected References

BP, 2017, BP Energy Outlook, 2017 edition. Website accessed June 2, 2017, <http://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2017/bp-energy-outlook-2017.pdf>.

Hubbert, M.K., 1956, Nuclear energy and the fossil fuels: Shell Development Company Publication No. 95; published in Drilling and Petroleum Practice, American Petroleum Institute, 1956, 57p.

International Energy Agency (IEA), 2016, Energy, Climate Change and Environment: 2016 Insights. Website accessed June 2, 2017, <http://www.iea.org/publications/freepublications/publication/ECCE2016.pdf>.

New York Times, 2011, Petrochemicals All Around (June 25). Website accessed June 2, 2017, <http://www.nytimes.com/imagepages/2011/06/26/opinion/26cliffordmarshgrp.html?action=click&contentCollection=Sunday%20Review&module=RelatedCoverage®ion=Marginalia&pgtype=article>.

Patterson, R., (guest post of V. Bruno), 2015, Looking back 10 years after peak oil: Peak Oil Barrel. Website accessed June 2, 2017, <http://peakoilbarrel.com/looking-back-10-years-after-peak-oil/>.

Shell Global, 2016, Shell Scenarios: Better life with a healthy planet: Pathways to net-zero emissions. Website accessed June 2, 2017, http://www.shell.com/energy-and-innovation/the-energy-future/scenarios/a-better-life-with-a-healthy-planet/_jcr_content/par/tabbedcontent/tab/textimage.stream/1475857466913/a1aa5660d50ab79942f7e4a629fcb37ab93d021afb308b92c1b77696ce6b2ba6/scenarios-nze-brochure-interactive-afwv9-interactive.pdf.

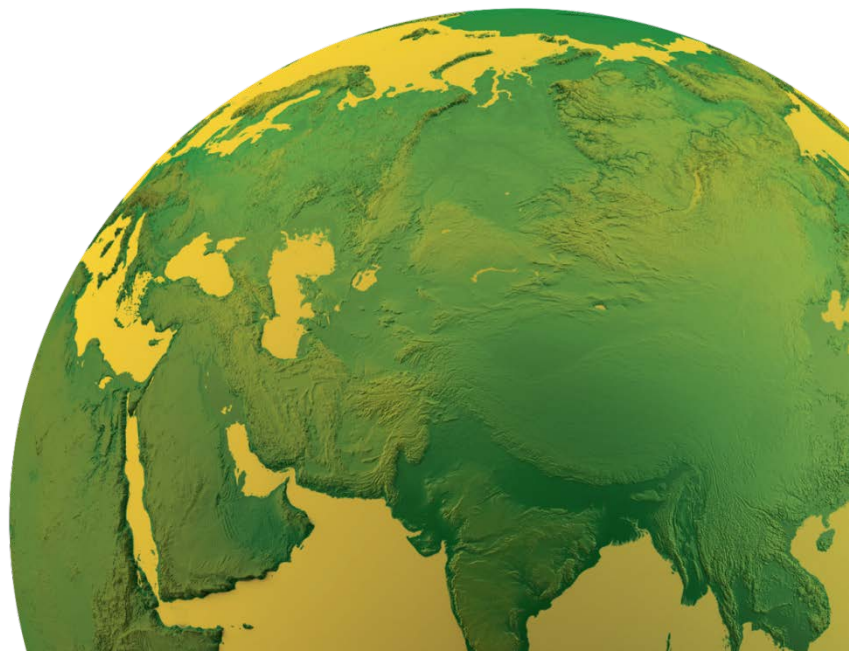
Outlook: 2120

Global Petroleum Resources and Transportation Fuel Options

Cindy Yeilding

BP America

AAPG Annual Convention and Exhibition, April 2017



Objective

Explore future energy demand, sources of energy, transportation methods and role/uses of petroleum

Outline:

