How ambitious are oil and gas companies' climate goals?

Supplementary methods and results

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2nd September 2021

Version post peer-review, pre copy-editing

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Companies' assessed product

O&G companies are active at different levels of the value chain, ranging from pure E&P companies focused on extraction to more downstream-focused integrated companies involved in extraction, refining and distribution. Companies also vary in their degree of non-energy petrochemical production and in their diversification into renewable energy. We developed the concept of 'assessed product' to enable comparisons between O&G companies with different structures and foci.

We segment energy products sold externally into five categories. The relative importance of these categories varies widely according to company structure. The five categories of energy sales are:

1) *Primary, 'unrefined' products*. This principally includes crude oil, Natural Gas Liquids (NGLs; collectively known as liquids) and natural gas, but can also include coal. When companies only disclose production of primary products, as opposed to sales, further assumptions need to be made in order to obtain external sales. If an integrated O&G producer does not disclose external sales of primary products, we assume all liquid production is consumed internally by the company's downstream refinery activities, or, if refinery throughput data are available, we assume that the amount of externally sold primary liquids equals the difference between primary liquids production and refinery throughput. We assume that all natural gas production is sold externally unless otherwise stated. When a pure E&P company discloses liquid production rather than liquid sales, we assume that all produced liquids are sold externally. Royalty production owned by host governments is excluded from assessed product.

2) *Refined products*. Liquid production must typically be refined before it can be used as an energy product. Integrated companies refine both their internal, upstream production and liquids purchased externally. Some companies exclusively focus on refining. When no explicit sales data are available, we assume that refinery production equals sales.

3) *Finished products*. Refined liquid products, either internally produced or purchased from external suppliers, are blended and distributed as fuel to end-customers (i.e. at gasoline/petrol stations).

4) *Physically traded products*. Some integrated O&G companies sell energy products (natural gas and liquids) originally extracted by third parties, without transforming them.

5) *Other energy products*. Some O&G companies are diversifying into supplying electricity and heat generated from fossil fuels and low-carbon sources, including biofuels, solar and wind.

The objective is to only measure emissions and supply from energy products sold externally, so that emissions arising from any other activities that companies are engaged in are excluded, otherwise companies' emissions intensity may be mis-estimated. Some O&G

products have a non-energy use, mainly in the plastics and petrochemicals industry. In excluding emissions from and supply of non-energy products, it is important to make a distinction between energy and non-energy uses of liquids.

According to ref. (*1*), 8% of carbon in produced oil and 1.9% of carbon in gas is permanently stored through non-energy use (measured in energy equivalent units), such as for plastics and petrochemicals. Using these carbon storage factors thus allows us to account for the fact that some non-energy outputs such as plastics are burned at the end of their lifecycle for energy. This is also reflected in the benchmark low-carbon scenarios, because some non-energy products feed back into primary energy in the form of waste. Hence, when calculating a company's use of sold product emissions and energy content, an adjustment is made to reflect the portion of hydrocarbon output destined for non-energy uses. While companies disclose the production of individual non-energy products, the total is not typically stated and therefore an assumption must be made. For companies where the sum of disclosed non-energy products such as naphtha or lubricants is equal to or higher than 10% of liquids sold, no adjustment is made. Where it is less than 10%, an adjustment is made so that a minimum of 10% of liquid production is treated as non-energy. The adjustment is made to the sum of all liquid energy products sold externally by a company. In low-carbon scenarios, including our benchmarks, the ratio of non-energy to primary energy from O&G increases (*2*, *3*). At the company level, we make no adjustment for any impact that a rising proportion of non-energy sales may have. Such changes in the sales mix may already be factored into companies' emissions targets and there is no straightforward way of making adjustments at the company level without explicit guidance.

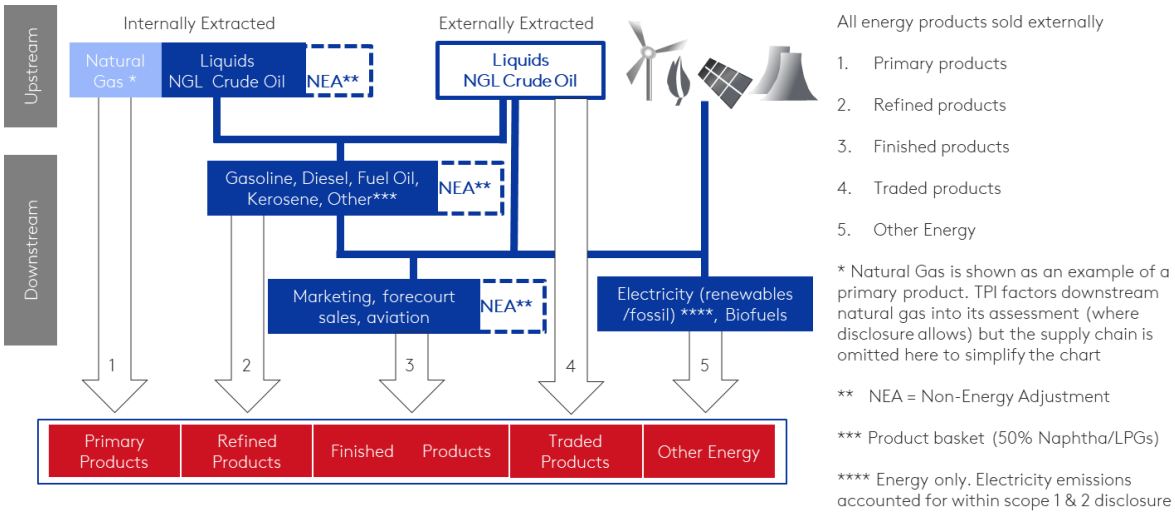
Companies disclose production/sales outputs in a range of different units that must be converted into a consistent measure of energy (MJ). Typically output is disclosed in either: (1) volume – barrels, cubic meters/feet etc. for gas and liquids; (2) weight – tons/tonnes etc.; (3) energy – Boe, BTU, MWh etc. of heat, electricity.

