National Academy of Sciences
Deployment of Deep Decarbonization Technologies

Energy lives here™

Washington DC
22 - 23rd July, 2019

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Summary

- Dual Challenge – providing reliable, affordable energy to support prosperity and enhance living standards and the need to do so in ways that reduce impacts on the environment, including the risks of climate change
  - Middle class continues to grow in the non-OECD countries resulting in increased demand for energy
- Additional technology advances needed to be on a 2ºC pathway
- Potential technology solution sets
  - Efficiency is likely to be the most cost effective element of a lower carbon pathway – efforts need to continue; e.g. cogeneration, low energy separations, process intensification
  - Lower carbon energy and fuel sources like natural gas, wind, solar, and nuclear have been progressively reducing carbon intensity
  - Carbon capture, sequestration and utilization are expected to have an important role; challenges: policy, and cost
  - Lower CO_2 footprint H_2 could be an energy carrier, source of thermal energy, and a feedstock for further synthesis; challenge: cost
  - Biomass sources of fuel and feedstock could add to the portfolio of choices; challenges: availability and cost
- Policies
  - Market-based systems that place a uniform, predictable cost on CO_2 emissions are more effective policy options than mandates or standards
  - Regulations that are technology neutral promote innovation
  - Life Cycle analysis is a better methodology to assess potential solution sets.

