CO-BENEFITS

of Energy Efficiency and Renewable Energy for Sustainable Development

IN MEXICO

Study Report Co-Benefits

Mexico, December 2019

IASS POTSDAM

CONECC
Conectando energía y cambio climático

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TOWARDS A JUST AND SUSTAINABLE ENERGY FUTURE FOR MEXICO

Mexico's government has affirmed the social promise of bringing greater equality and social justice to Mexican citizens. At the same time, the country has embarked on a transition to adopt clean sources of energy, which will be decisive in reducing the climate footprint of the Mexican energy sector and for unlocking a wide spectrum of social and economic opportunities for the country.

In a fruitful partnership, the Mexican Ministry of Environment and Natural Resources (Semarnat) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), in collaboration with the Institute for Advanced Sustainability Studies of Potsdam (IASS) have prepared this in-depth assessment, which examines the important social and economic co-benefits of renewable energy and energy efficiency in Mexico's energy transition, as well as suitable policy options to deliver these benefits for the people of Mexico.

We particularly highlight and acknowledge the strong dedication and active representation of the federal states of Baja California Sur, Mexico City, Oaxaca, and Yucatan, which provided important guidance on framing co-benefits assessment topics and ensuring the political relevance of the social and economic opportunities addressed.

We are also indebted to our highly valued research and knowledge partners, Ithaca Environmental and the Iniciativa Climática de México (ICM), for their unwavering commitment and dedicated work on the technical implementation of this study. The Co-benefits Mexico study at hand has been facilitated by the project Enhancing the Coherence of Climate and Energy Policies in Mexico (Conecc) of the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) through financial support from the International Climate Initiative of Germany (IKI).

Mexico, among 187 parties to date, has ratified the Paris Agreement to combat climate change and provide current and future generations with opportunities to flourish. With this study, we seek to contribute to the success of this international endeavor by offering a scientific basis for harnessing the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just energy transition, thereby making climate action a success for the planet and the people of Mexico.

We wish the reader inspiration for the important debate on a just and sustainable energy future for Mexico!

Mexico City, December 2019

Jonas Russbild

Project Director Conecc, GIZ.

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AAGR	Average Annual Growth Rate
AC	Air Conditioning
AMDEE	Mexican Association of Wind Energy *Asociación Mexicana de Energía Eólica*
ANUIES	National Association of Universities and Higher Education *Asociación Nacional de Universidades e Instituciones de Educación Superior*
Asolmex	Mexican Association of Solar Energy *Asociación Mexicana de Energía Solar*
AZEL	National Atlas of Areas with high potential for Clean Energy *Atlas Nacional de Zonas con Alto Potencial de Energías Limpias*
BAU	Business as usual
CCGT	Combined-cycle gas turbine
Cenace	National Center for Energy Control *Centro Nacional de Control de Energía*
CFE	Federal Electricity Commission *Comisión Federal de Electricidad*
Conafe	National Commission for Educational Promotion *Comisión Nacional de Fomento de Educativo*
Conecc	Coherence of Climate and Energy Policies in Mexico *Convergencia de la Política Energética y de Cambio Climático en México*
Conuee	National Commission for the Efficient Use of Energy *Comisión Nacional para el Uso Eficiente de la Energía*
CRE	Commission for Energy Regulation *Comisión Reguladora de Energía*
CSIR	Council for Scientific and Industrial Research
DAC	High domestic consumption
DNP	Distributed Node Price
DIT	Industrial demand in transmission
DIST	Industrial demand in sub-transmission
DG	Distributed Generation
DOF	Official Gazette of the Federation *Diario Oficial de la Federación*
EE	Energy Efficiency
Fide	Trust for the Saving of Electric Energy *Fideicomiso para el Ahorro de Energía Eléctrica*
FTE	Full-time equivalent
GDBT	High demand in low voltage
GDP	Gross domestic product
GDMTO	High demand in medium ordinary voltage
GDMTH	High demand of medium hourly voltage
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
GWH	Gigawatt hour
IASS	Institute for Advanced Sustainability Studies
IEA	International Energy Agency
I-JEDI	International Jobs and Economic Development Impacts
IKI	International Climate Initiative of Germany
IMSS	Mexican Institute for Social Security *Instituto Mexicano del Seguro Social*
Indaabin	National Institute of Administration and Appraisals of National Assets *Instituto Nacional de Administración y Avaluos de Bienes Nacionales*
Inifed	National Institute of Physical Education Infrastructure *Instituto Nacional de la Infraestructura Física Educativa*
INECC	National Institute for Ecology and Climate Change *Instituto Nacional de Ecología y Cambio Climático*
INEEL	National Institute for Electricity and Clean Energy *Instituto Nacional de Electricidad y Energías Limpias*
IPCC	Intergovernmental Panel on Climate Change

IPC	Istanbul Policy Centre
IPP	Independent power producers
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
ISSSTE	Institute for Social Security and Services for State Workers *Instituto de Seguridad y Servicios Sociales para Trabajadores del Estado*
LPG	Liquefied petroleum gas
LTE	Energy Transition Law *Ley de Transición Energética*
MW	Megawatt
MWH	Megawatt hour
MLTE	Goals of the Energy Transition Law *Metas de la Ley de Transición Energética*
NDC	Nationally Determined Contributions
NDP	National Development Plan
NGO	Non-governmental Organization
NREL	National Renewable Energy Laboratory
O&M	Operation & Maintenance
OECD	Organisation for Economic Cooperation and Development
PDBT	Low demand in low voltage
PEF	Federation Expenditure Budget *Presupuesto de Egresos de la Federación*
Pemex	Mexican Petroleum *Petróleos Mexicanos*
Pols	Connection points
Prodesen	National Electric System Development Program *Programa de Desarrollo del Sistema Eléctrico Nacional*
Pronase	National Program for Sustainable Energy Use *Programa Nacional para el Aprovechamiento Sustentable de la Energía*
PV	Photovoltaic
PVDG	Photovoltaic Distributed Generation
RBF	Revenue-based financing
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Program
SDG	Sustainable Development Goal
Sedema	Secretary of the Environment of Mexico City *Secretaría de Medio Ambiente de la Ciudad de México*
Sedena	Mexican Ministry of Defense *Secretaría de Defensa Nacional*
Salud	Mexican Ministry of Health *Secretaría de Salud*
Semar	Mexican Ministry of the Navy *Secretaría de Marina*
Semarnat	Mexican Ministry of Environment and Natural Resources *Secretaría de Medio Ambiente y Recursos Naturales*
Sener	Mexican Ministry of Energy *Secretaría de Energía*
SEP	Mexican Ministry of Education *Secretaría de Educación Pública*
SIN	National Interconnected System *Sistema Interconectado Nacional*
STPS	Mexican Ministry of Labor *Secretaría del Trabajo y Previsión Social*
tCO_2e	Tonnes of CO_2equivalent
TERI	The Energy and Resources Institute
TWH	Terawatt hour
UNAM	National Autonomous University of Mexico *Universidad Nacional Autónoma de México*
UNFCCC	United Nations Framework Convention on Climate Change
USD	US Dollar
ZCT	Zero Carbon Transition pathway