We convert the amount of product sold into a unit of energy using the IPCC's net calorific values for each energy product category.(*4*) Assigning an appropriate IPCC category to a company's energy product is relatively straightforward in most cases, but wherever there is some ambiguity, we reference IPCC's product category definitions to determine the most appropriate classification (see Annex 1).

Typically, companies disclose quantities sold in a unit other than weight and therefore the disclosed unit is either converted into weight or straight into joules depending on the original unit of disclosure and fuel type. For volume disclosures, we use energy density figures expressed in tonnes per barrel published by the UN. See Annex 2 for more details on the conversion ratios.(*5*)

Finally, to calculate the assessed product, all categories of energy products sold externally are added together (see Figure 1).

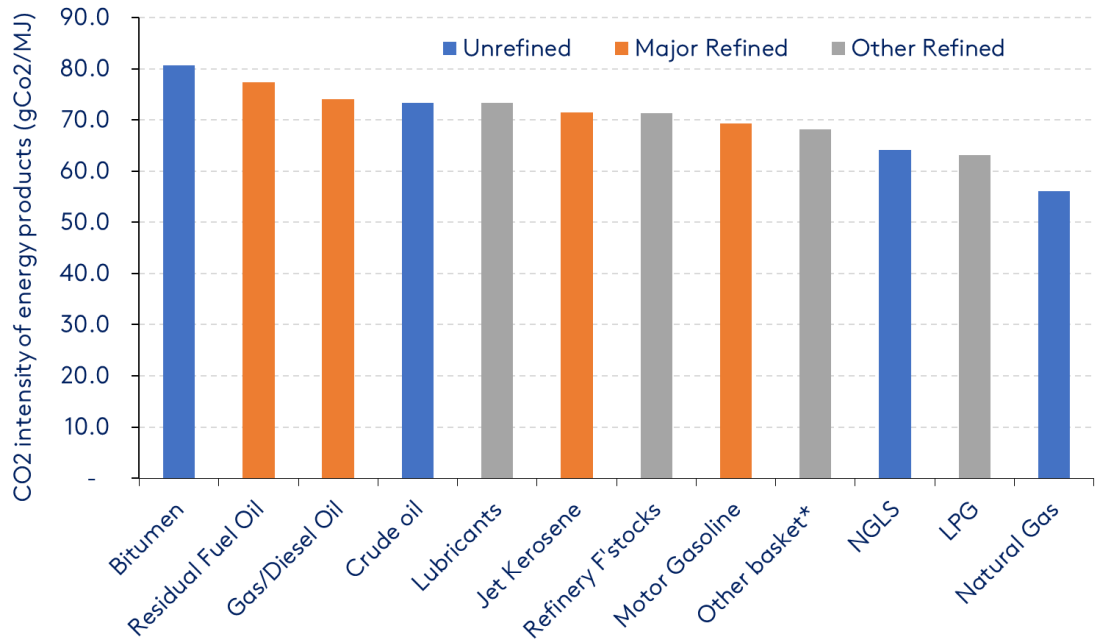
Figure 1. Schematic representation of how assessed product is calculated based on different categories of energy product and their relationship with the value chain.



Estimating Scope 3 emissions from use of sold products

While most O&G producers disclose their Scope 1 and 2 emissions, fewer currently disclose their Scope 3 use of sold product emissions and those that do provide data that are inconsistent and incomparable with other companies. Therefore we calculate emissions from use of sold products by combining data on assessed product with product-specific emissions/energy factors (see Figure 2 and Annex 2).(*4*)

Figure 2. The CO2 intensity of disclosed energy products.

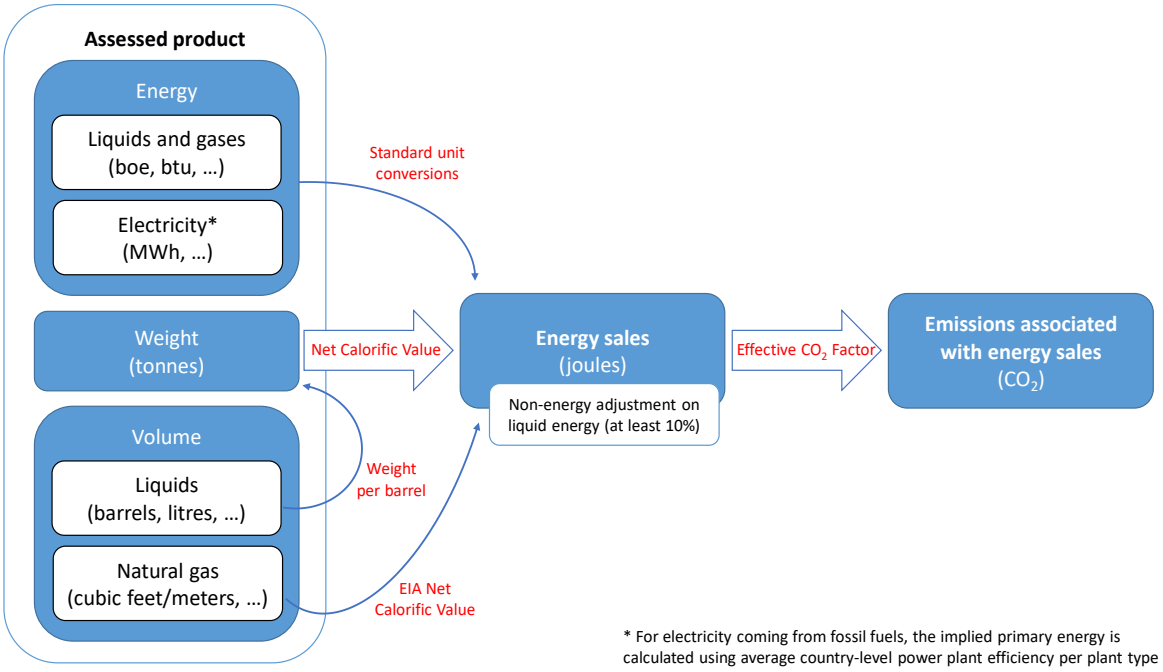


* Bitumen is classified as an energy product when it is disclosed as primary product and a non-energy product when it is disclosed as a refined product.

