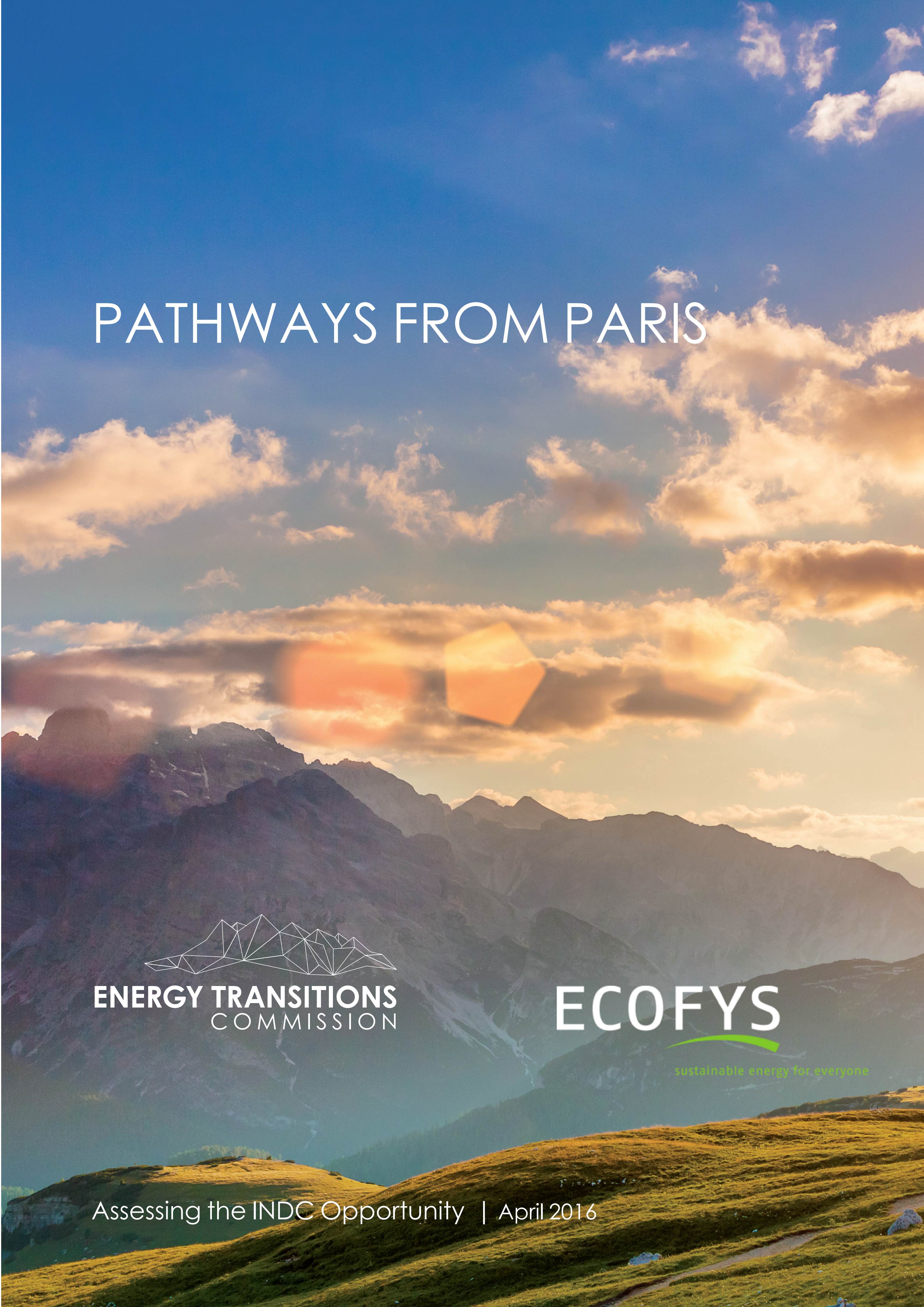


PATHWAYS FROM PARIS

ENERGY TRANSITIONS COMMISSION

ECOFYS

sustainable energy for everyone

Assessing the INDC Opportunity | April 2016

INTRODUCTION

At the 2015 United Nations international climate change conference in Paris (COP21), 195 countries agreed to limit global warming to well below 2°C and pursue efforts to limit it to 1.5°C. In advance, the participating countries submitted plans to reduce their greenhouse gas emissions – the Intended Nationally Determined Contributions (INDCs). Every five years these plans will be updated with the first update due in 2018.

A number of studies[1] have shown current INDCs will not limit global warming to well below 2°C. If fully implemented, they will set the average global temperature on a path to rise between 2.2°C and 3.4°C by 2100[2]. By 2030, emissions will need to be about 30% below those resulting from current INDCs to achieve the "well below 2°C" objective (Exhibit 1).

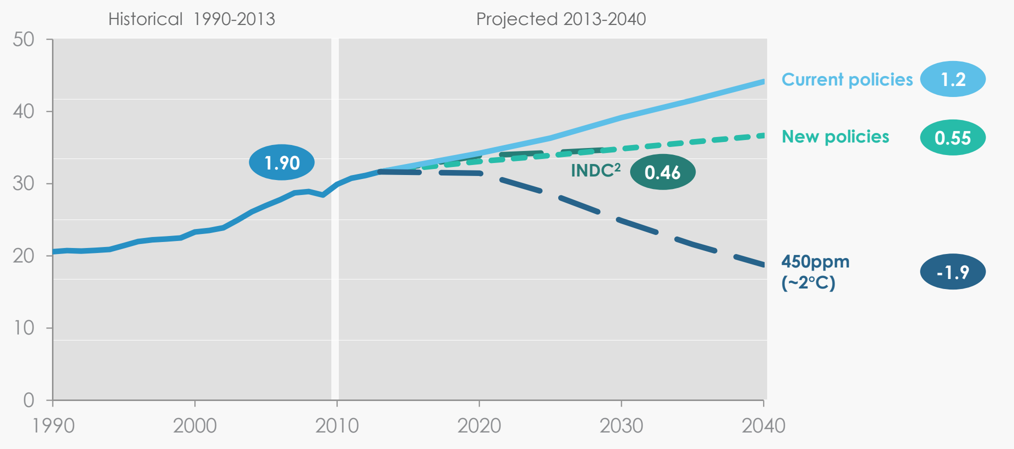
This is, however, not surprising. It is the first time that countries have been asked to develop national plans that decouple economic growth from carbon emissions to increase growth and decrease emissions. Knowledge about how to lower the costs and increase the economic benefits of low-carbon growth is relatively new and unevenly shared across the world.

In this context, understanding in detail countries' plans to transition to low-carbon societies should show where opportunities for accelerating these transitions might lie. With this in mind, the Energy Transitions Commission (ETC) asked Ecofys to analyze the INDCs of 16 countries and one region (the EU-28), which accounted for 78% of global energy-related CO_2 emissions in 2012[3]. These INDCs cover both developed and developing countries, which for the purpose of this report include emerging markets. The analysis drew on secondary sources that are defined in the Appendix; these are primarily laws, programs, and measures mentioned in the INDCs as well as data developed by other organizations that have assessed the INDCs and their planned impact. This report presents the main findings and their implications for energy decision makers.