EXECUTIVE SUMMARY

EXPLORING THE CO-BENEFITS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY FOR SUSTAINABLE DEVELOPMENT IN MEXICO

This report explores how the co-benefits of renewable energy and energy saving measures can play an active role in connecting Mexico's energy transition with key development processes and commitments that the country has determined, for instance the National Development Plan (NDP) 2019-2024 and the climate goals, Nationally Determined Contributions (NDC), that Mexico has committed to under the Paris Agreement. The underlying study, issued in the context of the Enhancing the Coherence of Climate and Energy Policies in Mexico project (Conecc), provides quantitative evidence on the co-benefits of two energy transition pathways related to the Energy Transition Law (LTE), but with differing degrees of ambition, and indicates how the co-benefits of renewables and energy efficiency measures can play an active role in achieving national development objectives.

The term **'co-benefit'** refers to simultaneously meeting several interests or objectives resulting from a political intervention, private-sector investment, or a mix thereof (Helgenberger, S., Jänicke, M. & Gürtler, K., , 2019). In the context of climate action, the co-benefits of mitigating carbon emissions emphasize positive outcomes in other policy areas, such as air quality and health, economic prosperity and the efficient use of resources. Besides the relevance of the study for the government's commitment to increase equality and social justice for the citizens of Mexico, the co-benefits approach is also an important facilitator for overcoming policy silos and creating new policy coalitions (IASS, 2017a).

KEY STUDY FINDINGS: SOCIAL AND ECONOMIC CO-BENEFITS OF MEXICO'S ENERGY TRANSITION

The co-benefits assessment focused on three high-priority areas that were identified, in consultation with government partners and relevant stakeholder groups, as being potential social and economic opportunities connected to Mexico's energy transition and the scaling up of renewables and energy efficiency measures:

- Saving costs and generating income in public buildings with renewable energy and energy efficiency measures.
- Saving costs and generating income for local communities through renewable energy.
- Employment opportunities and future skills through renewable energy.

This co-benefits assessment report connects country-level analyses with regional evidence from case studies in the federal states of Baja California Sur, Mexico City, Oaxaca, and Yucatan. The assessment takes a policy-directed scenario approach, to connect with existing policy environments and to learn from comparing the socio-economic performance of contrasting energy transition pathways in Mexico. Two contrasting reference policy pathways have been specified as the basis of the co-benefits assessments for the period 2020 to 2050:

1. **Current policy pathway (MLTE)**, building on Mexico's LTE and drawing on the Mexican National Program for the Development of the Electricity Sector (Prodesen) of 2019.
2. **Zero Carbon Transition pathway (ZCT)**, building on Prodesen, but projected to a greater ambition in terms of decarbonizing Mexico's energy sector and the deployment of renewable energy.

Building on the study results, as well as on qualitative analyses of conversations held during a series of regional and national Enabling Policy Workshops (cf. Chapter 3) with representatives from national and sub-national governmental organizations, the report outlines potential policy options for policy makers and implementers in three high-priority areas to unlock the identified socioeconomic co-benefits. The identified policy options are distributed at national, subnational and national-subnational level.

GENERATING SAVINGS AND INCOME IN PUBLIC BUILDINGS WITH RENEWABLE ENERGY AND ENERGY EFFICIENCY MEASURES

Policy options at the national level

POLICY OPTION #1

Encouraging public buildings as role models for energy and cost savings by including them in Mexico's NDC — In light of their high GHG mitigation potential, public buildings can play an important role in the national mitigation strategy. Mitigation targets based on energy efficiency measures in public buildings could be further specified in revising Mexico's NDC. Public buildings could thereby become role models for energy and cost saving and incentivize subsequent initiatives among private building owners.

It is economically feasible to substantially reduce the carbon footprint of public buildings. The total greenhouse gas (GHG) mitigation potential of public hospitals and schools deriving from introducing energy efficiency measures combined with solar self-generation, amounts to more than 1,800 million tCO_2e annually.

By combining investment in PV self-generation and medium-level energy efficiency investments, public schools in Mexico can make a leap towards decarbonization and unleash an annual GHG mitigation potential of more than 500,000 tCO_2e , with an estimated payback period of 5 years.

POLICY OPTION #2

Incentive scheme for public schools and hospitals to create financial benefits from savings — Although schools and hospitals can achieve substantial savings in energy costs and contribute to GHG reductions at almost zero cost, these entities do not yet directly benefit from the energy cost savings, resulting in little or no incentive to implement energy efficiency measures. Public hospitals and schools are not responsible for paying their electricity costs, thereby having little incentive to implement energy efficiency measures. By exploring new payment schemes, the Ministry of Finance, in coordination with state governments, can provide additional incentives for public school and hospital administrations to engage in energy and energy cost saving measures.

Public hospitals in Mexico can save more than 900 million pesos (*USD 47 million*[1]) per year by implementing medium-level energy efficiency measures such as motion detectors for lighting, and by greater use of sun shields to reduce cooling demand. These measures would require an overall investment of around 1.8 billion pesos (*USD 94 million*), the estimated payback period of this investment being about 2 years. Through these simple measures electricity consumption in public hospitals can be reduced by 5%, representing an annual GHG mitigation potential of nearly 265,000 tCO_2e.

Public schools in Mexico can save 2 billion pesos (*USD 105 million*) per year by implementing medium-level energy efficiency measures such as motion detectors for illumination, and high-efficiency air conditioning systems. With an estimated overall investment of around 2.6 billion pesos (*USD 136 million*), the expected payback period is just over 1 year. Through these measures, electricity consumption in public schools can be reduced by almost 25%, with an annual GHG mitigation potential of more than 470,000 tCO_2e.

POLICY OPTION #3

Budget-neutral programs to cover upfront investments in energy saving — Despite the attractive return on investment of energy efficiency measures, institutional budgets might not cover the initial investment costs, which can represent an important barrier to their implementation. Climate finance programs and public/private partnerships can facilitate investments by schools and hospitals in energy saving measures and enable them to benefit from cost savings. The substantial GHG mitigation potential of combined solar energy / energy saving measures can be used as an additional argument to roll out upfront investment programs.