- 100 years...
- Future View
 - 2035
 - 2050
 - 2120
- Summary

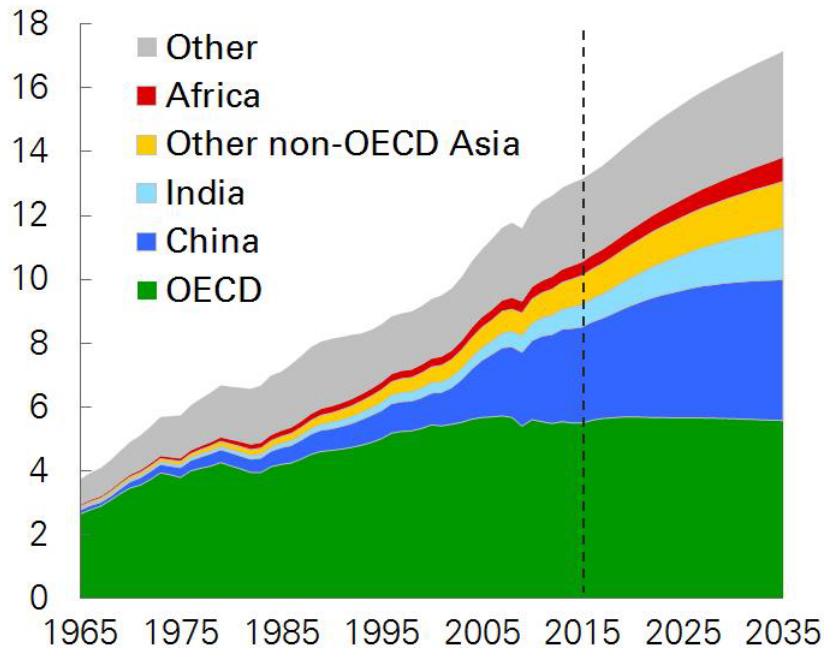


Disclaimer: All that's Certain is Uncertainty

Outlook: 2035 Reference Case

Demand: Consumption by region

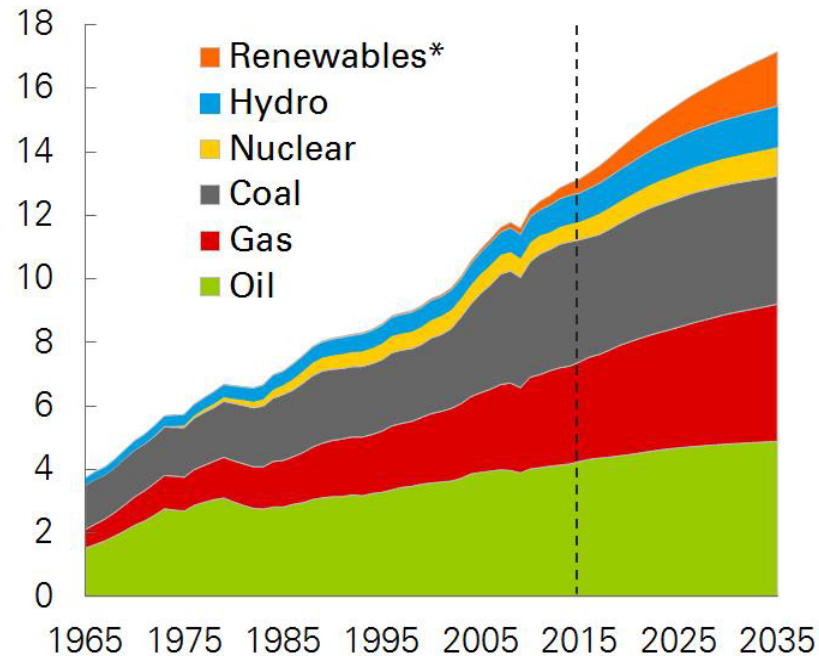
Billion toe



Source: 2017 BP Energy Outlook

Energy Mix: Consumption by fuel

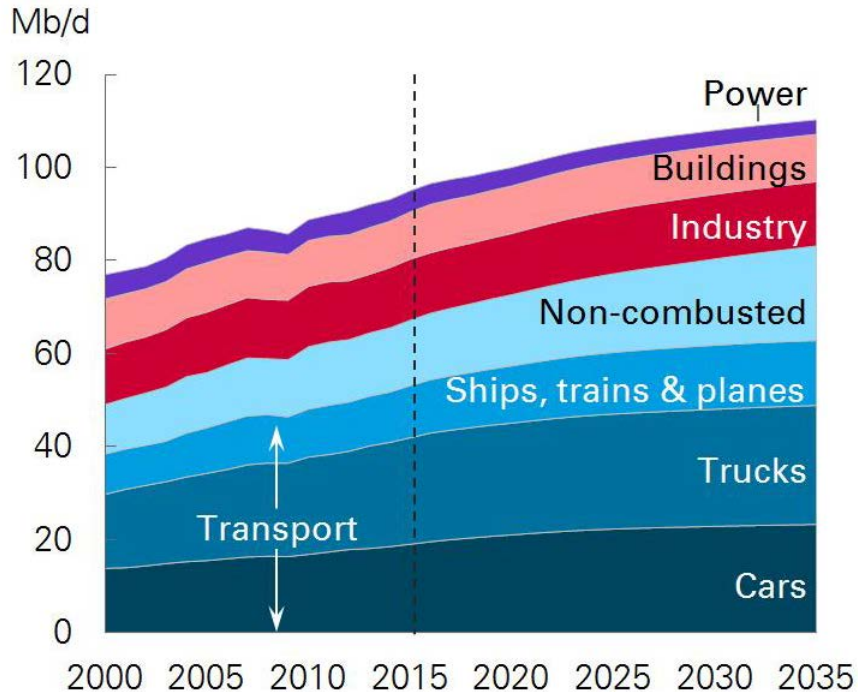
Billion toe



*Renewables includes wind, solar, geothermal, biomass, and biofuels