EXHIBIT 1

Without new policies, the world is tracking for more than 2°C warming

Global energy-related CO_2 emissions in IEA climate scenarios; Gt CO_2



1 Intended Nationally Determined Contributions to CO_2 emission reductions for COP21. Average growth rate 2013-2030

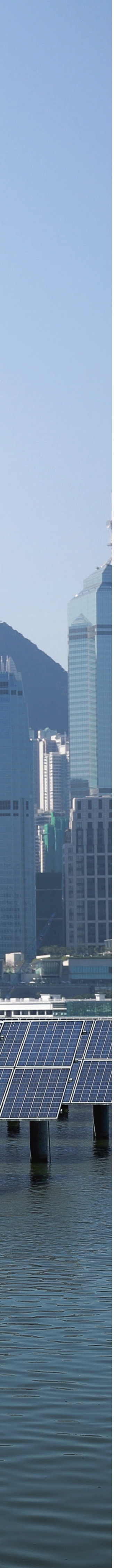
SOURCE: IEA (2014), CO_2 Emissions from Fuel Combustion; IEA (2015) World Energy Outlook; IEA (2015) World Energy Outlook Special Report on Energy and Climate Change

1 Climate Action Tracker (CAT), Australian-German Climate and Energy College (CEC), Climate Interactive, Danish Energy Agency (DEA), European Commission Joint Research Centre (EC-JRC), the International Energy Agency (IEA), London School of Economics (LSE), Massachusetts Institute of Technology (MIT), MILES Project Consortium (MILES), PBL Netherlands Environmental Assessment Agency, the UNFCCC, and the UNEP Emissions Gap Report.

2 CAT (2016) . The IPCC (2014) AR5 report projects 3.7-4.8°C. The UNEP estimates INDCs could limit temperature below 3.5°C.

3 All data and outputs can be found online at www.energy-transitions.org

The ETC aims to accelerate change towards low-carbon energy systems that enable robust economic development and limit the rise in global temperature to well below 2°C.



KEY FINDINGS

Countries have two main options for reducing their energy emissions[4]. Both options are needed and complement each other. One is to decarbonize their energy supply by increasing the share of (near) zero-carbon sources (whether in electrical power or nonelectrical energy). This could entail using renewable energy (including hydro-power and modern bio-energy), nuclear, or fossil fuels with carbon capture and storage or carbon capture and use (CCS/CCU). This can be complemented by a shift in the supply mix to less carbon-intensive fossil fuel sources. The other option is to reduce energy demand by improving energy productivity, measured by the amount of economic output gained for each unit of energy used. Pursuing this option entails introducing new production processes, technologies, and behaviors that use energy more efficiently. Both options will involve significant changes in a country's power, building, transport, industry, and agriculture sectors.

In developing their INDCs, countries were free to choose how to express their ambitions for reducing emissions and how to realize these targets. Many INDCs do not make all underlying assumptions explicit. As a result, the current INDCs are highly heterogeneous. Thus, their projected results cannot fairly be compared or aggregated. However, this analysis does reveal which levers individual countries prioritizie to reduce emissions compared to baseline (Exhibit 2), absolute changes expected in power generation capacity up to 2030, and underused policies that countries may want to make more prominent in their next INDC submissions in 2018.

As low-carbon energy technologies and policy settings continue to improve, it is reasonable to assume that future INDCs will contain even more significant decarbonization. Even since the submission of INDCs mainly in the fourth quarter of 2015, there have been positive developments especially in major developing countries. For example, in China's 13th five-year plan solar and wind energy capacity are expected to increase to 500 GW and 400 GW by 2030 respectively. This points to future opportunities for efficient, pro-growth decarbonization.

4 Beyond changes in carbon sinks through land use, land use change, and forestry (LULUCF), which are defined as non-energy levers.

Exhibit 2

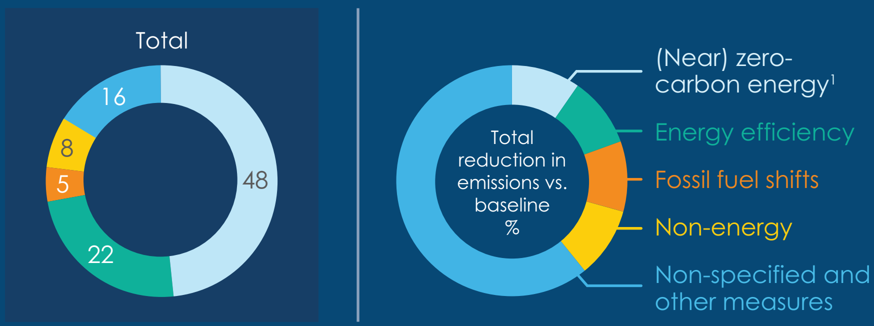
Countries prioritize different levers in their INDCs

Share in emissions reductions by 2030 compared to baseline; Percent

Note: Current policies baseline applied for US, EU and South Africa. Counterfactual emissions applied for China and India. Indonesia, Iran, Japan and Russia not shown due to data limitations. Numbers may not add up due to rounding

1 Renewables, nuclear and fossil fuels with CCS/CCU

2 There are studies that attribute a larger share of China's emissions reductions to energy efficiency. In this analysis a large share of this is already included in the baseline, which yields a larger dependence on the expansion of (near) zero-carbon energy.


Total
16
8
5
22
48
Total reduction in emissions vs. baseline %
(Near) zero-carbon energy[1]
Energy efficiency
Fossil fuel shifts
Non-energy
Non-specified and other measures


Turkey
Saudi Arabia
10
42
58
India
14
16
17
66
China[2]
20
3
9
8
81
Ethiopia
64
14
86
Vietnam
25
27
46
27
South Africa
54
13
23
7
57

Assuming the NDCs are implemented without revision, our analysis reveals five overall trends:

1. **A massive expansion in renewable electrical energy, especially in developing countries.** Worldwide, the planned aggregate increase in power generation from renewable energy is more than double the planned increase from fossil fuels. It is expected to increase by 4,400 TWh compared to a planned increase in fossil fuels of 1,800 TWh 2030. This will give renewables roughly one third of the combined power supply mix in 2030, up from 20% today. About 65% of the new renewable generation will be built in developing countries. China will increase its renewable power generation by more than the expansion in the EU, US, and Japan combined.

   The total expansion in renewables will require more than USD 2 trillion of investments over the next 15 years. This is about one third of business as usual (BaU) total power generation investments. It doubles investments in renewable energy compared to BaU[5].

   Solar and wind power alone will make up 70% of the increase in renewable capacity. Power supplies will become more variable – particularly in the EU and US, where variable renewables will make up about 29% and 20% of the power supply mix respectively[6]. We are already seeing rapid improvements in the software and hardware solutions needed to manage that variability, but will require more innovation and planning.

2. **Limited growth in natural gas power generation in developed economies and significant growth in coal-generated power in developing countries.** Natural gas-fired power generation will see a net increase of almost 1,600 TWh, but only about 480 TWh of this will be in industrialized nations, representing about 2% of their total generation. Currently planned growth in coal-fired power generation in China and India of more than 1,800 TWh will exceed the expected reduction in developed countries of about 1,400 TWh. There are however indications, based on recent trends in China of coal-fired power generation hours bottoming out, that the net increment may be less than 40% of what is currently planned and estimated in this report. Indeed, the increase in coal capacity is likely to be smaller as next rounds of INDCs accelerate the expansion of renewable capacity and introduce more stringent fossil fuel policies.