Public hospitals in Mexico can reduce their energy-related expenditures by 2.2 billion pesos (*USD 115 millio*n) by implementing combined energy efficiency measures and solar PV self-generation. These measures would annually mitigate almost 630,000 tCO_2e, with a payback period of 2.4 years.

Public schools in Mexico can reduce their energy consumption by more than 7% simply by introducing low- to zero-cost energy efficiency measures, such as disabling the standby mode of electronic appliances and enabling the energy-saving mode for computers. In addition to annual cost savings of around 822 million pesos (*USD 43 million*), these measures can mitigate more than of 193,000 tCO_2e annually.

Policy options at the subnational level

POLICY OPTION #4

Combined Energy Saving & Education programs — Involving students in the planning and implementation of energy saving

1 All exchange rates as of November 2019.

programs does not only contribute to an applied school curriculum, it also serves as multiplier within the students' social environments and families. To this end, a share of the cost savings can be allocated to school community budgets to co-create innovative school projects, thereby adding another incentive, particularly for 'low-hanging fruit' improvements in energy efficiency.

Policy options at the national-subnational level

POLICY OPTION #5:

Adding cost saving potential to existing monitoring schemes for energy usage — Strengthen existing efforts to monitor the energy demand and usage of public buildings. Data collection can be complemented by monitoring and disclosing related cost saving potentials for the public sector. Additional surveys and detailed audits according to building types and climatic regions will further strengthen the information base and help to specify cost-saving opportunities.

GENERATING SAVINGS AND INCOMES FOR COMMUNITIES

Policy options at the national level

POLICY OPTION #1

Reinvesting government subsidies in developing a community oriented renewable energy industry — Federal Electricity Commission (CFE), together with the Ministry of Finance, can programmatically reduce subsidies to medium and large industry in order to encourage investment in renewable energy and energy efficiency measures, while at the same time increasing economic benefits for affected consumers. Such a reinvestment program can be designed to be socially just for affected consumer groups and can gradually release federal budgets to address other investments prioritized in the social and economic program of the NDP (see Box 1 in Chapter 1).

> **CFE subsidies represent a national opportunity cost of 45.5 billion pesos** (*USD 2.3 billion*). The Medium Enterprise and Industrial Sector tariffs rank the highest at approximately 25.5 billion pesos. To put these potential savings into context, the federal budget for the second largest governmental program (Youth building the future) was 40 billion pesos during 2019 (DOF, 2018a).

POLICY OPTION #2

Tendering and licensing procedures to foster local economic participation in renewable energy projects — Tendering and licensing procedures can be revised to include regulations for project developers, mandating developers and implementers to ensuring financial participation from large-scale renewable energy projects (e.g., through levies for community funds) and inviting local shareholding and revenue-creation energy regulatory institutions to create a framework that fosters local economic benefits and local community support.

Policy options at the subnational level

POLICY OPTION #3

Communication program on local economic opportunities — The states can direct an assertive communication strategy and research-based campaign to identified end-users in municipalities and regions, communicating the potential savings, income generation, and multiple co-benefits of renewables and energy efficiency measures. Constant communication with the Agrarian Attorney General Office, which serves as the legal representative of *ejidos*[2] and communally owned land, would help to improve the relationships with local communities and include them in project implementation and economic participation.

POLICY OPTION #4

State programs to foster local shareholding and revenue creation in renewable energy projects — State governments can additionally foster local shareholding by introducing state programs to cover upfront investments for municipalities, small businesses, and households to co-invest in local renewable energy projects. These would be refinanced over time by local sharholders through a specified share of attained revenues from these projects.

Policy options at the national-subnational level

POLICY OPTION #5

Technical guidelines to facilitate distributed generation by solar PV — The Commission for Energy Regulation (CRE) can incentivize small projects by increasing the maximum limit on distributed generation (DG) from 499 kW to at least 1 MW in circuits or areas where there is installed capacity. Guidelines that facilitate collective DG, considering a collective scheme for net metering in different entry connection points (PoIs) within the same price area, or at least within the same distribution circuit, can create additional support. This option could be accompanied by a capacity building program to increase the participation of small projects and foster income generation at the sub-national and regional level.

> **By 2030, cumulative energy cost savings under the net metering scheme across all sectors in Oaxaca will have surpassed 1 billion pesos** (*USD 52 million*), with the commer-

2 Land subject to a special regime of social ownership in land tenure; such personality is constitutionally recognized and its patrimony is specially protected (Cámara de Diputados, 2014).

cial sector as the main beneficiary (more than 50%) of these savings, regardless of the energy transition pathway.

Starting from 2030, the ZCT leads to significantly higher economic benefits under the net metering scheme in Oaxaca compared to MLTE. By 2040, cumulative cost savings for all analyzed sectors in Oaxaca under the ZCT pathway would be 63% greater than those achieved through the current policy pathway, exceeding 7 billion pesos (*USD 366 million*). This figure is estimated to more than double to 17.7 billion pesos (*USD 925 million*) by 2050.

By the year 2030, domestic, commercial, medium enterprises and large industrial consumers in Oaxaca can expect economic benefits of 640 million pesos (*USD 33.5 million*) from the net billing scheme under the current policy. These benefits can be increased by more than 20% to 780 million pesos (*USD 40 million*) under an ambitious decarbonization policy environment (ZCT).

By the year 2030, under the current policy, domestic, commercial, medium enterprise, and large industrial consumers in Yucatan will benefit by 4.5 billion pesos (*USD 235 million*) under the net metering scheme. These benefits can be increased by 50% to 6.7 billion pesos (*USD 350 million*) under an ambitious decarbonization policy (ZCT), with commercial and medium enterprises being the main beneficiaries, achieving more than 90% of the cumulative cost savings.

By the year 2030, under the current policy environment, domestic, commercial, medium enterprise, and large industrial consumers in Yucatan are expected to see cumulative economic benefits of 4 billion pesos (*USD 209 million*) resulting from the net billing scheme. These benefits can be increased by more than 40% to 5.8 billion pesos (*USD 303 million*) under ZCT.

By the year 2030, the analyzed municipalities in Yucatan are estimated to accumulate 5 billion pesos from distributed PV generation through the net metering scheme under ZCT, thereby exceeding savings under MLTE by almost 50%. By the year 2040, total savings in all the analyzed municipalities under the ZCT pathway are estimated at 35 billion pesos (*USD 1.8 billion*), thereby doubling the economic benefits expected of MLTE.

GENERATING FUTURE-ORIENTED EMPLOYMENT AND SKILL DEVELOPMENT

Policy options at the national level

POLICY OPTION #1

Job creation through the accomplishment of climate and energy targets — By fully implementing the targets set in the LTE[3], Mexico will have created more than 375,000 direct and indirect job years by 2030 and more than 1 million direct and indirect job years by 2050.