Outlook: 2035 Reference Case

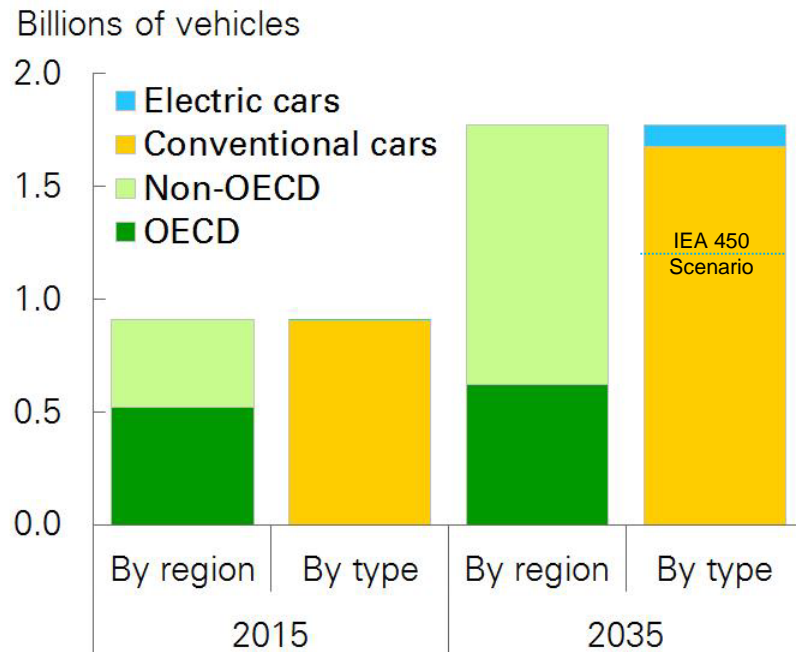
Liquids demand



Liquids includes oil, biofuels and derivatives of coal and natural gas

Source: 2017 BP Energy Outlook

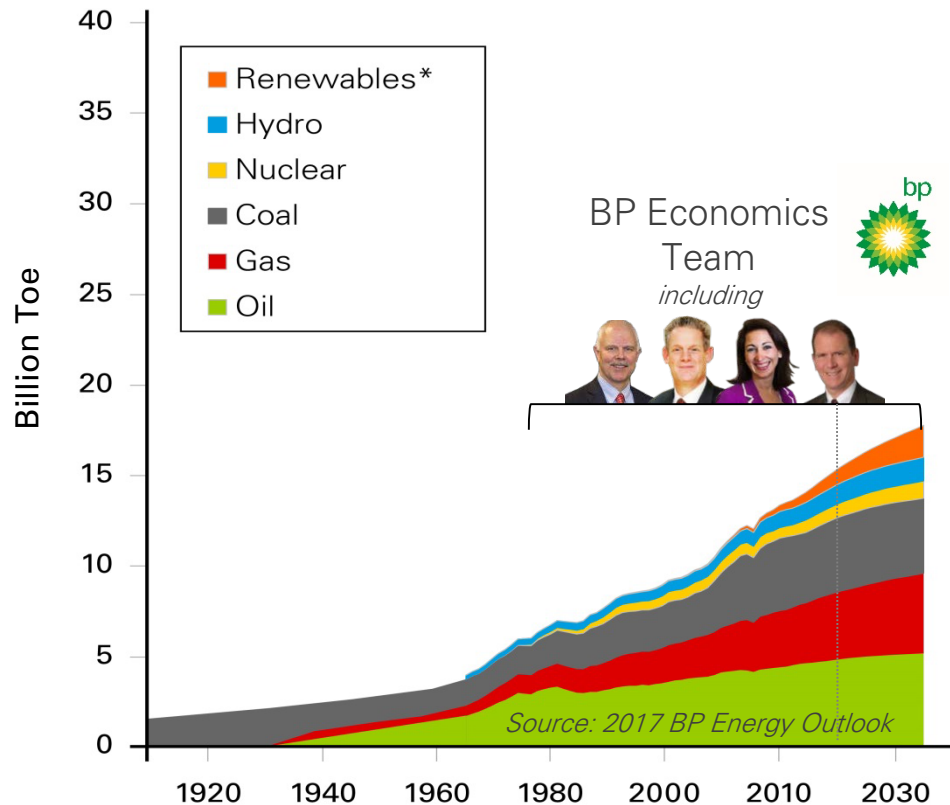
Transportation: global car fleet



Electric Vehicles: Uncertainties:

- Battery technology and costs, policy, subsidies, emission reduction, efficiency of conventional vehicles
 - S. Dale: The "Cool" Factor

Outlook: 2035 Reference Case



Key Messages: Energy Mix

In this model:

- Demand growth of 33%, driven by non-OECD* countries
- Growth in renewables to 10% of mix
- Fossil fuels 75% of energy mix
- Non-combusted petroleum growth

IEA 450 (2040) scenario

- Fossil fuels 45% of energy mix

Transportation assumptions

- Planes, trains and automobiles
- Car and ride sharing, public transport, autonomous vehicles
- Electric vehicles increasing ("cool factor"?)
- Aviation fuels petroleum-based