   A continuing expansion in coal-fired capacity would risk locking energy systems into rising emissions from coal-fired power, especially as there are no compensating large commitments to CCS/CCU in most INDCs. Decision makers face no easy task in defining the contribution of fossil fuels to energy transition pathways that are compatible with keeping global warming well below 2°C. Their decisions must simultaneously provide growing populations with increased energy services for economic development, avoid the economic waste of "stranded assets", enable rapid increases of low-carbon energy sources, and be compatible with further progress to total decarbonization. One often-discussed strategy is to use natural gas as a source which, compared to coal can achieve significant immediate emissions reductions provided methane leakages are limited. In shifting towards natural gas, it will also be critical to ensure that energy strategies (and resulting infrastructure build-out are compatible with progress to still lower carbon and zero-carbon energy at a later stage. However, it is notable that the INDCs actually indicate only a limited increase in natural gas capacity in developed countries.

5 Global Commission on the Economy and Climate (2014), "The New Climate Economy Technical Note – Infrastructure investment needs of a low-carbon scenario" – base case projections.

6 If the non-hydro renewable target in the US is also covered with, e.g., bio-energy, the share of solar and wind is lower.

3. **Very limited measures to decarbonize energy supply beyond the power sector.** The increase in renewables capacity will ensure significant progress in decarbonizing power. However, power on average accounts for only one third of countries' primary energy consumption today[7]. Few INDCs specify details about how to decarbonize energy supply to the transport, building or industry sectors, either directly or through increased electrification. To achieve the internationally agreed climate objectives, decision makers will need to develop policies that will ensure that transport systems, heating in buildings, and industrial processes are eventually decarbonized. Decarbonization of these sectors should progress whenever it is technologically possible and cost-effective compared with further power sector decarbonization or energy efficiency improvements. One option is to extend electrification to those sectors, once the power mix is sufficiently decarbonized.

   There is a need to expand carbon sinks such as forests, bio-energy, and CCS/CCU if mitigation plans for 2030 are not strengthened. These can help reduce emissions in the short term and will be required in the long term to achieve zero-net emissions. There are significant opportunities in developing countries to strengthen these sinks, and a large number of INDCs include concrete goals in the forest sector. Very few refer to CCS/CCU.

4. **Average energy productivity to improve by 1.8% a year, but with large variations.** This estimated improvement will mainly result from China and India's better performance achieved through greater energy efficiency and a structural shift from industry to less energy-intensive sectors. This is a large improvement relative to historic trends. However, INDCs rarely specify how different sectors are likely to achieve these efficiencies and there are still many opportunities, through better policies (e.g., standards, energy pricing) and new technologies to drive energy productivity more systematically.

   Local improvements will also not necessarily translate into a global gain if industry shifts to less energy-efficient countries. INDCs do not address this given their focus on emissions produced within each country. Countries will need to learn more from each other and coordinate better to achieve a global net improvement in energy productivity. We need measures that accurately compare levels of energy efficiency in power, industry, buildings, and transport sectors across geographies. These would make it easier to identify the most effective means by which energy productivity could be increased and energy demand reduced, whilst improving living standards at the same time. Developing such measures is difficult, but should be a priority.

5. **One fifth of the total emissions reductions depends on international financial support and technology transfer to seven developing countries.** 100% of the planned emissions reductions of Ethiopia and India are described as being contingent on some degree of international financial support, as do about 70% of Vietnam, 60% of Nigeria, and 30 to 50% of Argentina, Indonesia, and Mexico. This points to the critical importance of strengthening mechanisms for international capital mobilization, such as the multilateral development banks and specialized 'climate finance' mechanisms. Development banks can provide technical support for the development of sustainable infrastructure sectoral plans (and project pipeline development), together with long-term finance that can help to mitigate investment risk, crowding in private sector finance. Strengthening the international architecture for mobilizing and allocating long-term finance to the right kind of infrastructure. Energy systems and urban development (which drives structural demand through transport and buildings) will be critical to the next 15 years of low-carbon growth.

7 Enerdata (2015), "Final consumption by energy source, Mtoe".

TRACKING PROGRESS

The ETC's Energy Transitions Matrix (Exhibit 3) presents in simplified terms what the world needs to do to meet both required energy expansion and action to reduce emissions: improve energy productivity and decarbonize To limit global warming to well below 2°C at least 3% annual improvement in the average global energy productivity is needed up to 2050. And, the share of zero-carbon energy in the overall system requires an increase of at least 1 percentage point per annum between now and 2050.

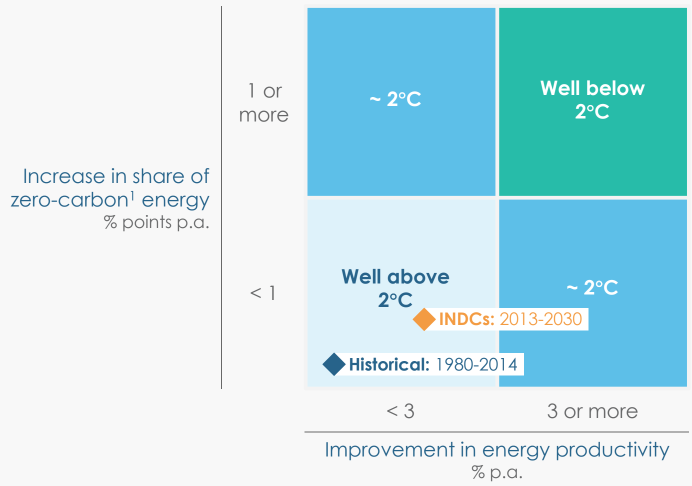
Implementing the analyzed INDCs in their current form in full would result in a greenhouse gas emissions reductions of 10 $GtCO_2e$ by 2030, achieved through an average yearly increase of 0.4 percentage points in the share of zero-carbon energy in the countries' combined total primary energy supply and a yearly average improvement in their combined energy productivity of 1.8%. This is not enough. It leaves the world in the bottom left of the matrix, and thus on a path towards warming significantly above 2°C. An additional 7 to 24 $GtCO_2e$ are needed to remain well below 2°C[9].

The fundamental challenge that the world faces is how to move to the top right of the matrix. To do this, it needs to build on and refine the newly established INDC process. The first step, attempted initially in this paper, is to understand the different assumptions, policies, and priorities implicit in the countries' INDCs. The next is to achieve greater standardization of baselines and targets, and to develop comparable measures of efficiency. This will help identify further opportunities for cost-effective improvements in both supply decarbonization and energy productivity improvements, enabling over time a sequence of INDC revisions that can move us towards a space compatible with warming well below 2°C.

EXHIBIT 3

Energy productivity and the share of zero-carbon energy will drive overall system change

Global primary energy demand, 2012-2050



1 We include here renewables, nuclear, biomass and fossil fuels if and when their use can be decarbonized through carbon capture and use or storage (CCS/CCU). However, if a large share of the increase is from CCUS, a higher share is required since this does not reduce emissions to zero completely

SOURCE: Enerdata (2015), Historic actuals

8 For a derivation and more details, see the ETC (2016) Position Paper: "Shaping Energy Transitions"

9 CAT (2016).

Implementing the analyzed INDCs in full would result in an average yearly increase of 0.4 percentage points in the share of zero-carbon energy and a yearly average productivity improvement of 1.8%, below the required 1 percentage point and 3% to remain well below 2°C.

DETAILED RESULTS

The INDCs differ greatly in their level of ambition, scope, specificity, and underlying baseline assumptions.

