Glossary

Assessed 2°C scenarios: Technology and policy pathways associated with various climate stabilization targets (e.g., 450, 550 ppm CO_2 equivalent or CO_2e) from a comprehensive multi-model study coordinated by the Energy Modeling Forum 27 (EMF27)[6] at Stanford University[3], partially in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

CCS: Carbon capture and storage is a set of technologies to capture CO_2 and inject it into carefully selected geological formations for safe, secure and permanent storage. CCS is recognized as a key option for reducing CO_2 emissions.

CCU: Carbon capture and utilization is a set of technologies to capture CO_2 and utilize it to make useable products and services.

Conventional vehicle: A type of light-duty vehicle with an internal combustion engine, typically either a gasoline-fueled spark ignition engine or a diesel-fueled compression ignition engine. Conventional includes vehicles with advanced technologies such as turbocharging and "mild hybrid" features such as a stop-start engine.

Electric vehicle (BEV): A type of light-duty vehicle that uses an electric motor exclusively. The motor is powered by a rechargeable electric battery.

Generation efficiency: The ratio of useful energy output to energy input in the generation of electricity from primary energy sources. Generation efficiency typically varies by generation type and region, however wind, solar PV and hydro are assumed to be 100 percent efficient.

Heavy-duty vehicle (HDV): A classification of road vehicles, primarily for commercial use, that include light, medium and heavy trucks, and buses. Heavy-duty fuel demand also includes other unclassified road fuel demand, such as 3-wheel vehicles.

Hybrid vehicle: A "full" hybrid is a type of light-duty vehicle that has a battery (usually a nickel metal hydride) and an electric motor, as well as a conventional internal combustion engine. When brakes are applied, the energy of the moving vehicle is stored in the battery and can be used later, thus saving fuel.

Hydrogen fuel cell vehicle: A type of light-duty vehicle for which hydrogen is the fuel and is stored onboard. This hydrogen is passed through a fuel cell that then provides electricity to power the vehicle.

Light-duty vehicle (LDV): A classification of road vehicles that includes cars, light trucks and sport utility vehicles (SUVs). Motorcycles are not included in the light-duty vehicle fleet size or fuel-economy, but the fuel used in motorcycles is included in light-duty transportation demand.

Liquefied natural gas (LNG): Natural gas (predominantly methane) that has been super-chilled for conversion to liquid form for ease of transport.

Liquefied petroleum gas (LPG): A classification of liquid hydrocarbon fuel including propane, butane and other similar hydrocarbons with low molecular weight.

Liquids: An energy classification that includes oil, liquid biofuels (such as ethanol and biodiesel) and derived liquids (e.g., gas-to-liquids)

Natural gas: An energy classification that includes natural gas (primarily methane) and synthetic gas (e.g., from coal-to-gas). Natural gas demand includes flared gas.

Natural gas liquid (NGL): A liquid fuel produced chiefly in association with natural gas. NGLs are components of natural gas that are separated from the gaseous state into liquid form during natural gas processing. Ethane, propane, butane, isobutane and pentane are all NGLs.

Oil: Oil supply includes crude oil (such as that coming from conventional, tight oil, deepwater and oil sands developments), condensate and natural gas liquids. Oil demand includes products such as gasoline, diesel, naphtha, kerosene/jet fuel, fuel oil, ethane, LPG, lubricants, asphalt, pet coke and refinery gas produced in oil refineries, natural gas processing plants or derived liquids plants (e.g., gas-to-liquids). Oil demand also includes crude oil and condensate that is used directly (e.g., for electricity generation). Oil excludes liquid biofuels.

Organisation for Economic Co-operation and Development (OECD): A forum for about 36 nations from across the world that work with each other, as well as with many more partner nations, to promote policies that will improve the economic and social well-being of people around the world. In this Outlook, **OECD** is referring to the 36 nations that are members of the forum; **Non-OECD** is a term used collectively for countries other than the 36 OECD nations.

"Other [geography]" / "Rest of [geography]": Used in chart labels to cover the remaining geography referenced less any regions or countries independently plotted and/or represented on the chart.

Plug-in hybrid electric vehicle (PHEV): A type of light-duty vehicle that typically uses an electric motor. Unlike other electric vehicles, a PHEV also has a conventional internal combustion engine that can charge its battery using petroleum fuels if needed, and in some cases power the vehicle.

Primary energy: Includes energy in the form of oil, natural gas, coal, nuclear, hydro, geothermal, wind, solar and bioenergy sources (biofuels, municipal solid waste, traditional biomass) consumed as a fuel or used as a feedstock (i.e., for the production of chemicals, asphalt, lubricants, waxes and other specialty products). Coal demand includes metallurgical coal. Gas demand includes flared gas. To avoid double counting, derived liquids (e.g., gas-to-liquids) and synthetic gas (e.g., from coal-to-gas) are only accounted for in their final form (i.e., liquid or gas) and not in the energy type from which they were derived (i.e., gas or coal). The fuel and loss involved in the conversion process is accounted for in the energy industry sub-sector. Primary energy does not include electricity, market heat or hydrogen, which are secondary energy types reflecting conversion /production from primary energy sources.

Secondary energy: Energy types, including electricity, market heat and hydrogen, that are derived from primary energy sources. For example, electricity is a secondary energy type generated using natural gas, wind or other primary energy sources.