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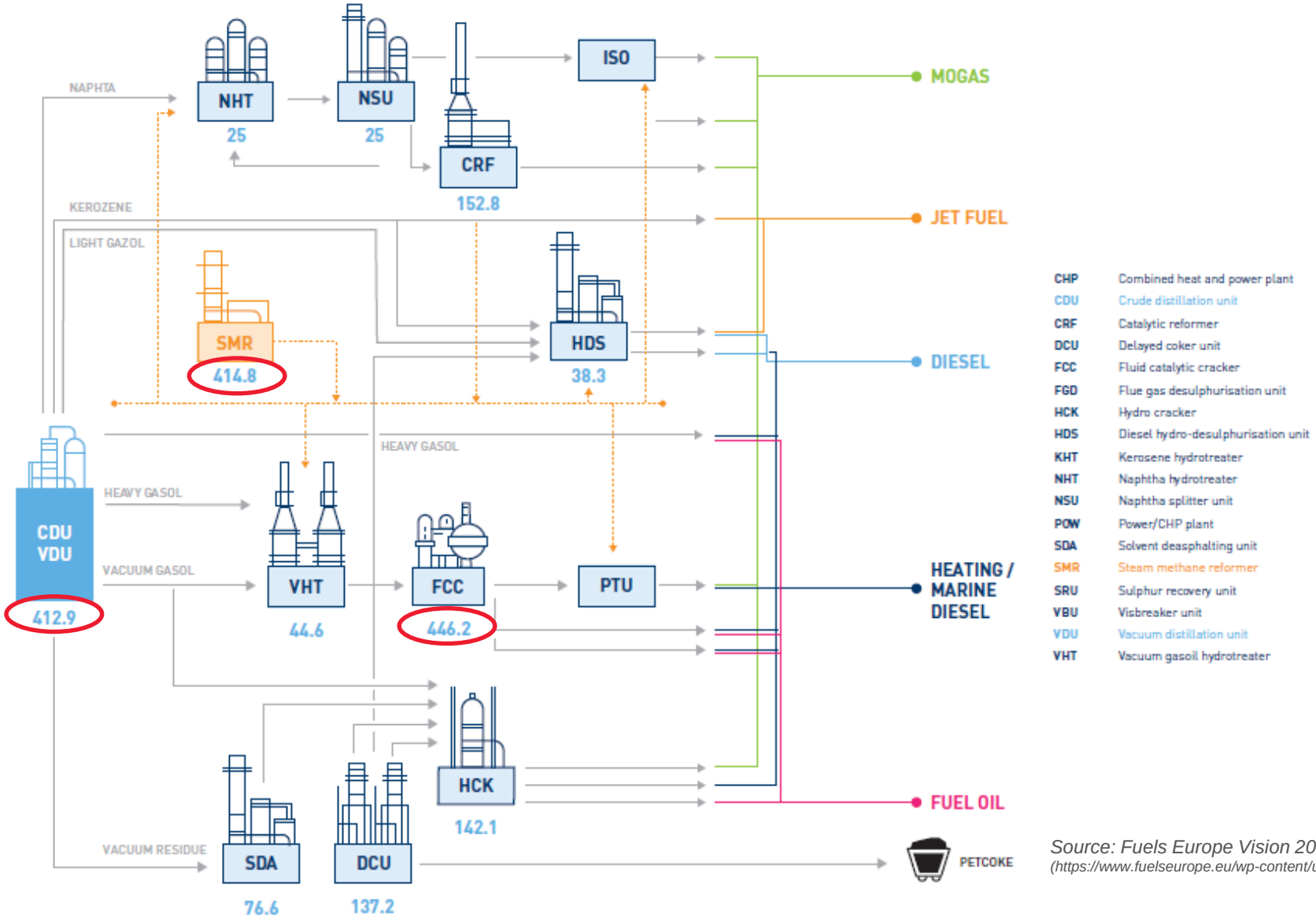
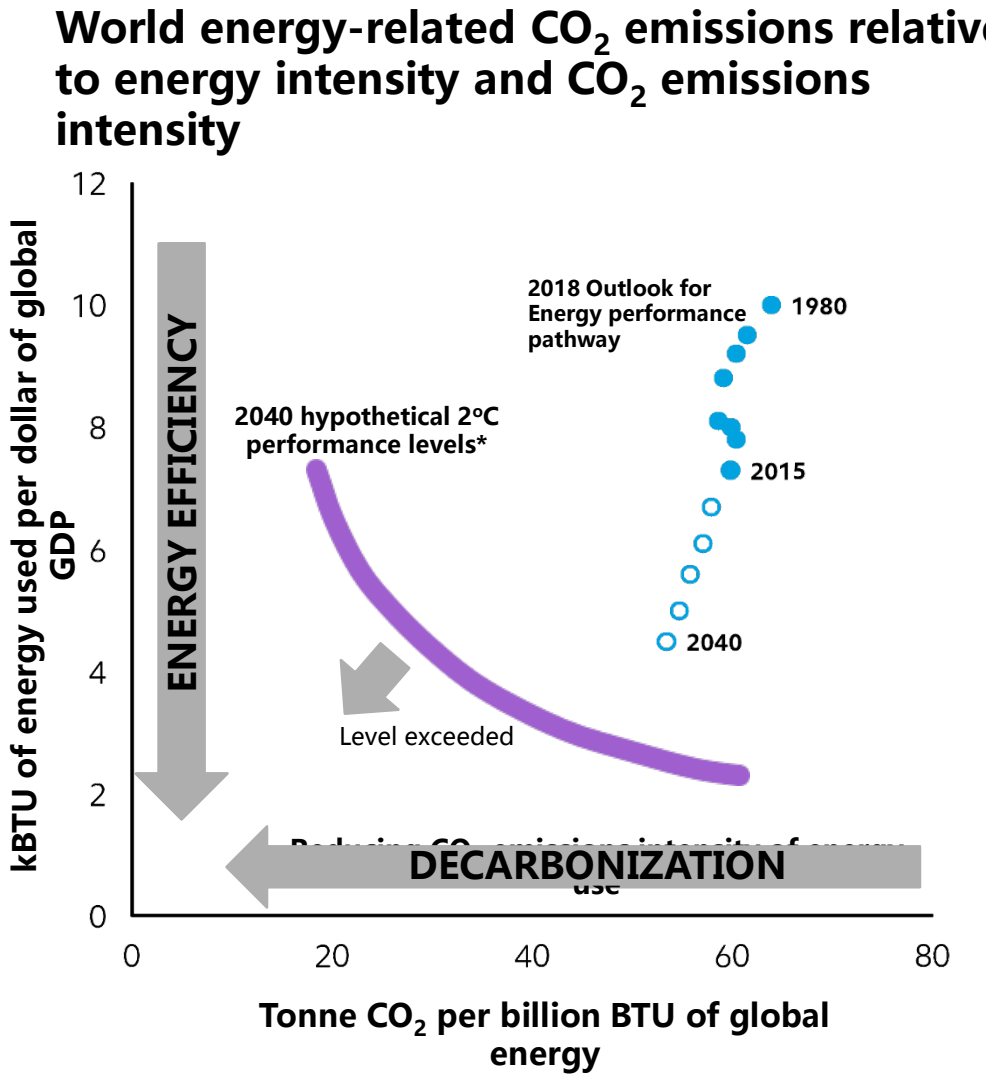
Typical Complex Refinery and Emission Sources



CHP	Combined heat and power plant
CDU	Crude distillation unit
CRF	Catalytic reformer
DCU	Delayed coker unit
FCC	Fluid catalytic cracker
FGD	Flue gas desulphurisation unit
HCK	Hydro cracker
HDS	Diesel hydro-desulphurisation unit
KHT	Kerosene hydrotreater
NHT	Naphtha hydrotreater
NSU	Naphtha splitter unit
POW	Power/CHP plant
SDA	Solvent deasphalting unit
SMR	Steam methane reformer
SRU	Sulphur recovery unit
VBU	Visbreaker unit
VDU	Vacuum distillation unit
VHT	Vacuum gasoil hydrotreater