The 17 INDCs analyzed together represent about 78% of the global energy-related carbon-dioxide emissions in 2012 (Exhibit 4). However, the individual INDCs vary signficantly making a fair comparison and aggregation difficult. We rather focus on the individual INDCs, complementing these with underlying country policy documents and previous analyses such as by the International Energy Association (IEA)[10].

In our analysis, we remain as far as possible true to the content of the INDCs, e.g., to the baseline and targets that the countries have chosen. Some countries compare their projected 2030 emissions to those of a specific year (e.g., US and Europe) or to a hypothetical BaU baseline (e.g., Argentina and Mexico). Others express their goal as an energy intensity target (e.g., China and India in CO_2e/GDP). Other types of targets include the proportion of non-fossil energy supply in the supply mix or the size of carbon sink represented by forests. In some cases, we had to construct a baseline based on other current policy estimates (Exhibit 5) and translate zero-emission targets into comparable results using assumptions on, e.g., economic growth rates.

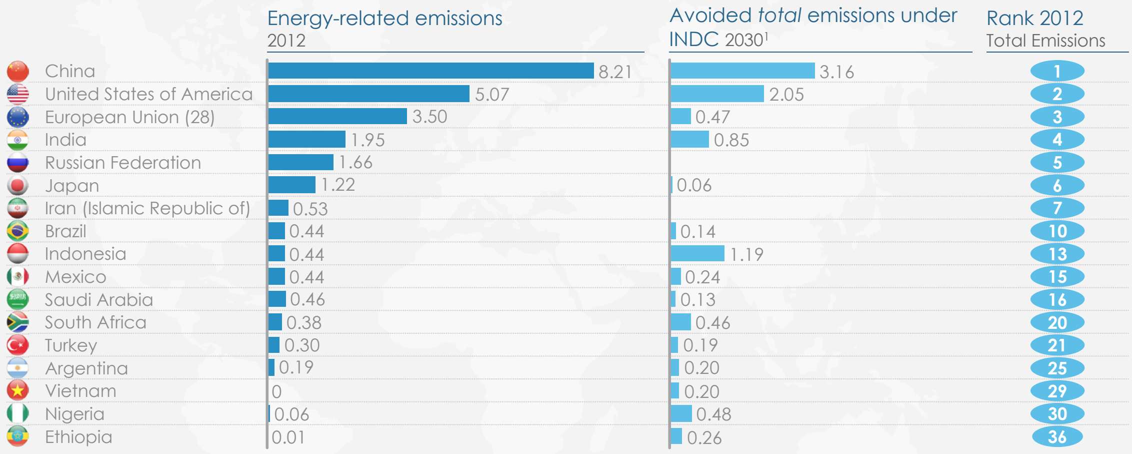
The effort countries will need to make to meet their targets depends on their baseline. For example, the baselines of Nigeria, Vietnam, Ethiopia, and Turkey are the 2030 emission level – which assumes strong economic growth from now until then (Exhibit 6). If these countries grow at lower rates than those assumed, they will be more likely to achieve their emissions reductions targets without having taken targeted action. Comparison of INDC targets against IEA Current Policies Scenarios shows that some countries will need to implement many new policies to

10 Scenarios have been used that are consistent with the trends expected under realization of INDCs. These include Current and New Policies scenarios from the 2015 World Energy Outlook and the INDC scenarios for selected countries that were published mid-2015.
IEA (2015) World Energy Outlook 2015; IEA (2015) Energy and Climate Change WEO Special Report; WRI (2015) Interpreting INDCs: Assessing Transparency of Post-2020 Greenhouse Gas Emissions Targets for Eight Top-Emitting Economies.

EXHIBIT 4

INDCs of 17 countries were assessed, representing 78% of global energy-related emissions

$GtCO_2e$



1 Calculated as aggregate avoided emissions of all measures specified in INDC. Avoided emissions include LULUCF emissions for Indonesia, Mexico, South Africa, Vietnam and Ethiopia

achieve their targets, while others are already on the way because of policies they have already enacted. For example, in the US, the means of achieving about one third of the emissions reductions remains unspecified so the country will have to implement many new policies to meet its target. In contrast, the EU has defined emissions reductions policies up to 2020 and is developing policies for the subsequent period. Likewise, in China and India, a large number of relevant policies are already in place and thus are not included in the impact of the INDC.

Hence, many countries will need new policies and stronger political commitment to achieve their INDC targets. In addition, of the 17 INDCs analyzed, seven countries have conditional targets. This makes about one fifth of the total emissions reductions (2 $GtCO_2e$) contingent on international financial support and technology transfer[11].

The different baselines and economic growth projections, as well as different degrees to which implementation policies are already in place, make it essential to be careful when comparing the different means by which countries intend to achieve their objectives. However, disaggregating each country's INDCs does give a clear understanding of what that country's main policy levers are and the magnitude of the energy transitions that are ahead of us.

We hope that this analysis, and the data that can be found at www.energy-transitions.org will be a usefull basis for further research.

11 According to the CAT, globally, 2.5 $GtCO_2e$ of total emissions reductions intended in INDCs depends on international financial support and technology transfer.

EXHIBIT 5

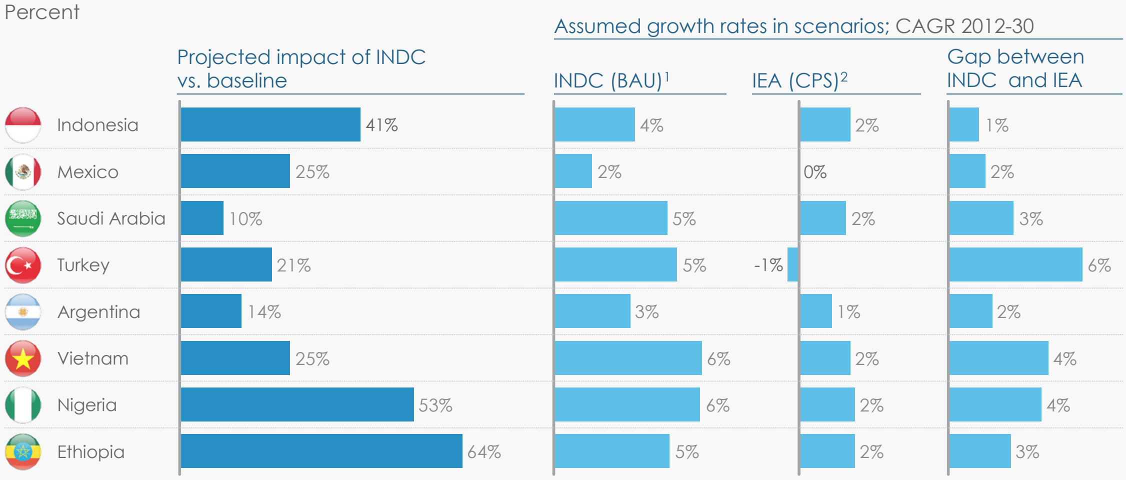
To assess the size of the levers, different baselines were used. Consequently, comparison of countries requires care

Country	Reference INDC	Baseline used to calculate levers
Russia	1990	None
Japan	2013	Relative to 2013 emissions
US	2005	US State current policies ex. the CPP & new LDV standards
EU	1990	EU's own baseline (2013), including policies until 2020
Brazil	2005	Current policies estimated by the Climate Action Tracker
Indonesia	BAU	BAU from INDC
Mexico	BAU	BAU from INDC
Saudi Arabia	BAU	BAU estimated by the Climate Action Tracker
Turkey	BAU	BAU estimated by the Climate Action Tracker
Argentina	BAU	BAU from INDC
Vietnam	BAU	BAU from INDC
Nigeria	BAU	BAU from INDC
Ethiopia	BAU	BAU from INDC
South Africa	Absolute	Current policies from South African Mitigation Report
Iran	BAU	None
China	2005	Counterfactual: INDC levels in line with current policies
India	2005	Counterfactual: INDC levels in line with current policies

EXHIBIT 6

Vietnam, Nigeria and Ethiopia have high baseline growth rates, making it easier to reach their INDCs when economic growth slows

Percent



1 Including LULUCF for Indonesia, Mexico, Vietnam, Ethiopia . Excludes process emissions for Vietnam
2 IEA provides region growth rates only. Refers to CO2 emissions from fuel combustion only

Expanding zero-carbon electrical sources of energy[12] is the most clearly specified emissions reductions lever in current INDCs. It accounts for about 48% of the total emissions countries plan to avoid (Exhibits 7 and 8).