* Renewables include wind, solar, geothermal, biomass and biofuels

* OECD: Organization for Economic Co-operation and Development

Outlook: Houston in 2050



**Public Transit and
Walkways/Bike paths
Electric vehicles**

**Green spaces, recycled
building materials**

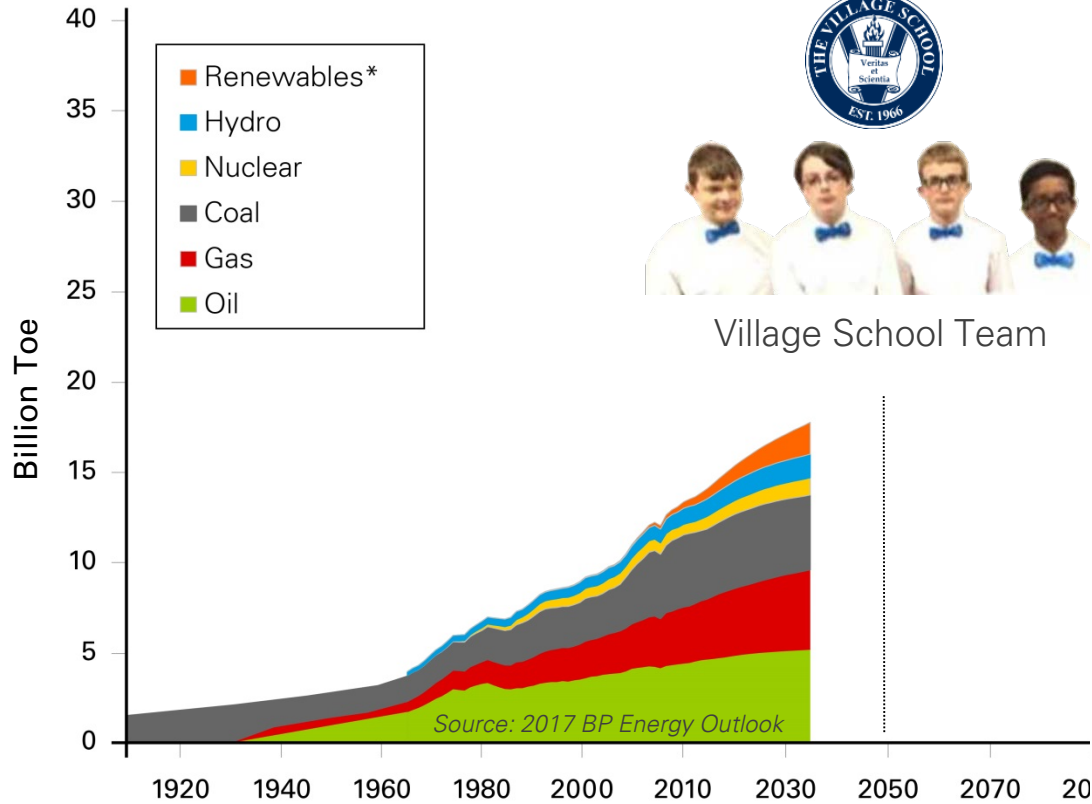
**Local Energy
Sources Utilized**



A panoramic view of the Houston skyline at night. Numerous skyscrapers are illuminated with warm yellow and orange lights, creating a vibrant contrast against the dark, cloudy sky. The city lights reflect on the water in the foreground. The overall atmosphere is one of a bustling, modern metropolis.

Houston, Texas

Outlook 2050



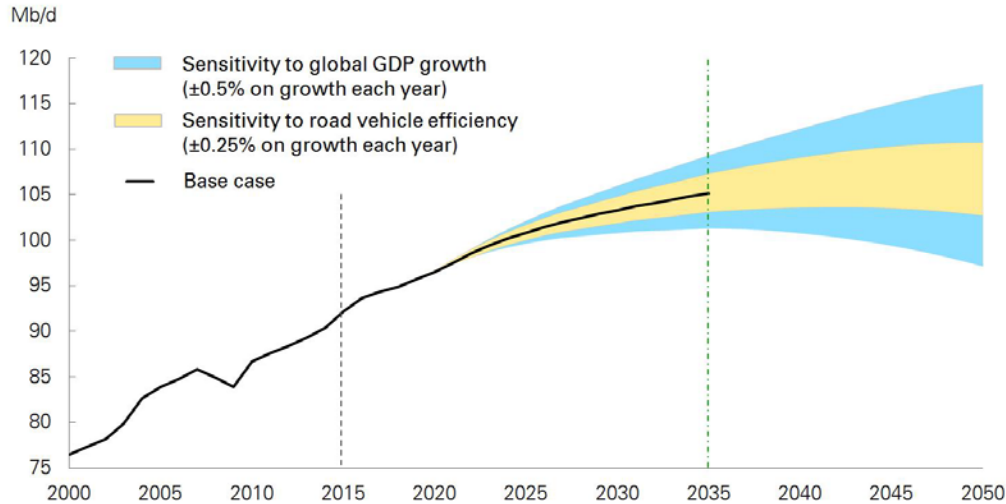
Village School Team

Key Messages:

- **Energy Sources: local**
 - Solar power
 - Biofuel (algae)
 - Wind
 - Ocean thermal
 - LNG
- **Transportation**
 - Electromagnetic Elevated Trains
 - Hydrogen-cell Powered Buses
 - Biofueled and Electric Vehicles
 - Bike trails and footpaths
- **Sustainability**
 - Highways absorb CO₂ and H₂O
 - Green space
 - Recycled materials

* Renewables include wind, solar, geothermal, biomass and biofuels

“Peak Oil” Demand: Illustrative paths



Source: 2017 BP Energy Outlook

Illustrative paths for oil demand under different assumptions:
Predicted as early as 2035

“The Stone Age didn’t end because we ran out of stones”
Sheik Ahmed Zaki Yamani, former Saudi Oil Minister