Source: Fuels Europe Vision 2050
(https://www.fuelseurope.eu/wp-content/uploads/DEF_2018_V2050_Narratives_EN_digital.pdf)

Significant Technology Advances Needed



*Based on average Stanford EMF27 full technology / 450ppm scenarios' CO_2 emissions (~20 billion tonnes including energy and industrial processes), ExxonMobil GDP assumptions consistent with 2018 *Outlook*

ExxonMobil 2018 Outlook for Energy

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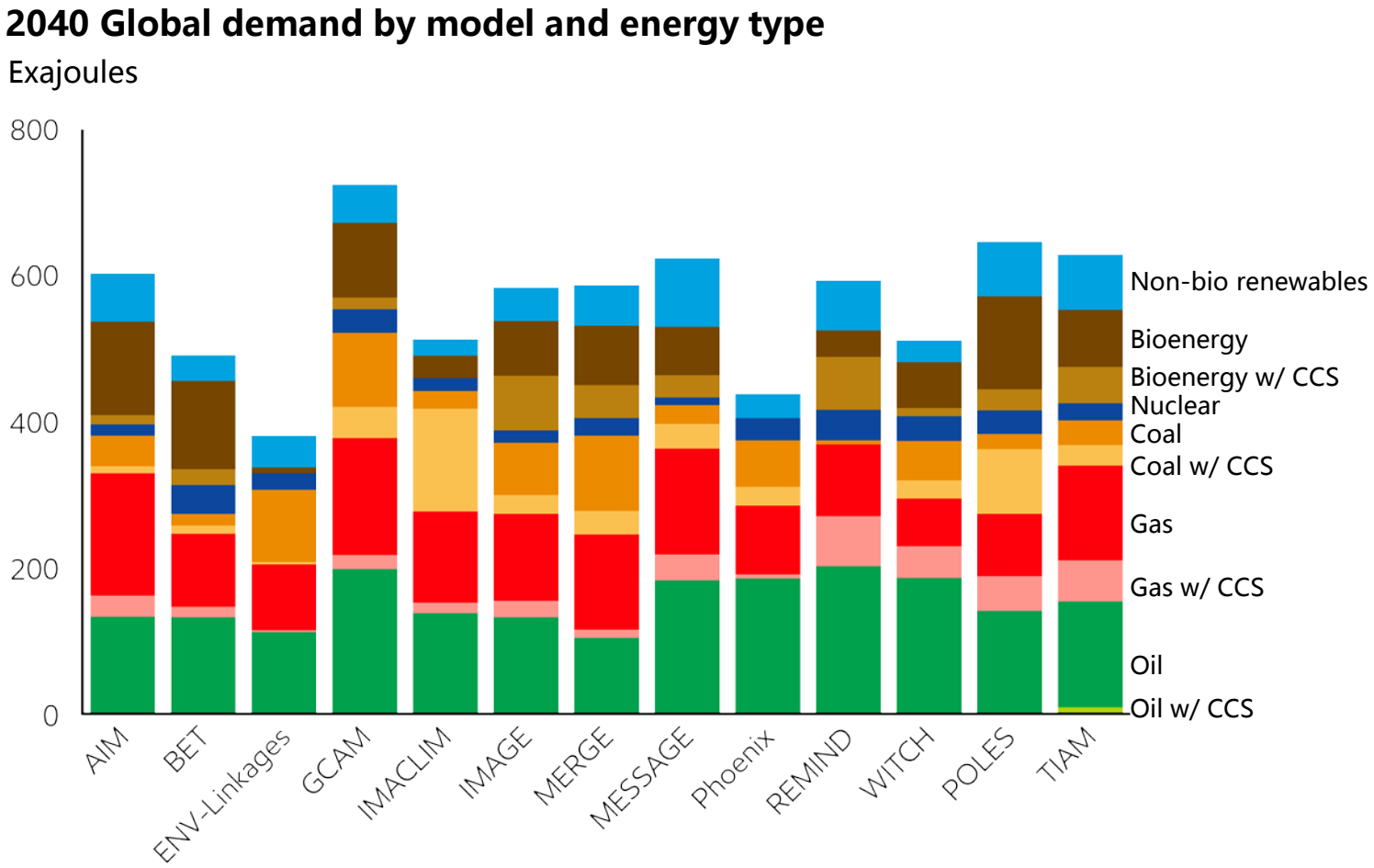
Efficiency gains and lower carbon energy sources needed