Overall, the amount of electricity generated from renewable energy sources will more than double to about 8,000 TWh in 2030 compared to 3,600 TWh in 2013[13]. Electricity from renewables will increase its share in total electricity generation from 21% today to 32% by 2030, and account for 4.4 $GtCO_2e$ of avoided emissions. Solar PV will account for 750 TWh of this growth and wind for 1,760 TWh. Renewables thereby outpace fossil fuel growth in the power sector with an increase in annual capacity of 30 GW for solar (10% CAGR) and 40 GW for wind (7% CAGR) until 2030, compared to the 24 GW per year (0.8% CAGR) for fossil fuels[14].Most of the remaining new renewable capacity will come from hydro. This growth in power from renewable sources stems from a planned total increase in renewable capacity of 126% between 2013 and 2030, compared to about 80% over the past 15 years[15].

Most INDCs do not quantify the total investment required to expand their renewable energy as planned. However, our estimates point to a combined investment of at least USD 2 trillion over the next 15 years[16]. This is about one third of the total amount that would be invested in power generation in a BaU scenario and double the amount that would be invested in renewables in BaU[17]. Our investment estimates are higher than the IPCC's, which put cumulative worldwide investment in renewable energy from 2013 to 2029 at USD 1.4 trillion[18].

Current INDCs yield a net increase in electricity from fossil fuels of 403 GW by 2030. Yet, their share in electricity generation will drop from 67% in 2013 to 54% in 2030[19]. Most of the growth in fossil fuel capacity will occur in developing countries, with China and India alone contributing an additional 637 GW, while most of the decrease in fossil fuels, primarily coal- and oil-fired, will occur in developed countries. The US, the EU, and Japan will together reduce their fossil fuel-fired power generation capacity by 271 GW.

Power generation from nuclear fuels will grow at the moderate pace of 8 GW a year, leading to a net increase of 133 GW by 2030 and an approximate share in power generation of 14%. Growth in nuclear electricity between 2013 and 2030 will occur mainly in China and India, which will generate an additional 93 GW and 51 GW respectively.

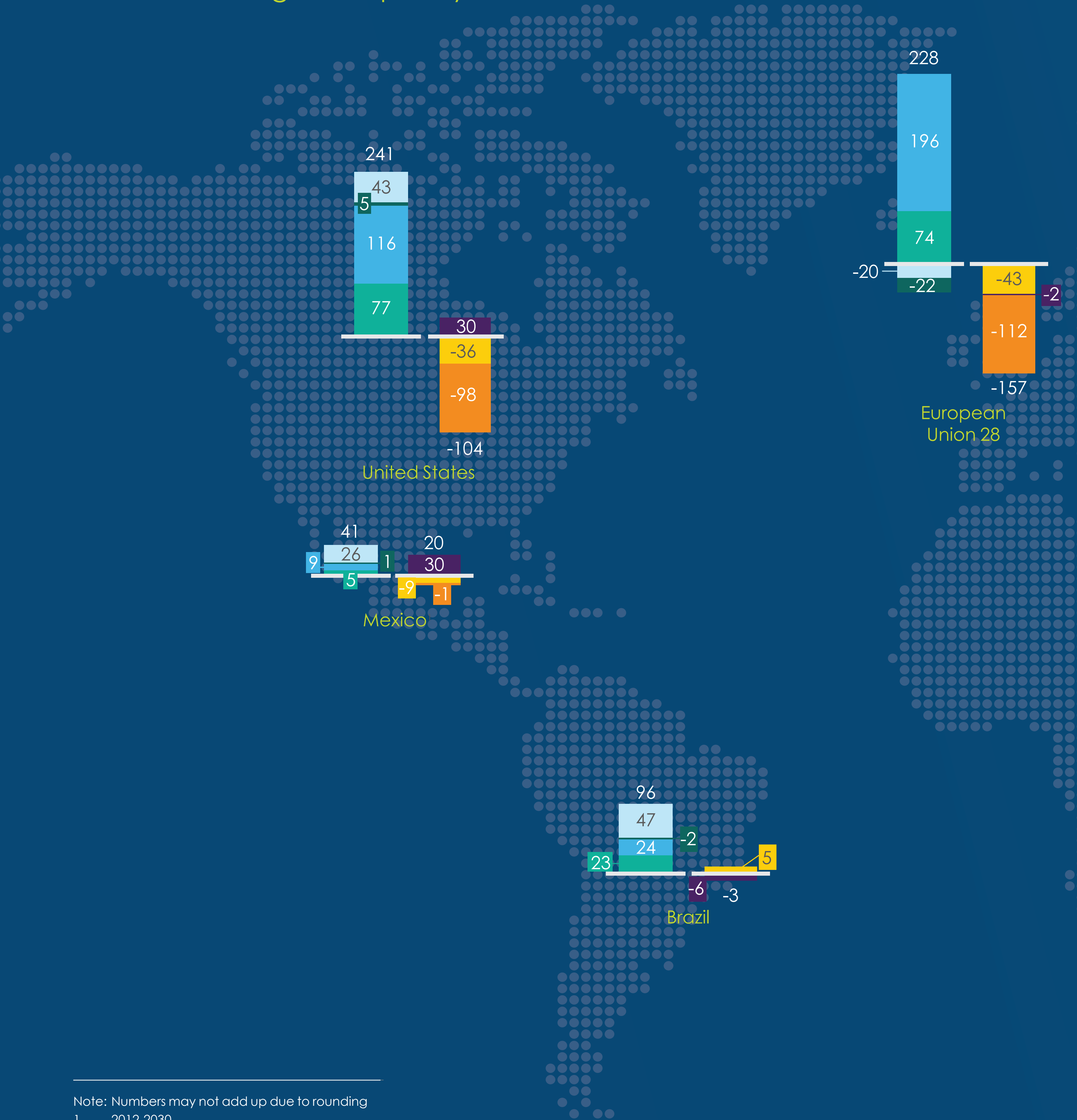
The share of intermittent renewable energy in the electricity supply mix will grow to 29% in the EU and 20% in the US by 2030[20]. This intermittent share will be even higher in some EU countries and US states. A more intermittent power supply in these areas will necessitate measures to ensure greater energy flexibility. These may include improvements in the electricity grid

12 Zero-carbon power generation includes intermittent renewables, biomass, geothermal, and nuclear.
13 Base year is 2013 for most countries. For others, it is either 2012, 2014, or 2015.
14 Growth from 2013 to 2030.
15 Enerdata (2015), historical actuals.
16 Only Ethiopia and South Africa indicate required investments. We based our investment projection on estimates of capital costs per GW installed capacity for power generation in those countries for which renewable capacity additions could be estimated. It excludes investments in electricity infrastructure or early retirement of fossil stock. For solar PV, we applied 2020 cost estimates, to reflect the sharply decreasing investment costs for this technology. Costs of hydro can vary widely: investments needed in hydropower could increase the total cumulative investments required.
17 Global Commission on the Economy and Climate (2014), "The New Climate Economy Technical Note – Infrastructure investment needs of a low-carbon scenario" – base case projections, median value.
18 Based on assessment of electricity production in China, the US, EU-28, India, Russia, Japan, Brazil, Mexico, Turkey, and Ethiopia.
19 The share in the US depends on the amount of bio-energy in the 20% non-hydro target. The IEA estimates the wind and solar PV share to reach 14%, but EIA estimates higher shares.