** Other basket is 50% naphtha and 50% LPGs based on IEA analysis of residual fuels.

After performing any necessary non-energy adjustments to the calculated amounts of energy, the energy of the remaining assessed product is converted into emissions by applying each fuel-specific emissions factor published by the IPCC. For a general schematic please refer to Figure 3.

Figure 3. Scope 3 methodology schematic



O&G companies also sell other forms of energy, most notably in the form of biofuels and electricity and heat (both from fossil fuels and renewables).

Biofuels can either be sold in their pure form or blended with refined oil products like motor gasoline. When sold in its pure form, the energy is calculated based on the appropriate energy density factor (see Annex 3) and Scope 3 emissions from use of sold products are assumed to be zero. Some companies blend their biofuel production into one or more of their finished fuels (typically motor gasoline). To obtain an estimate of Scope 3 use of sold product emissions for the company's particular blend, we proceed as follows. First, both the biofuel and the finished fuel are converted into their respective weights, if not already disclosed in a weight unit. Second, the amount of biofuel is subtracted from the amount of gasoline sold to obtain the biofuel-based 'emissions-free' proportion and the fossil-based 'emissions-intensive' proportion. Both weights are then converted into energy, but Scope 3 emissions from use of sold products are only calculated for the fossil-based proportion.

Electricity sales are usually disclosed in watt-hours. Based on average country-level power plant efficiency per fossil plant type (see Annex 4), the primary energy input implied by electricity output is calculated in joules. The primary energy equivalent of electricity is only calculated for electricity generated from fossil fuels. Electricity from renewables is taken directly and no fossil fuel equivalent is calculated, consistent with IEA methodology. If a company discloses the primary energy going into electricity generation, we prefer using those data. Associated Scope 3 use of sold product emissions are not calculated, because, regardless of whether the source of the energy is burning fossil fuels or renewables, the emissions will already be accounted for in Scope 1 and 2 disclosure.

Estimating Scope 2 emissions

In a few cases, only Scope 1 emissions are disclosed, not Scope 2. In these cases, we estimate the missing Scope 2 emissions to complete an assessment. We do this using an average ratio of Scope 1 to Scope 2 emissions computed across comparable companies. For E&P companies, the median ratio is 13% (calculated from a sample of 12) and for integrated companies the median ratio is 8% (calculated from a sample of 17).

Incomplete disclosure

Most O&G producers appear to disclose emissions from all their operations, albeit employing different reporting boundaries, but some explicitly do not, or it is unclear whether the disclosure is comprehensive. When it is either explicitly incomplete or unclear, a further assessment is made to determine whether the omission of some facilities would bias the emissions intensity assessment. Ultimately, we make judgements on a case-by-case basis as to whether a reliable assessment can be made from existing disclosures.

Coverage of target

There are various types of targets that O&G companies disclose, but they can be broadly categorised into emissions intensity targets and absolute emissions targets. Targets can cover different scopes of emissions and apply only to specific operations, or to the whole organisation. In particular, we are faced with the following permutations:

- *Absolute targets relating to operational emissions (either Scope 1 or Scope 1 and 2).* As these targets only cover part of total emissions, assumptions are required to calculate how emissions outside the scope of the target evolve. Consistent with the approach used in other TPI sectors, we assume the emissions intensity of activities outside the scope of the target remains constant at the level in the latest disclosure year. To convert an absolute emissions target into an intensity target, we make an assumption about the future growth of energy sold externally by the company. Consistent with the approach adopted in other TPI sectors, we assume that a company's energy sales grow in line with IEA's global forecasts.
- *Absolute Scope 1, 2 and 3 or Scope 3 target.* Similar to the above, we make an assumption about the future growth of energy sold externally by the company to convert an absolute emissions target into an intensity target and assume the emissions intensity of activities outside the scope of the target remains constant at the level in the latest disclosure year. If both an absolute and intensity target are

disclosed, we verify that both are consistent with/complement each other. If so, we prefer the intensity target to avoid assumptions regarding the company's future energy output. If not, further research is needed to accurately reflect a company's decarbonisation pathway.

- *Emissions intensity targets applying to Scope 1 and 2 only.* These are disclosed, or can be expressed as, percentage reductions against a base year. We apply the percentage reduction to the Scope 1 and 2 emissions intensity calculated for the designated base year and assumes Scope 3 use of sold product emissions remain constant at the intensity in the latest year of disclosure.
- *Comprehensive intensity targets including Scope 1, 2 and 3 use of sold products emissions.* These are usually expressed as percentage reductions against a base year. We apply the same percentage to our calculated intensity in the designated base year.

As mentioned, some companies set targets that only apply to Scope 1 emissions, or a part of Scope 1 emissions, as opposed to Scope 1 and 2 emissions from energy supply as a whole. In the case of a partial absolute emissions target, the target intensity for the specified part of emissions is calculated by applying the target to the emissions and dividing that by projected energy sales (calculated using the global growth projections of IEA). Further, it is assumed that the intensities of all other relevant emissions remain constant at the level in the latest year of disclosure. In case of a partial Scope 1 emissions intensity target, the total emissions intensity is calculated by applying the target to the intensity of the specified emissions and assuming that the emissions intensity of all other relevant emissions (other Scope 1, 2 and 3 emissions) remains unchanged. Additionally, some companies disclose Scope 3 targets only covering part of their energy sales. In this case, we apply the target to the Scope 1, 2 and 3 emissions of those externally sold energy products covered by the target. We assume that the intensity of energy sales not covered by the target remains the same as the level of the latest disclosure, and that the proportion of energy covered by the target compared to that not covered by the target remains constant at the level of the latest disclosure as well (i.e. the energy sales mix remains constant). Not all partial targets meet minimum requirements to reliably estimate future emissions intensities at the company level. Whether or not they do so is decided on a case-by-case basis, but the following types of target are typically insufficiently specific on a company level: product- or region-specific targets, targets expressed against an unspecified business-as-usual baseline, and targets including so-called "avoided emissions".