POLICY OPTION #2

Achieving employment through renewable energy — In the construction phase, all renewable energy technologies outperform fossil power generation technologies, particularly wind power with more than 21 job years per installed MW, and photovoltaic distributed generation (PVDG) with around 9.5 job years per installed MW, compared to 5.5 job years for coal power and 1 job year for gas power (combined-cycle gas turbine, CCGT). In the operation & maintenance (O&M) phase, solar photovoltaic and PVDG perform particularly well, albeit at a lower overall level, with around 0.4 years per installed MW, compared to 0.14 job years for coal power, 0.08 for wind, and 0.05 job years for gas power.

POLICY OPTION #3

"Youth building the future" program on renewable energy — Targeting companies in the renewable energy industry to join forces with successful governmental welfare programs to attract young talent to the emerging industry and sending a strong message on the growing relevance of this sector. Additionally, public/private participation mechanisms can be explored, through which renewable energy projects can directly contribute to these programs.

POLICY OPTION #4

Introducing local content requirements — Tendering and licensing procedures can be revised to include regulations on using local technology components, thereby strengthening domestic industrial development and jobs (direct and indirect) across the renewable energy value chain. Additional requirements concerning local community employment can foster local employment impacts and contribute to social and economic community development. However, the design phase of these measures should investigate and consider positive as well as negative cost effects of local content and manufacturing.

Policy options at the subnational level

POLICY OPTION #5

Have the right job in the right place — The skill gap assessment shows that Mexico can cover most of the skill demand for the renewable energy sector on a national basis; however, skilled labor must be localized so that the employment needs generated by the construction and O&M of projects can be met. States with large potential for PV and wind power deployment should engage more with the private sector and educational and training institutions in order to identify the skills, knowledge, mindsets, and behaviors required by the renewables industry along the supply chain; universities should review their undergraduate programs accordingly, in order to better prepare students to join the industry.

Mexico's education and university system can meet the increasing labor demand in the renewable energy sector. Although a certain degree of labor mobility across the coun-

3 According to the LTE, Mexico should achieve 35% and 50% of electricity generation from clean energy sources (renewable energy including hydro, but also including gas power) by the year 2024 and 2050 respectively.

try can be assumed, additional analyses (e.g., analysis on the educational and skill attainment level) can provide further evidence on geographical distribution effects, in order to tailor skill development to regional demands.

Policy options at the national-subnational level

POLICY OPTION #6

Future energy transition partnerships — Advancements in renewable energy and sustainability do not only come from established actors. Sparking local innovations through contests among students and young developers — and creating renewable energy laboratories for these target groups, private companies, start-ups, and universities — can facilitate the recognition of renewable energy as a future-oriented industry in Mexico.

CO-BENEFITS AS FACILITATORS OF SUSTAINABLE DEVELOPMENT IN MEXICO: KEY POLICY OPPORTUNITIES

The Mexican Government has reiterated its commitment to transform the country and bring greater **equality and social justice to Mexican citizens.** By discussing and fostering the incorporation of renewable energy into the power generation mix and energy efficiency measures as decisive transformative actions, the country will be reducing the considerable climate footprint[4] of Mexico's energy sector, while at the same time opening up key social and economic opportunities for the country.

In line with the **National Development Plan 2019–2024 (NDP)**, federal state governments and local community leaders can spearhead community-centered energy planning to unlock local benefits, creating more equitable and democratized negotiations with local communities and fostering ownership of these projects among citizens. Recent international experiences, such as the regional Just Transition Dialogues on South Africa's energy future, can be used as impulses for shaping Mexico's energy transition.

POLICY OPPORTUNITY #1

Just Energy Transition Dialogues — Launching a dialogue series (federal and regional level) with representatives of local communities and businesses, local policy makers, and implementers, to address local opportunities as well as concerns, jointly identifying options to maximize the social benefits of renewable energy and energy efficiency projects, can be an important step in aligning Mexico's energy transition with the NDP and the government's mission to achieve greater wellbeing for everyone.

Besides **global climate action**, worldwide social and economic opportunities for welfare and prosperity have become the main drivers of continuously increasing investments in renewable energy and energy efficiency. By ratcheting up Mexico's energy transition and making the NDC a declaration of opportunity for current and future generations in Mexico, the government can both deliver on its social promises and strengthen the country's frontrunner position in global climate action.

POLICY OPPORTUNITY #2

Making co-benefits part of Mexico's NDC — Building on the introductory notion of Mexico's NDC to enable health and well-being co-benefits for the Mexican population, through its NDC revision, the government can make use of the opportunity to include a 'Co-Benefits' section that specifies and communicates the social and economic co-benefits it seeks to leverage for the country, outlining how climate action can play an active role in the government's social policy.

The **2030 Agenda for Sustainable Development** and the growing body of research on its implementation provide an analytical framework for identifying the relevant co-benefits of sectoral policies and to design policy schemes to maximize cross-sectoral co-benefits, e.g., between climate pledges, energy policies, and the NDP. On the other hand, regional exchanges (such as the 2019 Co-benefits Mexico Workshops in Baja California, Oaxaca, Mexico City, and Yucatan) can play an important role in visualizing and reaching for the Sustainable Development Goals (SDG) within local communities.

POLICY OPPORTUNITY #3

Introducing a co-benefits approach to inter-ministerial working groups— Building on the insights and impulses of the suggested regional and national energy transition dialogues, inter-ministerial working groups (such as the Inter-Ministerial Commission on Climate Change (CICC) or the Advisory Board for the Energy Transition (CCTE) can be mandated to incorporate considerations of social and economic opportunities for local communities and businesses into their policy work. With its 2030 Agenda Directorate and in view of the SDG, the Office of the Presidency can be an important facilitator in shaping cross-sectoral policy interventions.

4 Term derives from Carbon Footprint, as the amount of carbon emitted by a country in a given period of time EPA, 2017.

1. FACILITATING SOCIAL JUSTICE AND EQUALITY THROUGH MEXICO'S ENERGY TRANSITION

The Mexican Government has reiterated its commitment to transform the country and bring greater equality and social justice to Mexican citizens. At the same time, the country has embarked on a transition to clean sources of energy, which will not only be decisive in reducing the climate footprint of its energy sector but at the same time is opening up an array of social and economic opportunities. With its NDP 2019–2024, the Federal Government has set an ambitious social and economic mission to achieve greater wellbeing for all. The NDP also defines the course of Mexico's new energy policy to be guided by social and economic opportunities, amongst others, linking citizens and communities more directly with the productive and economic benefits of energy from renewable sources (DOF, 2019a, see Box 1).