Exhibit 7

Zero-carbon energy sources increase ~1,600 GW compared to ~400 GW net increase in fossil fuel capacity

Absolute change in capacity between 2013 and 2030; GW



Note: Numbers may not add up due to rounding

1 2012-2030

Totals
200
150
Other Renewables
Nuclear
Wind
Solar
Oil
Natrual gas
Coal
Zero-Carbon
Fossil fuels
Country
Russia
29
12
12
1
-16
19
-4
-1
Turkey
106
78
5
13
10
22
India
246
44
51
54
97
227
5
62
160
China
732
218
93
244
177
409
122
288
Japan
57
7
6
58
-14
26
-34
-2
-10

and investments to guarantee a backup for baseload shortages, along with measures to make demand much more flexible, such as increased electrification. In other countries, the share of intermittent renewable energy in the total electricity supply will remain below 11%.

Countries' policies to encourage expansion in zero-carbon energy sources are a mix of command-and-control measures and market mechanisms. Some countries tend towards command and control, e.g., by setting concrete capacity targets. Other countries favor market mechanisms such as renewable energy certificates or support investment in renewables, e.g., through feed-in-tariffs, to make renewable energy sources a more attractive investment without setting a hard target[20].

Although current INDCs explicitly define expected expansion in renewable power capacity, they rarely specify whether and to what extent fossil fuel capacity will be phased out. Under current policies, developing countries would in fact still expand fossil fuel power capacity (Exhibits 7 and 8).

The projected net increase of electricity generated from fossil fuels of 403 GW[21] (from about 2,800 GW in 2013 to about 3,200 GW in 2030) will occur entirely in developing countries. India and China will contribute 228 GW and 409 GW respectively. However, this is what is currently planned to be installed over the next 15 years; the total is likely to be smaller as next rounds of INDCs plan for further expansion in renewable capacity, introduce more stringent reductions in fossil fuel capacity, increase efficiency, or assume more modest economic growth. On the other hand, if fossil fuel capacity does indeed continue to expand to 2030, this could cause a "lock-in" effect. If currently planned new fossil-fired power plants are not retired before the end of their lifetimes, they will continue to emit almost 2 $GtCO_2e$ a year beyond the middle of this century.

Despite the planned net increase in fossil fuel capacity, our analysis projects its share of total generating capacity to fall from 67% in 2013 to 54% in 2030. This exhibit lies between the WEO Current Policy Scenario exhibit of 64% and the exhibit from the WEO 450 ppm Scenario[22], which is 2°C compatible, of 43% (IEA, 2015).

Thus, developed countries are expecting a net reduction in power capacity generated by fossil fuel of 271 GW, driven by planned declines in coal of 212 GW in coal-fired capacity and 113 GW in oil-fired capacity. Natural gas-fired capacity in developed countries is planned to increase, but only by 54 GW, 10 times less than

20 We here do not undertake an extensive analysis of the policies driving country emissions reduction levers.

21 Based on IEA estimates in the World Energy Outlook 2015, the IEA INDC analysis, CAT data, and additional own analyses of INDCs and underlying documents (e.g., the EU's own baseline projections and impact assessment). A 292 GW increase in natural capacity, an expected 239 GW increase in coal capacity, and a 128 GW reduction in oil capacity globally underlie this net increase of 403 GW.

22 IEA (2015) World Energy Outlook 2015.

the 556 GW expansion of renewable capacity planned in the same group of countries. This shows that most of the replacement of coal-fired capacity in developed countries will come from renewables or reductions in demand rather than a shift from coal to natural gas. In the US, coal-fired capacity will be reduced by 98 GW, while natural gas-fired capacity is expected to increase by 30 GW. In the EU, both coal- and natural gas-fired capacity are projected to decline, by 112 GW and 2 GW respectively.

In developing countries, the increase in fossil fuel capacity stems mainly from coal. In India, the net increase in coal capacity is estimated to be 160 GW, while about 280 GW of new coal power capacity is now already in the pipeline[23]. China's INDC projects an increase in coal capacity of 288 GW, while 710 GW is already in the pipeline.[23] While some capacity might replace retiring capacity, there is still a risk of coal-fired plant overcapacity if all planned capacity is constructed. Natural gas capacity expands by 62 GW and 122 GW in India and China respectively, and there is a negligible change in oil capacity for power.

Coal-fired power from all the countries combined is projected to increase by only 412 TWh, while natural gas-fired power will increase by 1,592 TWh. Yet, power from coal will continue to play an important role in developing countries with their growing power demand. In 2030, it will still form 57% of India's power mix, compared to 73% in 2013, and 54% in China's, coming from 75% in 2013. However, while the share of power from coal in both countries will decrease, the amount of power produced from coal will increase along with the total amount of power generated, which is planned to increase by about 160% in India and about 70% in China.

Oil-fired power generating capacity is expected to decrease sharply to 146 TWh in 2030 from 387 TWh in 2013 across the countries analyzed. Oil's share in the power generation mix will be no more than 1% in 2030 in all countries, except for Turkey and Japan. In Japan, the share declines from 14% in 2013 to 1% in 2030; however, in Turkey it increases to 4% from 1% in 2013.

CCS/CCU are technologies which, if feasible and economic, could make perpetual fossil fuel use compatible with the well below 2°C climate objective. However, only South Africa explicitly mentions CCS in its INDC, while Mexico embeds it in the clean energy policies that underpin its INDC. The US Clean Air Act regulation governing coal plants also implicitly requires them to use CCS. However, the costs of this technology make its large-scale deployment unlikely before 2030. At most, only small-scale, pilot, and demonstration projects can be expected.

23 Permitted, Pre-permitted, announced capacity, and capacity under construction. See Global Coal Plant Tracker: http://endcoal.org/global-coal-plant-tracker/.

Exhibit 8

Renewables to increase their share in power generation, fossil fuels continue to provide more than 50%, except in Brazil, EU and Ethiopia

Power generation mix; Percent

1 Based on production levels; for some countries datapoint refers to 2012 or 2014 instead of 2013

Renewables
Nuclear
Natural gas
Oil
Coal
2013
2030
Country
Russia
18
16
48
3
15
20
21
45
12
Turkey
29
44
1
27
34
4
34
4
24
India
17
5
3
5
73
19
13
10
1
57
China
20
2
2
75
30
9
7
54
Japan
14
1
39
14
32
24
20
27
2
27
Ethiopia
99
1
100

In the six countries emitting the most carbon today, energy productivity is planned to improve by 1.8% a year on average until 2030, compared to 1.2% a year over the last 15 years[24]. However, INDCs are not specific about the demand-side measures that will lead to this improvement, particularly INDCs from developing countries (Exhibits 9 and 10).