Some companies disclose net targets. Unlike gross targets, net targets include emissions offsets and/or negative emissions, either within company boundaries or outside. Currently, we accept both gross and net targets and do not make an explicit distinction between them. We recognise there are additional risks from relying heavily on offsetting, but in principle it is a cost-effective mechanism to reduce emissions. Moreover, no company currently discloses sufficient detail on the contribution of offsets to their overall targets to allow any adjustment, e.g. the calculation of gross targets. Some companies disclose targets that include customer actions (e.g. (*6*)). These customer actions tend to be imprecisely defined in companies' disclosures, but presumably take the form of deployment of carbon capture and storage

technology by customers or customers' purchase of offsets. Our framework does not take customers' actions into account, as there is currently is no credible and established mechanism for tracking such targets.

Some companies disclose a target range. In this case the midpoint value is used. Finally, most companies express targets relative to emissions in a base year (e.g. 2010). However, some companies disclose targets without disclosing the base year. We then assume the base year is the latest year of disclosure prior to the publication of the target.

Supplementary results

Figure 4. Pairwise correlations between covariates of GHG intensity. Each cell in the matrix explores the correlation between two factors. The distributions of the data are plotted on the diagonal. Data points are colour-coded according to region instead of sub-industry as in the main body of the paper.

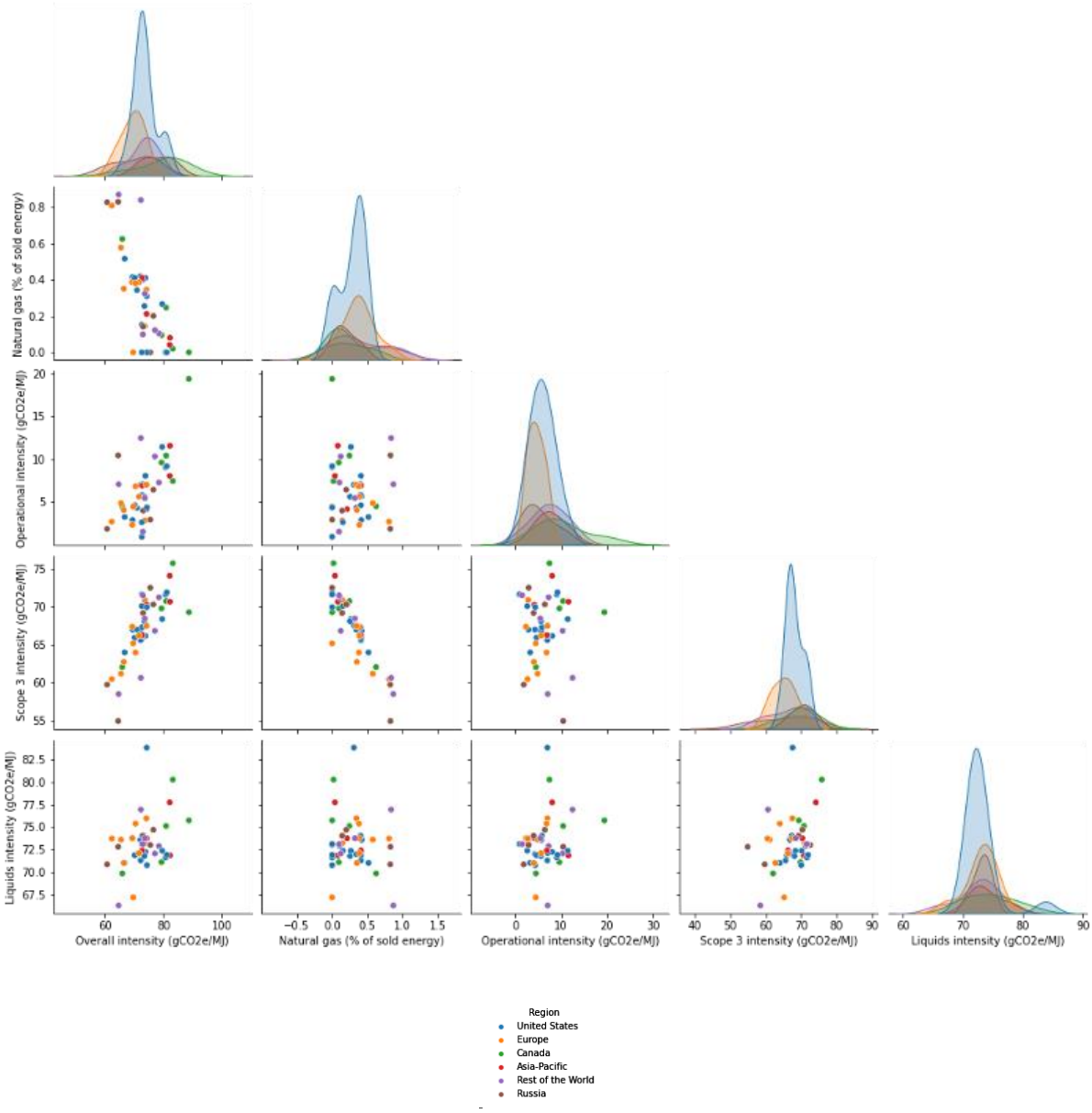
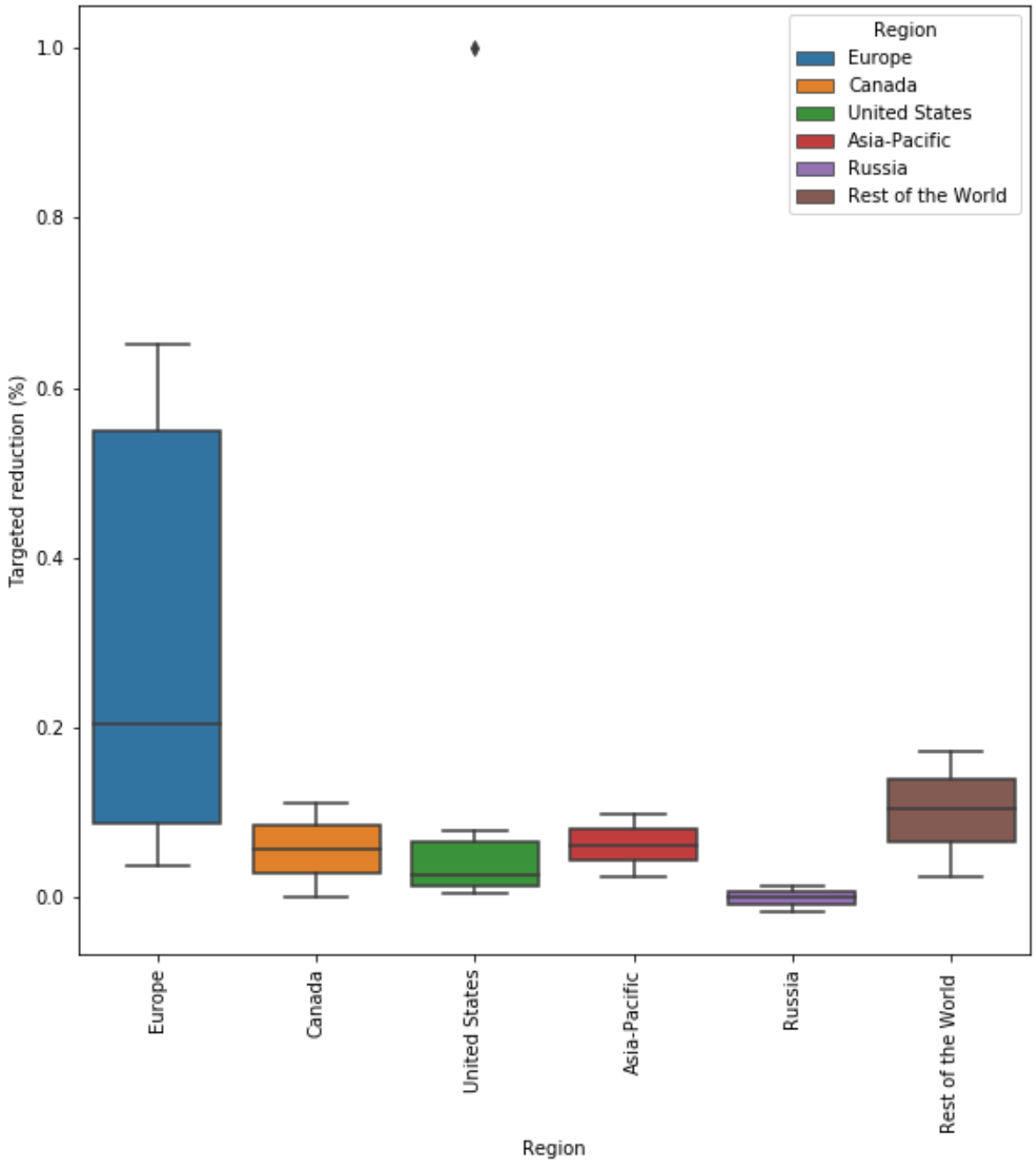