The social and economic development mission is also reflected in Mexico's environmental policies to combat global warming and its resulting impacts on the country. Mexico's international commitment to reducing overall GHG emissions has been introduced with the aim of prioritizing mitigation actions that are cost-efficient and enable health and wellbeing co-benefits for the Mexican population, a notion that is also reflected in Mexico's General Climate Change Law (DOF, 2012, 2015a, 2018b, see Box 3 Mexico's key energy and climate policies: legal framework and established goals)

Consequently, current decisions on the country's climate and energy pathways will have a considerable and sustaining impact upon the country's social and economic development. The search for a sustainable energy route and politically effective decision making that can activate the different social and economic benefits required in the country boils down to one question: **How can renewable energy and energy efficiency contribute to social justice and equality for the people of Mexico?**

By assessing and comparing important co-benefits of different energy transition pathways for Mexico, this report, issued in the context of the Co-Benefits Mexico project, seeks to provide answers to this question. The term 'co-benefits' refers to simultaneously meeting several interests or objectives resulting from a political intervention, private-sector investment, or a mix thereof (Helgenberger, S., Jänicke, M. & Gürtler, K., 2019). Besides the relevance of the study for the government's commitment to increase equality and social justice for the citizens of Mexico, the co-benefits approach is also an important facilitator for overcoming policy silos and transforming traditional conflicts of interest into new policy coalitions (IASS, 2017a).

Against this background, the study seeks to provide scientifically sound and quantifiable evidence on how the co-benefits of renewables and energy efficiency measures can play an active role in achieving the objectives of the NDP, issued in 2019 by the Government of Mexico (see Box 1 below). Furthermore, the results of the co-benefits assessment indicate that both the National Electric System Development Program (Prodesen) and the LTE at the national level, together with Mexico's NDC in the context of the Paris Agreement (see Box 2 and Box 3 Mexico's key energy and climate policies: legal framework and established goals) can act as important catalysts towards achieving the development objectives set out by the Government of Mexico if the planning aligns.

With its quantification of country-specific co-benefits and drafting of policy options to unlock identified opportunities, the report also contributes to connecting this new evidence concerning the Mexican context with the evolving international co-benefits discourse on seizing the social and economic opportunities of renewables and energy efficiency in different national contexts. In this regard, the study at hand also aims to contribute to international mutual learning with countries such as South Africa and India, where relevant studies on employment opportunities and income generation for local communities have recently been published (cf. IASS/CSIR, 2019a, IASS/TERI 2019a).

The study builds on the trusted collaboration with government ministries and agencies as well as government institutions of federal states such as Baja California Sur, Oaxaca, Yucatan, and Mexico City. The involvement of these institutions together with other policymakers and implementers has been decisive in ensuring the relevance of the study and in facilitating cooperation among these organizations toward unlocking the identified co-benefits.

Box 1. National Development Plan of Mexico (2019): Mexico's social and economic objectives and the road to meet them

NATIONAL DEVELOPMENT PLAN (NDP)

In 2019 the Mexican Government published its NDP for the period of 2019 to 2024 (NDP/'Plan Nacional de Desarrollo'; DOF, 2019a) as the key planning document establishing national public policy priorities under the general objective to achieve a "Well-being Economy". It defines the social and economic mission of the Federal Government in the near horizon, including the pathway to be followed during the six-year term of the current Federal Government.

The NDP sets core objectives for social and economic development — connecting national, state, and municipal agendas and sectoral programs — and outlines the pathways necessary to meet them. There are three work areas for public policy under the NDP:

1 — Politics and Government (Justice) — Reducing corruption, reactivating justice mechanisms, guaranteeing employment, health and welfare; the full exercise of human rights, guaranteeing the construction of peace, democratic governance, and the strengthening of Mexico's political institutions; recognizing and respecting the attributions and powers that the country's legal framework grants to indigenous communities and their decision-making bodies.

2 — Social Policy (Well-being) — Building a country with well-being, guaranteeing the effective exercise of economic, social, cultural, and environmental rights, with emphasis on the reduction of inequality and vulnerability conditions of populations and territories. Promoting sustainable development, the right to a safe environment with sustainability of ecosystems, biodiversity, and heritage and biocultural landscapes; creating and promoting social welfare programs for vulnerable groups such as the program for the elderly, pension programs for people with disabilities, scholarship programs for vulnerable communities, youth building the future, rural development programs, and economic development programs (complete list in NDP, DOF, 2019a)

3 — Economic (Development) — Maintaining healthy finances in the country, supporting the energy sector and the state utility companies; strengthening of the internal market, creating permanent and well-paid jobs; promoting development in vulnerable areas of the country and supporting rural communities.

PUBLIC ENERGY POLICY UNDER THE NDP

The NDP also defines the direction of Mexico's new energy policy as well as development priorities connected to Mexico's energy transition:

The new energy policy of the Mexican State will promote sustainable development by incorporating new renewable energy schemes in local communities. This will be essential for the electrification of small, isolated communities that still lack access to electricity, which together account for approximately two million inhabitants. The energy transition will boost the emergence of a social sector that will foster the reindustrialization of the country. (DOF, 2019a, pp. 50/51, own translation).

Box 2 Mexico's GHG mitigation commitment in its Nationally Determined Contributions (NDC)

NATIONALLY DETERMINED CONTRIBUTIONS (NDC)

The Paris Agreement (effective 4th November 2016) requires Parties to put forward efforts toward GHG emissions mitigation, adaptation, and financing via NDC. Mexico submitted its contribution in March 2015 (Federal Government of Mexico, 2015), presenting targets and actions for the post-2020 period. The NDC specifies Mexico's GHG mitigation commitment as follows:

Unconditional reduction

- Mexico is committed to reduce unconditionally 25% of its GHG and short-lived climate pollutant emissions (below business as usual, BAU) for the year 2030. This commitment implies reductions of 22% for GHGs and 51% for black carbon.
- This commitment implies a net emissions peak in 2026, decoupling GHG emissions from economic growth: emission intensity per unit of Gross Domestic Product (GDP) is to be reduced by around 40% from 2013 to 2030.

Conditional reduction

- The unconditional commitment to 25% reduction, expressed above, could reach 40%, subject to a global agreement addressing important topics including: an international carbon price, carbon border adjustments, technical cooperation, and access to low-cost financial resources and technology transfer, all at a scale commensurate with the challenge of global climate change.
- Within the same conditions, GHG reductions could increase up to 36%, and black carbon reductions to 70% in 2030.

Type

- Emissions reduction relative to a business as usual baseline.
- Business as usual scenario for emission projections based on economic growth in the absence of climate change policies, starting from 2013 (first year of applicability of Mexico's General Climate Change Law).