On average, energy efficiency improvements contribute about 24% of total emissions reductions. In industrialized countries' INDCs, this is the most prominent lever for reducing energy demand in the transport, industry, and building sectors (Exhibit 9). In INDCs from the US, the EU, and Japan, using energy more efficiently contributes about 33% of total avoided emissions, compared to only 10% in China and India. These two countries do have extensive policies on energy efficiency, but are not made explicit in their INDCs, or already part of existing policies. Indeed, there are studies that attribute a larger share (~30%) of China's emissions reductions to energy efficiency, decreasing the share of (near) zero-carbon energy.

The US', EU's, and Japan's efficiency measures aim at achieving comparatively larger emissions reductions. Their combined effect will be a reduction of 960 $MtCO_2e$, while China and India's combined emissions reductions from energy efficiency, at 400 $MtCO_2e$, will account for only half that amount. Emissions reductions from energy efficiency from all the other countries will be 880 $MtCO_2e$ in total. Despite planned improvements in energy efficiency, energy consumption and associated carbon emissions will grow substantially in developing countries to 2030, driven by their strong expected economic development.

China makes an important contribution to the aggregate 1.8% boost in energy productivity (Exhibit 10). Underlying its 4.0% yearly improvement in energy productivity is a combination of efficiency improvements in the end-use sectors of its economy, particularly industry and buildings, and a structural shift from industrial to service sectors. However, this improvement is not a result of measures in China's INDC, but of policies already in place following the twelfth five-year plan launched in 2011. Moreover, as the Chinese economy continues its structural shift, more energy-intensive production may move to neighboring countries.

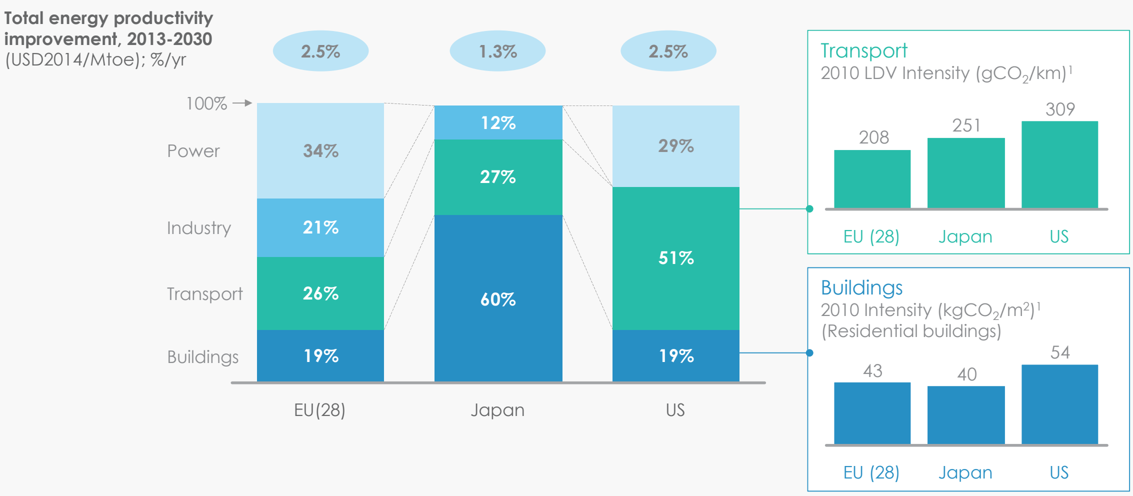
As with policies promoting renewable energy, policies to achieve energy efficiency vary in their mix of command-and-control and market mechanisms. Some policies are voluntary schemes or market-based mechanisms (e.g., India's Perform Achieve Trade scheme), while others are hard energy efficiency standards (e.g., the EU's minimum energy performance standards). Policies vary in their rigor and almost all of the emerging and developed economies have an energy efficiency law in place; however, these are not always stringently enforced. For example, fuel efficiency standards for cars in India, China, Mexico, and Brazil are less stringent than those in the US and the EU. Although details are not included in the INDCs, a comparison of the policies that underlay countries' climate contributions suggests that the same is true for building codes and minimum energy efficiency performance standards for appliances. Although some developing and emerging economies have adopted the latest, most stringent energy efficiency standards (e.g., Mexico's efficiency standards for heavy-duty vehicles are in line with those of the US), a lot more could be done.

24 Based on an assessment of the US, the EU, China, India, Russia, Japan, and Mexico, using IEA and CAT data as well as own estimates from the INDCs; selection based on availability of energy data. Energy productivity is measured here as the amount of GDP generated per unit of primary energy consumed. The average is weighted using the GDP at market exchange rates (MER). When GDP in terms of PPP is used, the contribution of China will lead to energy productivity improvement rates above 2% for the selected countries. It is, however, uncertain what the 2030 GDP MER to GDP PPP conversion rate will be.

EXHIBIT 9

Industrialized countries set different priorities for improving their energy intensity

Contribution to total energy efficiency per sector; Percent



Source: Climate Action Tracker (2016)

EXHIBIT 10

Energy productivity grows by 1.8% on average, particularly driven by improvements in the top-4 emitters (China, India, US and EU)

Annual improvement in energy productivity by country; Percent[1]

	INDC %/yr	GDP growth assumption Percent p.a.	2013 energy productivity billion USD/Mtoe[2]
China	4.0%	5.8%	5.5
India	3.0%	7.2%	8.7
USA	2.5%	2.2%	7.7
European Union (28)	2.5%	1.8%	10.7
Russian Federation	1.7%	1.9%	4.4
Japan	1.3%	0.8%	10.3
Mexico	1.1%	2.5%	10.5

Average: 1.8%

1At market exchange rates. In PPP terms, the contribution of China is larger and average energy productivity improvements could be higher
2 World Bank (2016), GDP per unit of energy use (PPP $ per kg of oil equivalent)

Addressing non energy-related emissions could help countries achieve their targets. Yet, in only a few INDCs this is a priority.

Non energy-related emissions account for more than 30% of global greenhouse gas emissions. The majority are emissions from industrial processes, methane and nitrous oxide emissions from agriculture, and emissions arising from leaks during oil and natural gas extraction and transport. China, Mexico, the US, and Ethiopia explicitly target non energy-related emissions of methane, HFCs, and black carbon in their INDCs. However, either the means to achieve them are undefined (i.e., only the US and Mexico mention a policy or program) or weak (i.e., the policy or program is aspirational and voluntary). Targets for CCS/CCU rarely exist in the INDCs. There are concrete goals for the forest sector in a large number of INDCs; however, non energy-related emissions usually take second place to energy-related emissions. Tackling those head-on could make reducing emissions by the amounts required to achieve country targets less burdensome for countries' energy sectors.

The INDCs' overall impact represents a promising first step to remaining well below 2°C. Countries can get closer to achieving this goal as they revise their INDCs for 2018.

Implementing the current INDCs will set the world on a pathway to an average warming of between 2.2°C and 3.4°C by the end of the century[25]. To remain well below 2°C, economic growth will need to be decoupled from emissions, particularly in developing countries, and developed countries will need to pursue further reductions in emissions per head (Exhibit 11). By 2030, China's emissions per head are projected to reach the same level as those of the EU today, or 45% more than the EU level in 2030. However, like India's, they will still be below those of the US', both today and in 2030. Across countries, it is important for developed countries to measure the carbon emissions resulting from imports, and to coordinate to implement policies to reduce these.