Assessed 2°C Scenarios: 2040 Global Energy Demand



Based on EMF27 full technology / 450 ppm scenarios (Assessed 2°C Scenarios)
EMF27 full technology scenarios data downloaded from: https://secure.iiasa.ac.at/web-apps/ene/AR5DB

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Carbon capture and sequestration is expected to have an important role

Technologies

Fuel Cells for CO_2 Capture and H_2 Production

Cogeneration

Biofuels and Bio-feedstocks

Renewable Power Utilization

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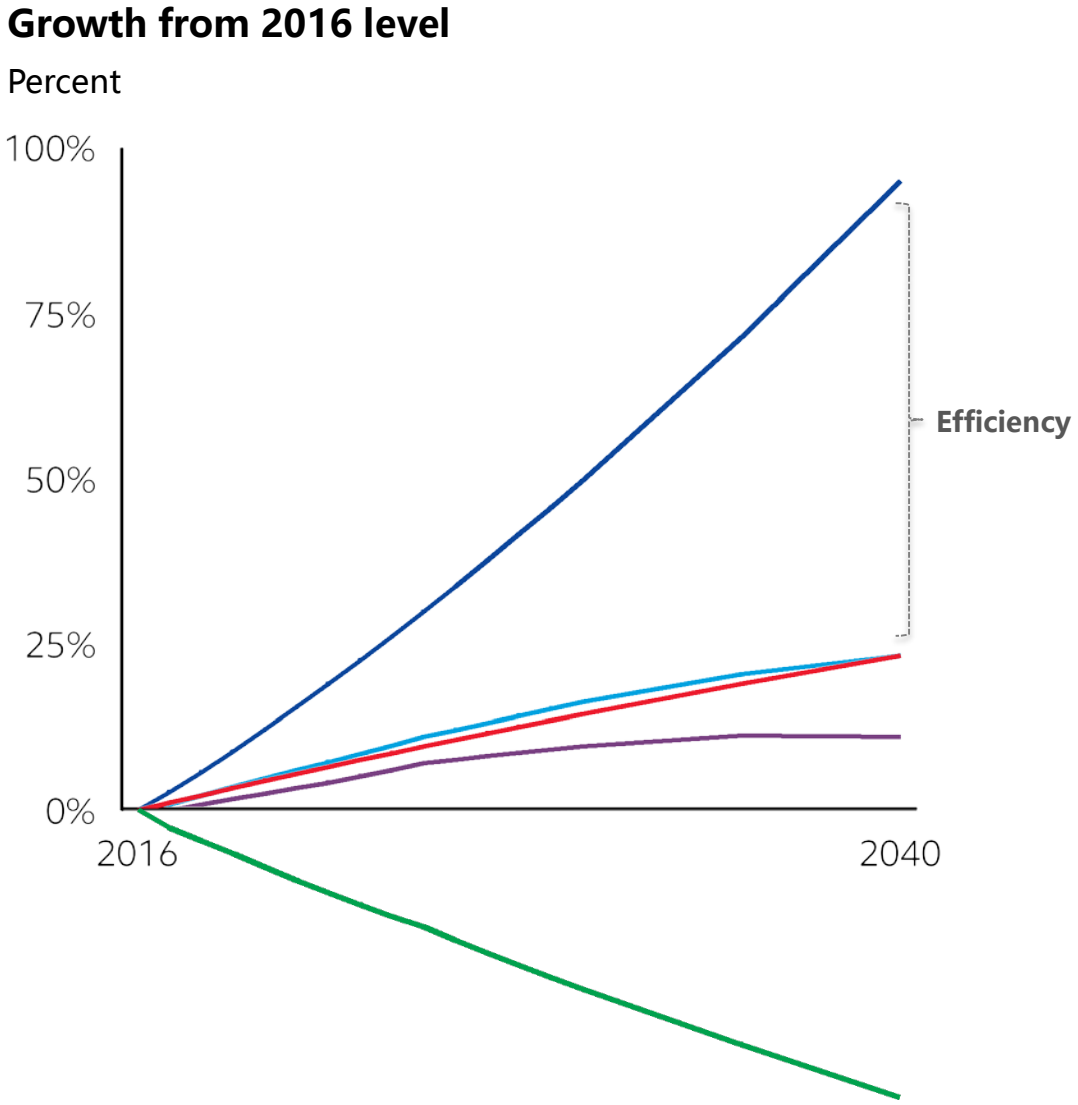
Photos from EMPhoto

BACKUP

Global Trends Continue to Evolve



2016

2x
GDP

+25%
demand

+1.7 billion
people

+10%
CO_2 emissions

-45%
CO_2 intensity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