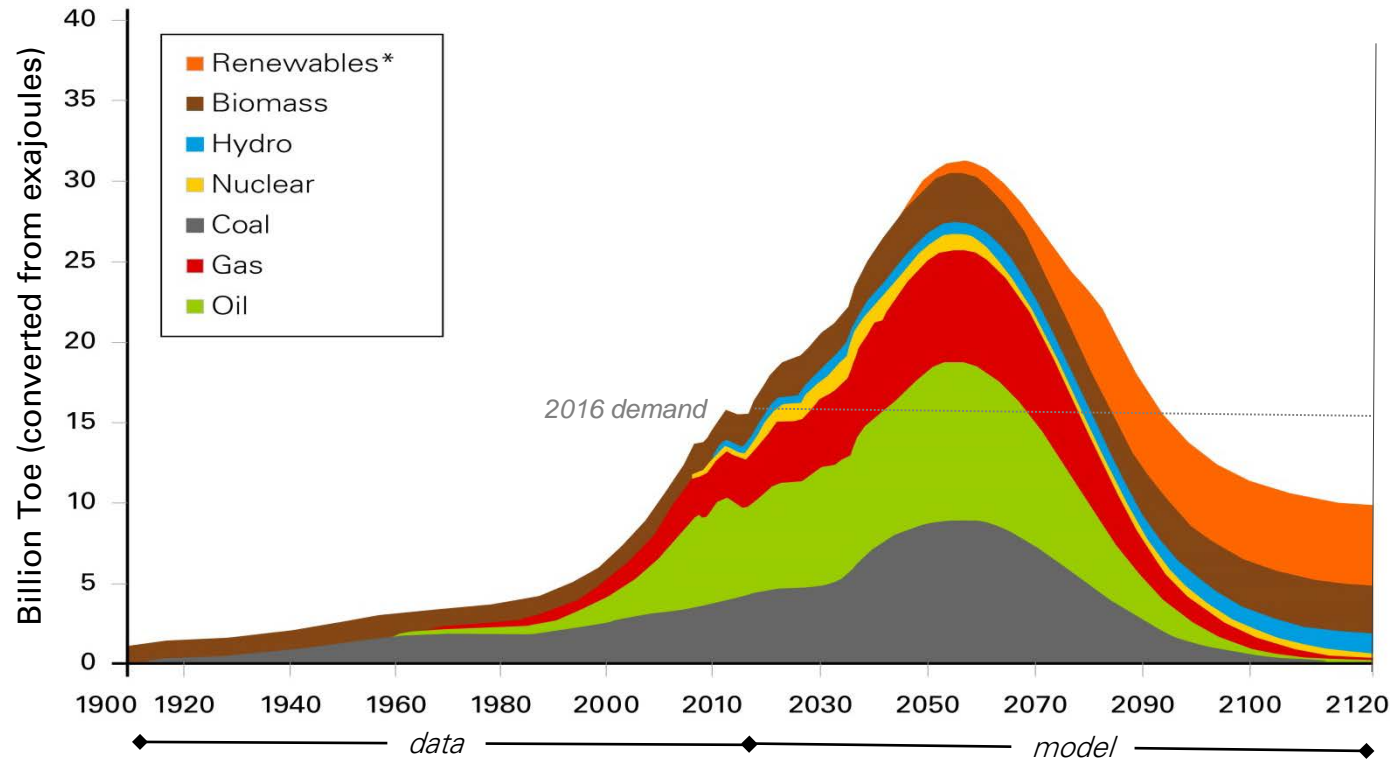
Decline in Oil Demand

- Original theory (Hubbert, 1956):
Time of maximum oil extraction
“running out of oil”
- Expanded to include:
Time of maximum demand
“stranded assets”

“Driven” by many factors, including:

- Fuel efficiency
- Rate of GDP growth
- Policy
- Technology
- Economy

Outlook 2120: "Post-Peak Oil" Case



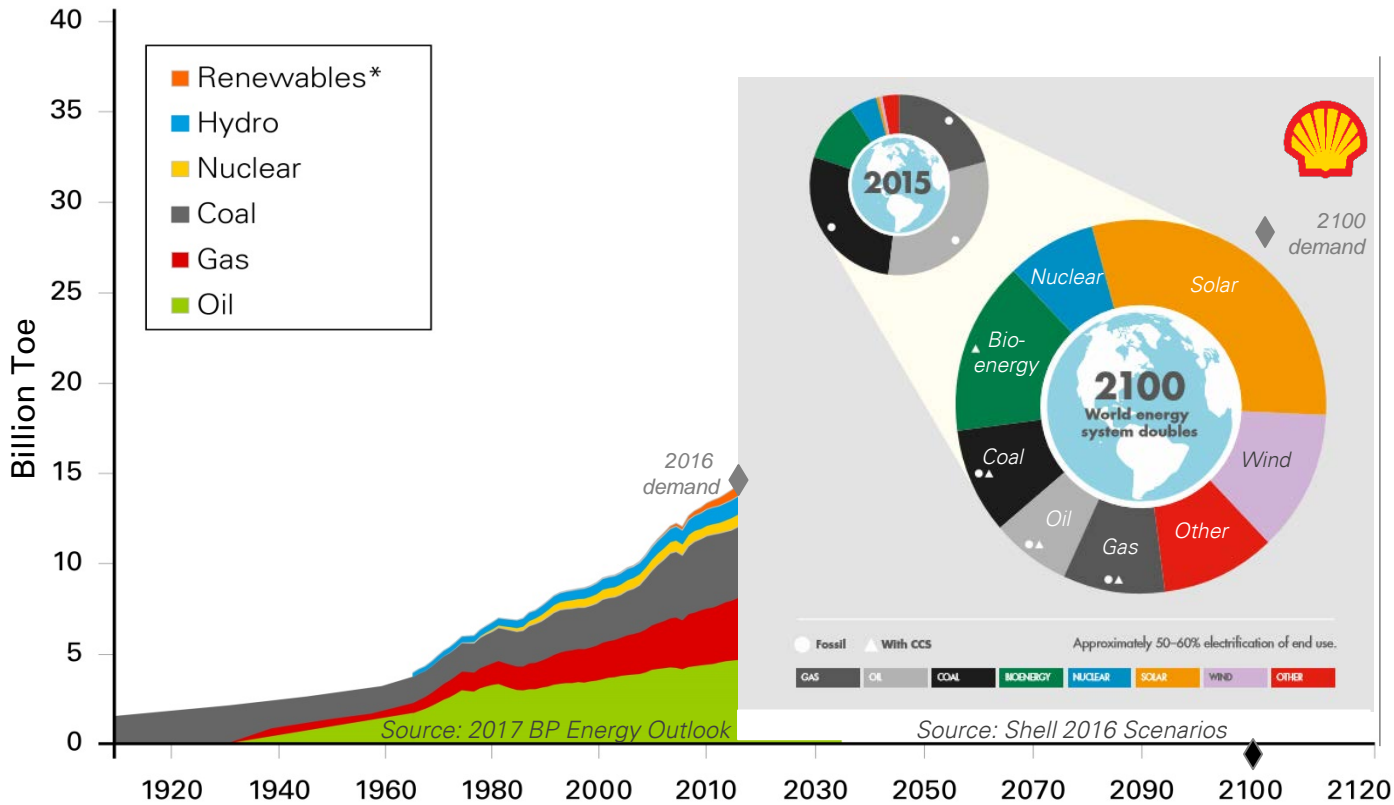
Key Messages:

- Assumes fossil fuel has already peaked in many OECD countries
- No fossil fuel combustion by 2100
- Nuclear, solar, wind and biomass are dominant resources
- Demand below 2016
- Assumes "shocks" to technology, efficiency, society &/or economic activity

From V. Bruno, [Peak Oil news and message boards](http://peakoil.com/consumption/looking-back-10-years-after-peak-oil)

<http://peakoil.com/consumption/looking-back-10-years-after-peak-oil>

Outlook: "2100 Shell Plausible Energy Mix" Case



Key Messages:

- Energy demand doubles from 2015
- Fossil fuels (oil, gas, coal) 20-25% of energy mix
- Gas displacing coal
- Net zero emissions via CCS/other technologies, policy actions and global carbon pricing
- Methane reduction via agricultural methods & land use

Petroleum demand: non-combustible

***"ONE WORD:
PLASTICS"***



Source: The Graduate

Non-combustible: Potential petroleum uses

Today's petroleum products include:



Source: NY Times, 2011

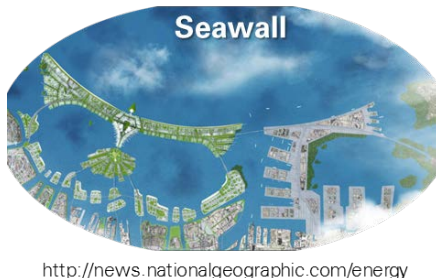
... will the future also include materials for major engineering and infrastructure?

Floating Cities



Population increase, sea level fluctuation?

Seawall



Protective Shield



Hostile atmosphere, population growth?

Colonies



Summary & Key Messages: 100-year outlook

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BP Energy Outlook

The Village School, Houston Texas

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