Co-benefits

With reference to the country's General Climate Change Law, Mexico's NDC is being introduced with the aim of prioritizing actions with the most cost-efficient mitigation effect and which enable health and wellbeing co-benefits for the Mexican population (Federal Government of Mexico, 2015).

Box 3 Mexico's key energy and climate policies: Legal framework and established goals

GENERAL CLIMATE CHANGE LAW (GCCL) AND ENERGY TRANSITION LAW (LTE)

In April 2012, the Mexican Congress unanimously approved the General Law on Climate Change, which entered into force in October of that year and made Mexico the first developing country to enact a comprehensive law on this subject. Under this law, Mexico aims to reduce its emissions 50% from 2000 levels by 2050 (DOF, 2012, 2015, 2018b).

In 2015 the Mexican LTE introduced targets to develop the country's energy system in line with the emission reduction targets in the General Climate Change Law and Mexico's international GHG mitigation commitments (DOF, 2015). In terms of electricity generation, the law aims to derive 35% of energy from clean sources (renewable energy including hydro, but also including gas power) by the year 2024.[5] In 2018, an amendment to the LGCC updated the goals in order to harmonize the Mexican Climate Policy with the Paris Agreement and the NDC commitment (DOF, 2018b).

NATIONAL PROGRAM FOR THE DEVELOPMENT OF THE ELECTRIC SYSTEM (PRODESEN)

In June 2019 the Mexican Ministry of Energy (Sener) issued the most recent update of Prodesen for the period 2019–2033 (Sener, 2019). The document outlines planning considerations for the national electric system concerning electricity generation, transmission, distribution, and commercialization. With the mission to facilitate sustainable economic prosperity, the document sets objectives to meet electricity demand, to maximize power generation, and on transmission, and distribution practices.

With regard to renewable energy, the 2019 strategy to implement Prodesen during 2019–2033 foresees an increase in installed electricity generation capacity (large scale, without DG) from 20 GW in 2018 to 49 GW in 2030, further increased to 57 GW by the year 2033 within an expected total installed generation capacity of 172 GW (Sener, 2019). Besides large-scale renewable energy capacities, the program foresees additional installation of smaller scale distributed renewable energy generation of up to 28 GW (cf. Oficina de Presidencia & GIZ, 2019, Sener, 2019).

Prodesen 2019-2033 acknowledges Mexico's commitment to the United Nations Framework Convention on Climate Change (UNFCCC) and the GHG mitigation goals under the 2015 Paris Agreement. It recognizes the requirement to align national energy planning with national GHG mitigation commitments in Mexico's Nationally Determined Contribution to meet these goals (Sener, 2019). The program also acknowledges the United Nations' SDG, with emphasis on the priority objectives formulated in its NDP.

NATIONAL PROGRAM FOR SUSTAINABLE ENERGY USE (PRONASE)

In 2016, Sener and the National Commission for the Efficient Use of Energy (Conuee) published the Transition Strategy to Promote the Use of Cleaner Technologies and Fuels, as an extended part of the Pronase 2014–2018. The strategy has three main objectives: (i) set goals and create a roadmap for the implementation of the goals traced in the Transition Strategy; (ii) promote the reduction of pollutant emissions caused by the electricity industry; and (iii) reduce, under economic viability criteria, the country's dependence on fossil fuels as a primary source of energy (Sener, 2016).

The strategy is the central document for energy efficiency in Mexico and establishes as a national energy efficiency goal: 1.9% annual average reductions in the intensity of final energy consumption between 2016 and 2030, and a 3.7% annual average reduction between 2031 and 2050 (Sener, 2016). In the building sector, a potential 35% reduction in energy consumption by 2050 is identified with respect to the baseline, transport 50% and industry 41% (Conuee, 2017).

5 The 2024 target of the Energy Transition Law has been amended by a 2050 target of 50% clean electricity generation through the government's 2016 Transition Strategy towards Clean Energy Usage (Estrategia de Transición para Promover el Uso de Tecnologías y Combustibles más Limpios) (Sener, 2016).

2. SUSTAINABLE DEVELOPMENT CO-BENEFITS OF ENERGY TRANSITIONS: INTERNATIONAL IMPULSES FOR FURTHERING THE DEBATE IN MEXICO

In the accelerating global transition to the new energy world of renewables, and further driven by growing public concern over existing environmental issues and an emerging climate crisis, governments worldwide are engaged in revealing and unlocking the opportunities of the energy transition in view of domestic development strategies (see the South African example, discussed below).

The notion of co-benefits, with their strategic role for building alliances and as enablers of socially inclusive and sustainable energy transitions, has also stimulated the international political discourse around the implementation of the Paris Agreement in the context of the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations 2030 Agenda for Sustainable Development and the SDG. The emphasis on co-benefits has helped to strengthen the strategic connection between the Paris Agreement and the 2030 Agenda for Sustainable Development (cf. Helgenberger, S., Jänicke, M. & Gürtler, K.,, 2019; for Mexico see Oficina de Presidencia & GIZ, 2019). As the following examples show, climate action is being considered not only in the long term as fundamental for societal prosperity but is also harnessed as a driver of social and economic development for people in the present and near future.

Particularly in the energy sector, the social and economic co-benefits of transitioning to renewable and efficient energy provision have moved from the sidelines to the center of climate -and energy- related debates. Important co-benefits under consideration include secure and affordable power for all; mitigating conflicts over scarce resources such as water; promoting the national economy, local businesses, and jobs; increasing people's health and wellbeing; unburdening governments and freeing resources;

Figure 1. Co-benefits of renewable energy: key categories (IASS, 2017a).

as well as empowering local communities and citizens (cf. IASS, 2017a; see Figure 1)

Global assessments of energy transition co-benefits, such as the International Renewable Energy Agency (IRENA) annual review of renewable energy and jobs (see IRENA, 2019 for the most recent edition), have increased international recognition of the topic, whereas country-specific assessments are key to connecting opportunities with domestic development agendas and interests. Recently, the co-benefits of climate action in the energy sector have been assessed and specified for a number of countries, such as South Africa, India, Turkey, and Vietnam, which can prove to be useful references for facilitating social justice and equality through Mexico's energy transition:

South Africa – Household Savings: South African households and businesses can save money by investing in solar energy. Annual savings for the residential sector alone amount to more than *USD 850 million* by 2030 (IASS/CSIR, 2019a).

India — Employment Benefits: India can significantly boost employment through the power sector by increasing the share of renewables. With the government´s pledge under the NDC to scale up renewables in the country, employment through the power sector can be expected to increase by an additional 30% by 2030 (IASS/TERI, 2019a).