Glossary (continued)

Unit	Description	Unit Type	Approximate conversion 1 QUAD =
Quadrillion BTU (QUAD) (1)	Quadrillion (10^{15}) British thermal units	Energy	1
Exajoule	Exa (10^{18}) joules	Energy	1.05
MBDOE (2)	Million (10^{6}) barrels per day oil equivalent	Energy	0.49
TWh	Tera (10^{12}) watt-hours	Energy	293
BCFD	Billion (10^{9}) cubic feet per day	Gas volume	2.9
TCF	Trillion (10^{12}) cubic feet	Gas volume	1.06
GW	Giga (10^{9}) watts	Power	N/A
Billion Tonnes CO_2 (3)	Billion (10^{9}) metric tons energy-related CO_2 emissions	Emissions	N/A

Table notes:
(1) For oil products, energy content is based on the specific energy density of each product (e.g., gasoline, diesel, LPG, etc.).
(2) MBDOE - Oil products are reported in physical barrels; all other energy types are reported on an oil-equivalent energy basis.
(3) CO_2 emissions from the combustion of fossil fuels.
In the *2019 Energy Outlook*, the combustion of biofuels is assumed to have zero net CO_2 emissions (i.e., CO_2 emissions from combustion exactly balances against the photosynthetic update of CO_2 in the growth of biomass used in biofuels), consistent with traditional biomass. This change is intended to bring estimation of energy-related CO_2 emissions from biofuels in line with the method used for other fuel types and is consistent with the methodology used by the IEA. Previous *Outlooks* attributed to biofuels the net carbon emissions over the full land-use cycle.

Update:
The chart on page 6, depicting the Human Development Index, was updated on September 11th, 2019. The x-axis is now shifted to the left. The relative depiction of the various countries, their HDI, their energy consumption and the relation between progress and energy consumption remains unchanged.

Publication footnotes:

[1] http://unfccc.int/paris_agreement/items/9485.php

[2] UNEP (2018). The Emissions Gap Report 2018. United Nations Environment Programme, Nairobi, page XIV and XV, http://wedocs.unep.org/bitstream/handle/20.500.11822/26895/EGR2018_FullReport_EN.pdf?sequence=1&isAllowed=y

[3] EMF was established at Stanford in 1976 to bring together leading experts and decisionmakers from government, industry, universities, and other research organizations to study important energy and environmental issues. For each study, the Forum organizes a working group to develop the study design, analyze and compare each model's results and discuss key conclusions. https://emf.stanford.edu/about. EMF is supported by grants from the U.S. Department of Energy, the U.S. Environmental Protection Agency as well as industry affiliates including ExxonMobil. https://emf.stanford.edu/industry-affiliates

[4] UNFCC website: https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry

[5] IEA, *Perspectives for the Energy Transition*, page 57

[6] To understand some of the characteristics of future transition pathways, we analyzed energy and emissions data from a range of EMF27 stabilization, policy and technology targets, primarily focusing on 450 and 550 stabilization targets, as well as no policy cases that utilize a full suite of technologies. The suite of full technologies (FT) includes a range of options, including: energy efficiency, nuclear, carbon capture and storage (CCS), biofuels and non-bio renewables such as solar and wind. The EMF27 study considered other technology-limited scenarios, but a key finding was that the unavailability of carbon capture and storage and limited availability of bioenergy had a large impact on feasibility and cost. Given the potential advantages to society of utilizing all available technology options, we focused on capturing the results of different EMF27 models that ran 450-FT cases; we were able to download data for 13 such scenarios, and utilized that data as provided for analysis purposes (most of the scenarios had projections extending to 2100). Data downloaded from: https://secure.iiasa.ac.at/web-apps/ene/AR5DB

[7] The assessed 2°C scenarios produce a variety of views on the potential impacts on global energy demand in total and by specific types of energy, with a range of possible growth rates for each type of energy as illustrated in this report. Since it is impossible to know which elements, if any, of these models are correct, we used an average of all 13 scenarios to approximate growth rates for various energy types as a means to estimate trends to 2040 indicative of hypothetical 2°C pathways.

[8] Poverty rates by region at $3.20/day in 2011 Purchasing Power Parity pulled from the World Bank's 2018 report on *Poverty and Shared Prosperity*. These rates were applied to 2017 population to estimate population below the poverty line.

[9] IEA, World Energy Outlook 2016, page 290

[10] International Energy Agency, Tracking Clean Energy Progress, Retrieved from https://www.iea.org/tcep/ on July 15, 2019

[11] Historical data profiles for energy demand, liquids and gas supply, demographic and economic trends are based upon publicly available third-party data. The historical data may be converted into different scientific metrics, or aggregated or disaggregated by regions, sectors or fuels where necessary to complete our analysis. Where there are differences, imbalances or gaps in reported historical data among credible third-parties, professional judgment is applied. 2018 is treated as a projection year because analysis and modeling for this report was conducted in 2018 and early 2019 before a comprehensive set of reliable historical data was available for 2018. Historical data compiled from third-party sources can be subject to later revision as new information becomes available.

[12] Proprietary, internally-developed models are used to model future (1) demand for energy services and energy sources, (2) oil and gas production and (3) natural gas trade flows via pipeline and liquefied natural gas. In addition to the historical foundation and projections of fundamental drivers, these proprietary models use our internal assumptions on many variables such as expected efficiency improvements, the pace of deployment of technology advances, costs, consumer preference and much more. Our internal assumptions are informed by our own proprietary data and analysis, publicly available data and the views of credible third-party consultants, academics and think-tanks. Estimates of energy-related CO_2 emissions from the combustion of fossil fuels are derived from the historical and projected energy demand by applying an emissions factor for each fossil fuel type.