Table 1. Summary statistics of lifecycle GHG intensity disaggregated by region (gCO2/MJ).

Region	count	mean	st. dev.	min.	25%	50%	75%	max.
Asia-Pacific	4	77.86	5.04	72.78	73.89	78.20	82.17	82.23
Canada	5	79.63	8.45	65.93	79.34	80.91	83.23	88.74
Europe	9	69.24	3.88	62.34	66.45	69.67	71.64	74.16
Rest of the World	6	73.18	4.82	64.68	72.44	73.29	76.20	78.46
Russia	5	70.08	7.05	60.74	64.53	73.07	75.49	76.58
United States	17	73.52	3.83	66.72	72.10	72.74	74.28	81.15

Figure 5. Box plot showing targeted reduction by region of only those companies with explicit emissions reduction targets (N=28). The diamond is Occidental Petroleum.



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4. IPCC, “2006 IPCC Guidelines for National Greenhouse Gas Inventories” (2006).

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Annex 1. IPCC product category definitions

	IPCC definition
Crude oil	Crude oil is a mineral oil consisting of a mixture of hydrocarbons of natural origin, being yellow to black in colour, of variable density and viscosity. It also includes lease condensate (separator liquids) which are recovered from gaseous hydrocarbons in lease separation facilities.
Orimulsion	A tar-like substance that occurs naturally in Venezuela. It can be burned directly or refined into light petroleum products.
Natural Gas Liquids	NGLs are the liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. These are those portions of natural gas which are recovered as liquids in separators, field facilities, or gas processing plants. NGLs include but are not limited to ethane, propane, butane, pentane, natural gasoline and condensate. They may also include small quantities of non-hydrocarbons.
Motor Gasoline	This is light hydrocarbon oil for use in internal combustion engines such as motor vehicles, excluding aircraft. Motor gasoline is distilled between 35ºC and 215ºC and is used as a fuel for land-based spark ignition engines. Motor gasoline may include additives, oxygenates and octane enhancers, including lead compounds such as TEL (Tetraethyl lead) and TML (Tetramethyl lead).
Aviation Gasoline	Aviation gasoline is motor spirit prepared especially for aviation piston engines, with an octane number suited to the engine, a freezing point of -60ºC, and a distillation range usually within the limits of 30ºC and 180ºC.
Jet Gasoline	This includes all light hydrocarbon oils for use in aviation turbine power units. They distil between 100ºC and 250ºC. It is obtained by blending kerosenes and gasoline or naphthas in such a way that the aromatic content does not exceed 25 percent in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa. Additives can be included to improve fuel stability and combustibility.
Jet Kerosene	This is medium distillate used for aviation turbine power units. It has the same distillation characteristics and flash point as kerosene (between 150ºC and 300ºC but not generally above 250ºC). In addition, it has particular specifications (such as freezing point) which are established by the International Air Transport Association (IATA).
Other Kerosene	Kerosene comprises refined petroleum distillate intermediate in volatility between gasoline and gas/diesel oil. It is a medium oil distilling between 150ºC and 300ºC.
Shale Oil	A mineral oil extracted from oil shale.
Gas/Diesel Oil	Gas/diesel oil includes heavy gas oils. Gas oils are obtained from the lowest fraction from atmospheric distillation of crude oil, while heavy gas oils are obtained by vacuum redistillation of the residual from atmospheric distillation. Gas/diesel oil distils between 180ºC and 380ºC. Several grades are available depending on uses: diesel oil for diesel compression ignition (cars,

	trucks, marine, etc.), light heating oil for industrial and commercial uses, and other gas oil including heavy gas oils which distil between 380ºC and 540ºC and are used as petrochemical feedstocks.
Residual Fuel Oil	This heading defines oils that make up the distillation residue. It comprises all residual fuel oils, including those obtained by blending. Its kinematic viscosity is above 0.1cm2 (10 cSt) at 80ºC. The flash point is always above 50ºC and the density is always more than 0.90 kg/l.
Liquified Petroleum Gases	These are the light hydrocarbons fraction of the paraffin series, derived from refinery processes, crude oil stabilisation plants and natural gas processing plants comprising propane (C3H8) and butane (C4H10) or a combination of the two. They are normally liquefied under pressure for transportation and storage.
Ethane (used to produce plastics)	Ethane is a naturally gaseous straight-chain hydrocarbon (C2H6). It is a colourless paraffinic gas which is extracted from natural gas and refinery gas streams.
Naphtha	Naphtha is a feedstock destined either for the petrochemical industry (e.g. ethylene manufacture or aromatics production) or for gasoline production by reforming or isomerisation within the refinery. Naphtha comprises material in the 30ºC and 210ºC distillation range or part of this range.
Bitumen	Solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in colour, obtained as a residue in the distillation of crude oil, vacuum distillation of oil residues from atmospheric distillation. Bitumen is often referred to as asphalt and is primarily used for surfacing of roads and for roofing material. This category includes fluidised and cut back bitumen.
Lubricants	Lubricants are hydrocarbons produced from distillate or residue; they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.
Petroleum Coke	Petroleum coke is defined as a black solid residue, obtained mainly by cracking and carbonising of petroleum derived feedstocks, vacuum bottoms, tar and pitches in processes such as delayed coking or fluid coking. It consists mainly of carbon (90 to 95 percent) and has a low ash content. It is used as a feedstock in coke ovens for the steel industry, for heating purposes, for electrode manufacture and for production of chemicals. The two most important qualities are "green coke" and "calcinated coke". This category also includes "catalyst coke" deposited on the catalyst during refining processes: this coke is not recoverable and is usually burned as refinery fuel.
Refinery Feedstocks	A refinery feedstock is a product or a combination of products derived from crude oil and destined for further processing other than blending in the refining industry. It is transformed into one or more components and/or finished products. This definition covers those finished products imported for refinery intake and those returned from the petrochemical industry to the refining industry.

Other Oil Refinery Gas	Refinery gas is defined as non-condensable gas obtained during distillation of crude oil or treatment of oil products (e.g. cracking) in refineries. It consists mainly of hydrogen, methane, ethane and olefins. It also includes gases which are returned from the petrochemical industry.
Paraffin Wax	Saturated aliphatic hydrocarbons (with the general formula CnH2n+2). These waxes are residues extracted when dewaxing lubricant oils, and they have a crystalline structure with carbon number greater than 12. Their main characteristics are that they are colourless, odourless and translucent, with a melting point above 45ºC.
White Spirit & SBP	White spirit and SBP are refined distillate intermediates with a distillation in the naphtha/kerosene range. They are sub-divided as: i) Industrial Spirit (SBP): Light oils distilling between 30ºC and 200ºC, with a temperature difference between 5 percent volume and 90 percent volume distillation points, including losses, of not more than 60ºC. In other words, SBP is a light oil of narrower cut than motor spirit. There are 7 or 8 grades of industrial spirit, depending on the position of the cut in the distillation range defined above. ii) White Spirit: Industrial spirit with a flash point above 30ºC. The distillation range of white spirit is 135ºC to 200ºC.
Other Petroleum Products	Includes the petroleum products not classified above, for example: tar, sulphur, and grease. This category also includes aromatics (e.g. BTX or benzene, toluene and xylene) and olefins (e.g. propylene) produced within refineries.
Anthracite	Anthracite is a high rank coal used for industrial and residential applications. It has generally less than 10 percent volatile matter and a high carbon content (about 90 percent fixed carbon). Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Coking Coal	Coking coal refers to bituminous coal with a quality that allows the production of a coke suitable to support a blast furnace charge. Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Other Bituminous Coal	Other bituminous coal is used for steam raising purposes and includes all bituminous coal that is not included under coking coal. It is characterized by higher volatile matter than anthracite (more than 10 percent) and lower carbon content (less than 90 percent fixed carbon). Its gross calorific value is greater than 23 865 kJ/kg (5 700 kcal/kg) on an ash-free but moist basis.
Sub Bituminous Coal	Non-agglomerating coals with a gross calorific value between 17 435 kJ/kg (4 165 kcal/kg) and 23 865 kJ/kg (5 700 kcal/kg) containing more than 31 percent volatile matter on a dry mineral matter free basis.
Lignite	Lignite/brown coal is a non-agglomerating coal with a gross calorific value of less than 17 435 kJ/kg (4 165 kcal/kg), and greater than 31 percent volatile matter on a dry mineral matter free basis.
Oil shale and tar sands	Oil shale is an inorganic, non-porous rock containing various amounts of solid organic material that yields hydrocarbons, along with a variety of solid products, when subjected to pyrolysis (a treatment that consists of heating the rock at high temperature). Tar sands refers to sand (or porous carbonate rocks) that are naturally mixed with a viscous form of heavy crude oil sometimes referred to as bitumen. Due to its high viscosity this oil cannot be recovered through conventional recovery methods.