India — Health-Cost Benefits: India can cut economic losses related to health costs, induced by the pollutant effects of fossil fuels, by greening the economy through renewable energy sources. By following an ambitious, low-carbon energy pathway, economic losses in 2050 could be reduced by more than *USD 165 billion* (IASS/TERI, 2019b).

Turkey — Industrial Development Benefits: Turkey can substantially promote industrial development by increasing the share of renewables. With the decision of the Turkish Government to increase solar energy capacity by 60% and to more than double wind energy capacity over the next 10 years, the government paved the way for a fifteen-fold (15×) increase in the value of production along the solar value chain and more than 31% along the wind value chain in the next ten years alone (IASS/IPC, 2019).

Vietnam — Energy Access Benefits: Vietnam has tremendous potential for off-grid renewable energy systems. Deploying low-wind-speed turbines to electrify clusters in rural areas is the cheapest means of providing low-cost energy access to remote areas of Vietnam (IASS/GreenID, 2019).

Furthermore, reports on the co-benefits of energy efficiency improvements, such as the International Energy Agency's flagship report on the multiple benefits of energy efficiency (IEA, 2014; for a recent update see IEA, 2019) have also sparked international interest and can be useful sources for the national co-benefits discourse in Mexico. In the building sector, for example, measures to reduce GHG emissions and to increase the energy efficiency of buildings have led to co-benefits related to the quality of labor; improved worker productivity; and the wellbeing and health of employees (lower disease incidence, reduced mortality) (cf. Næss-Schmidt, HS, Hansen, MB, von Utfall Danielsson, C., 2012).

Besides revealing opportunities for domestic socioeconomic development and adding to the international knowledge base on potential and existing co-benefits, the international co-benefits discourse also offers insights into political action to utilize this evidence, as demonstrated by the following examples on communicating the development benefits of Vietnam's NDC, and an inclusive dialogue process on harnessing the social opportunities of South Africa's energy transition:

In Vietnam, co-benefits are being considered as important means to communicate the relevance of the country's climate action pledge for social welfare domestically. In this sense, NDCs on mitigating climate change are more than technical documents: They can be showcases for national and international audiences, demonstrating the contribution and global responsibility that a country is willing to assume in reducing its GHG emissions. In the current NDC revision process some countries such as Vietnam have decided that their NDC should also be a means to communicate how climate action can simultaneously leverage social and economic opportunities for their countries, by including a 'Co-Benefits' section in their NDC. Besides rallying domestic support for climate action, this can spark imitation and contribute to building global momentum and stronger alliances for ambitious and early climate action (IASS, 2018).

In South Africa the government's National Planning Commission initiated a broad stakeholder dialogue in 2018, on *Pathways for a Just Transition*, with the aim of plotting different pathways for transitioning to a low-carbon society while addressing the triple challenges of reducing poverty and inequality and creating jobs. Building on South Africa's NDP, the nationwide and region-specific dialogues aim for a shared vision between government, labor, civil society, and business to harness the social opportunities of South Africa's energy transition as basis for a social compact (Government of South Africa, 2017, see Box 4).

By compiling these examples from countries such as South Africa, India, Turkey, Vietnam, as well as pointing to global co-benefits reviews such as the IRENA (2019) report on employment benefits, this Chapter has sought to provide relevant impulses for the domestic debate in Mexico. Policy responses, such as South Africa's Pathways for a Just Transition dialogue (further outlined in Box 4), can offer useful models for inclusive policy development, where new alliances are both possible and required. Intergovernmental dialogue and mutual learning on these issues can provide important sources of inspiration for both sides in preparing an enabling policy environment to reap the identified co-benefits. In this respect, this country-specific assessment for Mexico contributes to the international knowledge base on co-benefits and how to make use of them.

Box 4 International co-benefits case study, South Africa: Increasing social equity and justice through renewable energy.

SPOTLIGHT ON SOUTH AFRICA: INCREASING SOCIAL EQUITY AND JUSTICE THROUGH RENEWABLE ENERGY

Prioritize renewables in developing South Africa's power generation capacities

The Integrated Resource Plan (IRP) is the government's key energy sector planning document. IRP revisions seek to take into account ongoing developments concerning energy demand, the costs of different energy sources, as well as the country's social and economic development agenda, outlined in its NDP.

In its most recent revision, the IRP 2019 has continued past trends by giving renewable energy a pivotal position in developing new power generation capacities and substituting old, inefficient ones. The IRP 2019 has identified the requirement for at least an additional 14.4 GW of wind and 6.0 GW of solar PV by 2030 amongst a range of other newly-build capacity including coal, gas, imported hydro, and storage (CSIR, 2019). In comparison to previous drafts, IRP 2019 has given energy generation from wind and solar PV, as well as storage capacities, priority over coal power in building new generation capacities in the coming years.

Reaping socio-economic development benefits in South Africa's energy planning

The Renewable Energy Independent Power Producer Procurement Program (REIPPPP) procures new generation capacity from renewable energy. This has provided opportunities for the private sector to participate in the energy generation business, a function that was long reserved for the national power utility. The introduction of private sector generation is contributing greatly to the diversification of both the supply and nature of energy production, assisting in the introduction of new skills and new investment into the industry, and enabling the benchmarking of performance and pricing (Government of South Africa, 2016).

The Department of Energy recognized an opportunity for the REIPPPP to have a positive socio-economic impact, including in the communities where projects are located. Bidders are required to identify the needs of communities neighboring project sites and to formulate strategies on how such needs could be met by utilizing the projects' mandatory socio-economic development contributions (cf. Figure 2). At the bidding stage, independent power producers (IPP) are required to commit not less than 1% of their total project budget to local community development and should aim to reach a target of 1.5%.

South Africa's 'Pathways for a Just Transition' dialogue

South Africa's National Development Plan 2030 was prepared by the National Planning Commission (NPC) and adopted by the Parliament in 2012 as the country's long-term vision and detailed blueprint for eliminating poverty and reducing inequality by the year 2030 (Government of South Africa, 2012). Priority themes within the NDP include education and future-oriented skill development, sustainable human settlements and improved quality of household life, a healthy life for all South Africans, as well protecting and enhancing the country's environmental assets and natural resources (*ibid*.).

In view of South Africa's energy transition the NPC has formulated three specific developmental objectives (Government of South Africa, 2018):

1. Economic growth and development through adequate investment in energy infrastructure. The sector should provide reliable and efficient energy services at competitive rates, while supporting economic growth through job creation.
2. Social equity through expanded access to energy at affordable tariffs and through targeted, sustainable subsidies for needy households.
3. Environmental sustainability through efforts to reduce pollution and mitigate the effects of climate change.

To meet these development objectives and to harness the social opportunities of South Africa's energy transition in a politically inclusive process, South Africa's National Planning Commission in 2018 initiated a broad stakeholder dialogue on *Pathways for a Just Transitio*n.