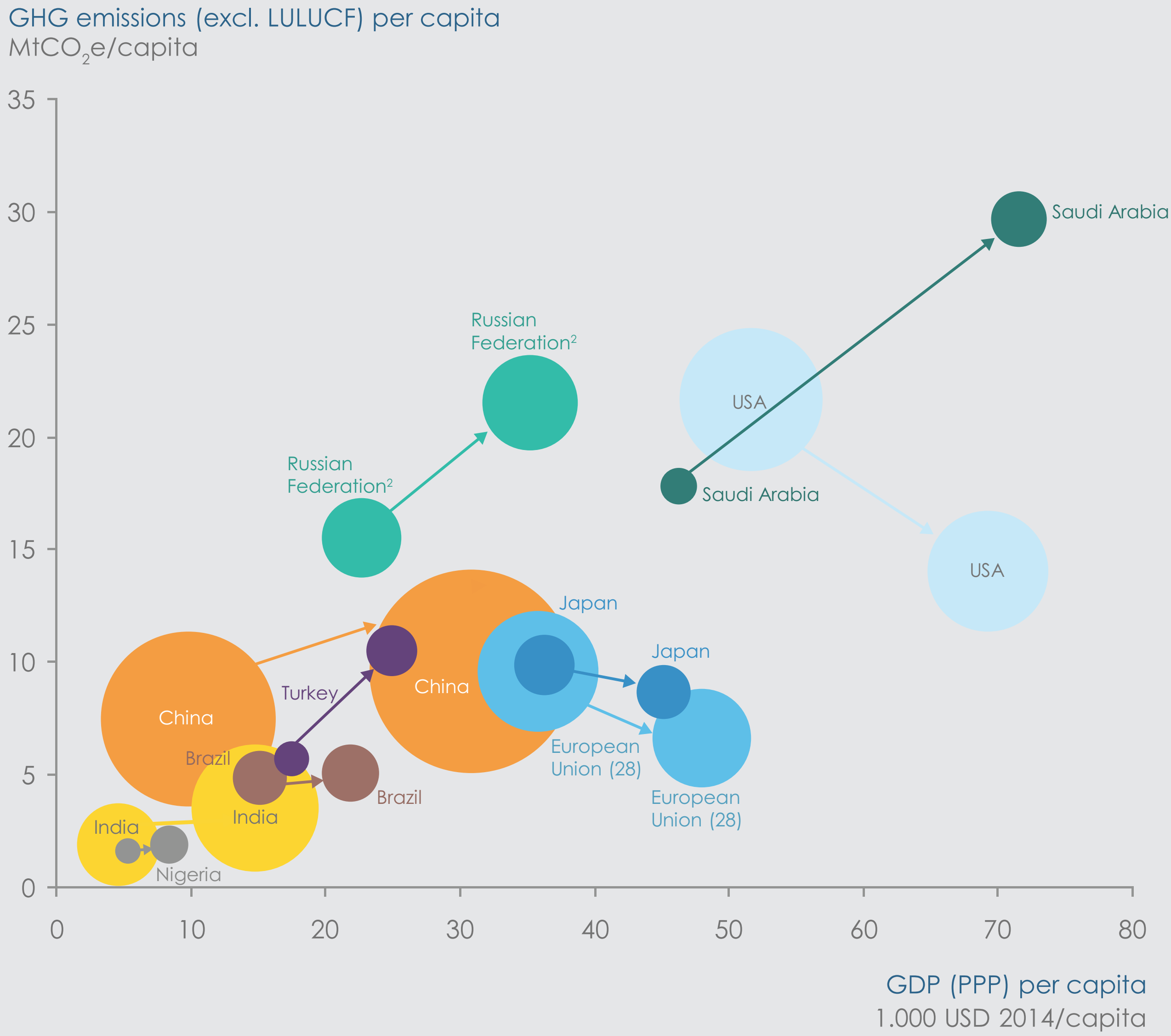
The commitments made in the INDCs represent a major step forward in terms of ambitions and the degree of international agreement achieved. This analysis revealed different opportunities for the next round of submissions in 2018. First, standardization of INDCs would facilitate tracking and cross-country coordination. Second, a number of emissions reductions levers can be further exploited to achieve the objective of limiting warming to well below 2°C. Countries that show a large growth in carbon-intensive sources such as coal could accelerate the deployment of zero-carbon electricity. Planned expansion in fossil fuel capacity could be complemented with CCS/CCU. Beyond the power sector (in buildings, transport, and industry), there is potential for accelerated action on energy productivity by adopting global best practices. The potential of alternative low-carbon energy sources (including increased low-carbon electrification) in these non-power sectors also requires more attention. The ETC expects to see further global decarbonization along these lines in the next round of INDCs.

25 According to CAT, estimates of the "emissions gap" range from 7 to 24 GtCO2e. The IPCC (2014) AR5 report projects a baseline increase in average surface temperatures by 2100 of 3.7 to 4.8°C above the 1850 to 1900 mean. The UNEP estimates that unconditional INDCs could limit the rise in global temperature below 3.5°C.

Exhibit 11

Decoupling of emissions and economic growth not yet occurring at global scale

2010-2030 development of emissions[1] per capita and GDP per capita
Size of the bubbles represents total emissions (excl. LULUCF)



1 If a country has a conditional and an unconditional INDC, the conditional INDC level is shown
2 Reflects INDC emission level. Under current policies 2030 emissions are expected to be lower

APPENDIX: SECONDARY SOURCES USED

- General (Brazil/China/India/South Africa): IEA (2015). World Energy Outlook (2015)
- General (US/Mexico): IEA (2015). "World Energy Outlook Special Report 2015: Energy and Climate Change", INDC scenarios
- European Union 28: EC (2014). "Impact assessment SWD 2014", 15 final (using the GHG40EE scenario)
- Ethiopia: CRGE, "Ethiopia's Climate-Resilient Green Economy"
- Mexico: Semarnat (2014), "Special Climate Change Program (PECC) 2014-2018"
- Turkey: (NREAP), "National Renewable Energy Action Plan"
- Vietnam: Renewable Energy Development Strategy (2015) & Socialist Republic of Viet Nam (2014). The initial biennial updated report of Viet Nam to the United Nations Framework Convention on Climate Change
- South Africa: Department of Environmental Affairs (2014), "South Africa's Greenhouse Gas (GHG) Mitigation Potential Analysis". Pretoria, Department of Environmental Affairs.
- US: EIA (2015), "Analysis of the Impacts of the Clean Power Plan"
- India: MNRE (2015), "Physical Progress (Achievements)"
- Russia: Ministry of Natural Resources and Environment (2013), "6th National Communication to the UNFCCC"
- Japan: USEPA (2012), "Global Mitigation of Non-CO_2 Greenhouse Gases", Washington, D.C., US
- Iran: Joint Research Centre (JRC) and Netherlands Environmental Assessment Agency (PBL) (2015), EDGAR database
- Brazil: IPEEC (2013), "Energy efficiency report Brazil"; Webpage (extracted 2016)
- Indonesia: State Ministry of Development Planning (2015), BAPPENAS. INDC Public Consultation
- Saudi-Arabia: King Abdullah University of Science and Technology (2014), "Appraisal and Evaluation of Energy Utilization and Efficiency in the Kingdom of Saudi Arabia"