Brown Coal Briquettes	Brown coal briquettes (BKB) are composition fuels manufactured from lignite/brown coal, produced by briquetting under high pressure. These figures include dried lignite fines and dust.
Patent Fuel	Patent fuel is a composition fuel manufactured from hard coal fines with the addition of a binding agent. The amount of patent fuel produced may, therefore, be slightly higher than the actual amount of coal consumed in the transformation process.
Coke Over Coke and Lignite Coke	Coke oven coke is the solid product obtained from the carbonisation of coal, principally coking coal, at high temperature. It is low in moisture content and volatile matter. Also included are semi-coke, a solid product obtained from the carbonisation of coal at a low temperature, lignite coke, semi-coke made from lignite/brown coal, coke breeze and foundry coke. Coke oven coke is also known as metallurgical coke.
Gas Coke	Gas coke is a by-product of hard coal used for the production of town gas in gas works. Gas coke is used for heating purposes.
Coal Tar	The result of the destructive distillation of bituminous coal. Coal tar is the liquid by-product of the distillation of coal to make coke in the coke oven process. Coal tar can be further distilled into different organic products (e.g. benzene, toluene, naphthalene) which normally would be reported as a feedstock to the petrochemical industry.
Gas Works Gas	Gas works gas covers all types of gases produced in public utility or private plants, whose main purpose is manufacture, transport and distribution of gas. It includes gas produced by carbonization (including gas produced by coke ovens and transferred to gas works gas), by total gasification with or without enrichment with oil products (LPG, residual fuel oil, etc.), and by reforming and simple mixing of gases and/or air. It excludes blended natural gas, which is usually distributed through the natural gas grid.
Oil Works Gas	Coke oven gas?
Blast Furnace Gas	Blast furnace gas is produced during the combustion of coke in blast furnaces in the iron and steel industry. It is recovered and used as a fuel partly within the plant and partly in other steel industry processes or in power stations equipped to burn it.
Oxygen Steel Furnace Gas	Oxygen steel furnace gas is obtained as a by-product of the production of steel in an oxygen furnace and is recovered on leaving the furnace. The gas is also known as converter gas, LD gas or BOS gas.
Natural Gas	Natural gas should include blended natural gas (sometimes also referred to as Town Gas or City Gas), a high calorific value gas obtained as a blend of natural gas with other gases derived from other primary products, and usually distributed through the natural gas grid (eg coal seam methane). Blended natural gas should include substitute natural gas, a high calorific value gas, manufactured by chemical conversion of a hydrocarbon fossil fuel, where the main raw materials are: natural gas, coal, oil and oil shale.

Municipal Wastes (non-biomass fraction)	Non-biomass fraction of municipal waste includes waste produced by households, industry, hospitals and the tertiary sector which are incinerated at specific installations and used for energy purposes. Only the fraction of the fuel that is non-biodegradable should be included here.
Industrial Waste	Industrial waste consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power and that are not reported as biomass.
Waste Oils	Waste oils are used oils (e.g. waste lubricants) that are combusted for heat production.
Peat	Combustible soft, porous or compressed, sedimentary deposit of plant origin including woody material with high water content (up to 90 percent in the raw state), easily cut, can contain harder pieces of light to dark brown colour. Peat used for non-energy purposes is not included.
Wood/Wood Waste	Wood and wood waste combusted directly for energy. This category also includes wood for charcoal production but not the actual production of charcoal (this would be double counting since charcoal is a secondary product).
Sulphite lyes (black liquor)	Sulphite lyes is an alkaline spent liquor from the digesters in the production of sulphate or soda pulp during the manufacture of paper where the energy content derives from the lignin removed from the wood pulp. This fuel in its concentrated form is usually 65-70 percent solid.
Other Primary Solid Biomass	Other primary solid biomass includes plant matter used directly as fuel that is not already included in wood/wood waste or in sulphite lyes. Included are vegetal waste, animal materials/wastes and other solid biomass. This category includes non-wood inputs to charcoal production (e.g. coconut shells) but all other feedstocks for production of biofuels should be excluded.
Charcoal	Charcoal combusted as energy covers the solid residue of the destructive distillation and pyrolysis of wood and other vegetal material.
Biogasoline	Biogasoline should only contain that part of the fuel that relates to the quantities of biofuel and not to the total volume of liquids into which the biofuels are blended. This category includes bioethanol (ethanol produced from biomass and/or the biodegradable fraction of waste), biomethanol (methanol produced from biomass and/or the biodegradable fraction of waste), bioETBE (ethyl-tertio-butyl-ether produced on the basis of bioethanol: the percentage by volume of bioETBE that is calculated as biofuel is 47 percent) and bioMTBE (methyl-tertio-butyl-ether produced on the basis of biomethanol: the percentage by volume of bioMTBE that is calculated as biofuel is 36 percent).
Biodiesels	Biodiesels should only contain that part of the fuel that relates to the quantities of biofuel and not to the total volume of liquids into which the biofuels are blended. This category includes biodiesel (a methyl-ester produced from vegetable or animal oil, of diesel quality), biodimethylether (dimethylether produced from biomass), Fischer Tropsh (Fischer Tropsh produced from biomass), cold pressed bio oil (oil produced from oil seed through mechanical processing only) and all other liquid biofuels which are added to, blended with or used straight as transport diesel.

Other Liquid Biofuels	Other liquid biofuels not included in biogasoline or biodiesels.
Landfill Gas	Landfill gas is derived from the anaerobic fermentation of biomass and solid wastes in landfills and combusted to produce heat and/or power.
Slude Gas	Sludge gas is derived from the anaerobic fermentation of biomass and solid wastes from sewage and animal slurries and combusted to produce heat and/or power.
Other Biogas	Other biogas not included in landfill gas or sludge gas.
Municipal Wastes (biomass fraction)	Biomass fraction of municipal waste includes waste produced by households, industry, hospitals and the tertiary sector which are incinerated at specific installations and used for energy purposes. Only the fraction of the fuel that is biodegradable should be included here.

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Annex 2. Conversion ratios

	Net Calorific Value (TJ/Tonnes)	Effective CO_2 emissions factor (Tonnes CO_2/TJ)	Weight of a barrel of specific fuel (tonnes/barrel)	Net Calorific Value (MJ/mCF)
Source:	**IPCC, 2006**	**IPCC, 2006**	**UN, 2016**	**EIA, 2019**
Crude oil	0.042	73.3	0.137	-
Orimulsion	0.028	77.0	-	-
Natural Gas Liquids	0.044	64.2	0.096	-
Motor Gasoline	0.044	69.3	0.118	-
Aviation Gasoline	0.044	70.0	0.116	-
Jet Gasoline	0.044	70.0	0.121	-
Jet Kerosene	0.044	71.5	0.129	-
Other Kerosene	0.044	71.9	0.129	-
Shale Oil	0.038	73.3	-	-
Gas/Diesel Oil	0.043	74.1	0.138	-
Residual Fuel Oil	0.040	77.4	0.151	-
Liquified Petroleum Gases	0.047	63.1	0.086	-
Ethane (used to produce plastics)	0.046	61.6	0.059	-
Naphtha	0.044	73.3	0.114	-
Bitumen	0.040	80.7	0.165	-
Lubricants	0.040	73.3	0.143	-
Petroleum Coke	0.033	97.5	0.181	-
Refinery Feedstocks	0.043	73.3	0.135	-
Other OilRefinery Gas	0.050	57.6	0.125	-
Parafin Wax	0.040	73.3	0.127	-
White Spirit & SBP	0.040	73.3	0.129	-
Other Petroleum Products	0.040	73.3	0.145	-
Anthracite	0.027	98.3	-	-
Coking Coal	0.028	94.6	-	-
Other Bituminous Coal	0.026	94.6	-	-
Sub Bituminous Coal	0.019	96.1	-	-
Lignite	0.012	101.2	-	-
Oil shale and tar sands	0.009	106.7	-	-
Brown Coal Briquettes	0.021	97.5	-	-
Patent Fuel	0.021	97.5	-	-

Coke Over Coke and Lignite Coke	0.028	107.1	-	-
Gas Coke	0.028	80.7	-	-
Coal Tar	0.028	44.4	-	-
Gas Works Gas	0.029	44.4	-	-
Oil Works Gas	0.039	-	-	-
Blast Furnace Gas	0.002	259.6	-	-
Oxygen Steel Furnace Gas	0.007	181.9	-	-
Natural Gas	0.048	56.1	-	1,094
Municipal Wastes (non-biomass fraction)	0.010	91.7	-	-
Industrial Waste		106.3	-	-
Waste Oils	0.040	73.3	-	-
Peat	0.010	106.0	-	-
Wood/Wood Waste	0.016	111.8	-	-
Sulphite lyes (black liquor)	0.012	95.3	-	-
Other Primary Solid Biomass	0.012	100.1	-	-
Charcoal	0.030	111.8	-	-
Biogasoline	0.027	70.8	-	-
Biodiesels	0.027	70.8	-	-
Other Liquid Biofuels	0.027	79.6	-	-
Landfill Gas	0.050	54.6	-	-
Slude Gas	0.050	54.6	-	-
Other Biogas	0.050	54.6	-	-
Municipal Wastes (biomass fraction)	0.012	100.1	-	-

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Annex 3. The energy content of biofuels

	Energy density toe/tonne	Energy density Toe/cubic meter
Source:	**European Commission, 2006**	**European Commission, 2006**
Biodiesel	0.86	0.78
(Bio)ethanol	0.64	0.51

Annex 4. Power plant efficiency

Coal

Country	Average power plant efficiency (%)
Source:	**GE, 2016**
World	34%
China	35%
United States	37%
India	27%
Russia	25%
Germany	36%
South Africa	34%
Japan	37%
Korea	35%
Australia	35%
Poland	34%
Ukraine	30%
United Kingdom	38%
Indonesia	31%
Kazakhstan	30%
Taiwan	38%
Czech Republic	28%
Turkey	34%
Canada	38%
Spain	36%
Vietnam	35%

Gas

	Average power plant efficiency (%)
Source:	**GE, 2016**
World	39%
Russian Federation	26%
United States	45%
Japan	45%
Saudi Arabia	32%
Iran	43%
United Arab Emirates	34%

China	39%
Korea	44%
Egypt	45%
India	45%
Uzbekistan	28%
Mexico	45%
Thailand	45%
Turkey	45%
Algeria	38%
Belarus	28%
Italy	45%
Canada	41%
Australia	39%
Turkmenistan	25%

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278 Other

Average operating rate for selected energy sources (Bt/kwh)

Source	**EIA, 2018**
Coal	10465
Petroleum	10834
Natural Gas	7812
Nuclear	10459

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