The framework was developed by the trade union movement to encompass a range of social interventions needed to secure workers' jobs and livelihoods when economies are shifting to sustainable production, including avoiding climate change, protecting biodiversity and ending war, among other challenges (Government of South Africa, 2017).

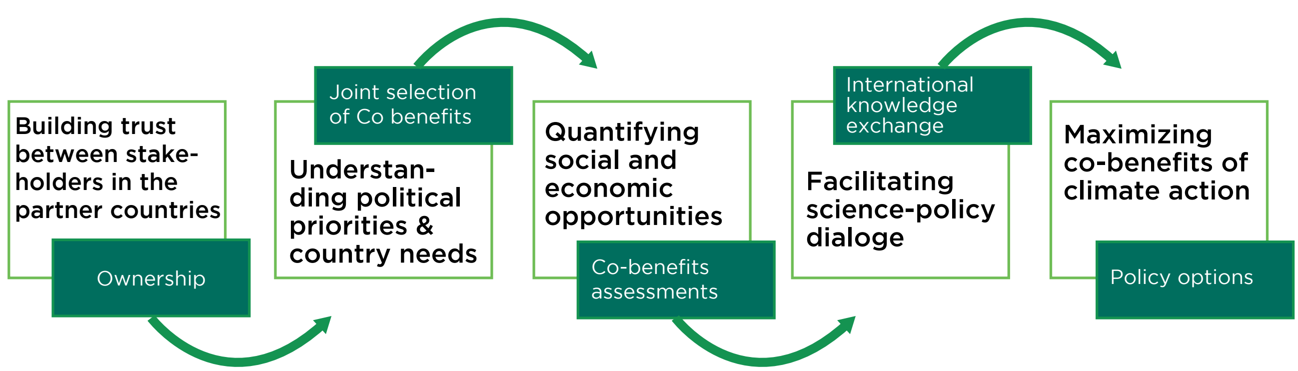
Nationwide and region-specific dialogues were conducted during 2018–2019, aiming to develop a shared vision between government, labor, civil society, and business as basis for a social compact (*ibid*.). The results of the Just Transition Dialogues are expected to be presented along with the results of country-specific co-benefits assessments in early 2020.

3. STRATEGIC CO-BENEFITS ASSESSMENT APPROACH FOR MEXICO

Co-benefits assessments represent systematic analyses of social and economic impacts and opportunities associated with specific policy interventions. With the aim of building policy and action coalitions across sectors, the 'Strategic Co-Benefit Assessments' approach addresses specific interests associated with particular social and economic co-benefits. They focus on specific opportunities that unfold within a timeframe relevant to the specific interest groups or countries (IASS, 2017a; Helgenberger, S., Jänicke, M. & Gürtler, K., 2019).

The particular aim of the study is to provide policy makers and implementers in Mexico's federal and state governments with scientific impulses to identify and unlock the social and economic opportunities of Mexico's energy transition to achieving national development targets. The political relevance of the results, the consent of political partners to the process, as well as the ownership and capacity to act on the results, are key factors in achieving this aim. Subsequently, the consultative feature of the strategic co-benefits assessment approach for Mexico shall be briefly outlined, to better understand the project co-design and knowledge co-creation process among representatives from science, policy making and implementation.

Figure 2 Strategic Co-Benefits Assessment Approach for Mexico



CO-BENEFITS SELECTION AND DEFINITION OF CASE STUDIES (NATIONAL WORKSHOP)

By prioritizing and specifying co-benefits for the Mexican context, this phase provided the basis for suitable and applicable country specific assessments of co-benefits. By connecting opportunities with the political interests of the stakeholders involved, the phase of co-benefits selection and prioritization also defined an important starting point for building alliances across different policy agendas.

In September 2018, the first phase of research and dialogue with key stakeholders[6], such as research centers, experts, organizations, and public institutions — at federal state and local levels — took place, with the aim of elaborating a deep analysis of renewable energies, energy efficiency, and existing studies on co-benefits in Mexico. This analysis helped identify relevant actors for orga-

6 For an overview of participating organizations during the consultation process see Annex Table 1 National and federal state government organizations and additional stakeholders involved in the study co-design and knowledge co-creation (in alphabetic order).

nizing an initial workshop — a process of institutional exchange and co-benefits dialogue that sought to identify priority co-benefits for Mexico, on a national and local scale. The workshop took place on 30th October 2018, and more than 15 public and private sector institutions and NGOs took part. The workshop contributed to identifying and prioritizing the potential social and economic co-benefits of energy efficiency and renewable energy. Furthermore, through a participative process, three regional case studies were identified (see Table 1).

CO-BENEFITS ASSESSMENT: INCREASING RELEVANCE AND APPLICABILITY (REGIONAL WORKSHOPS)

To ensure scientific robustness, a specific assessment method was defined for each co-benefit and the political context in which it should be assessed. Hence, assessment methods will differ depending on the country and region where the studies are conducted; the availability and access to information; connections to social agendas; and the necessities, features, and priorities of the country or specific region (for an overview of existing methods see IASS, 2017b). The methods adapted and applied to the context of the Co-Benefits Mexico study are outlined in Chapter 5 of this report.

Already at an intermediate stage of the assessment process, preliminary findings were shared and discussed with political representatives as well as further stakeholders at the case study level. Co-Benefits Mexico workshops took place in June 2019 at La Paz, Baja California Sur; Mexico City; Merida, Yucatan; and Oaxaca de Juarez, Oaxaca.

The direct feedback from participants, the questions they raised, local knowledge shared, as well as analysis of the discussions among participants, provided important input for concluding the assessment process reflected in the creating an enabling environment sections of Chapter 5.

CO-BENEFITS ENABLERS (NATIONAL WORKSHOP)

Policy makers and implementers create enabling policy environments that allow unlocking the identified co-benefits for people, businesses, and communities; both at national and sub-national levels. The third consultative step of the co-benefits assessment process in Mexico aimed to enabling policy options with the view of policy design and implementation. The national-level co-benefits workshop held in August 2019 allowed a wide range of participants from the public sector (national and sub-national levels), academia, and the private sector to contribute their experiences and ideas towards unlocking the identified co-benefits for Mexico, which fed into the 'enabling environment' sections in Chapter 5.

Table 1 Selected co-benefits and case studies

Selected Co-benefits	Co-benefits Case
Saving costs and generating income in public buildings (hospital and schools) with renewable energy and energy efficiency measures	Mexico City and La Paz, Baja California Sur
Saving costs and generating income for local communities through renewable energy	Oaxaca and Yucatan
Employment opportunities and future skills through renewable energy	Mexico (national analysis), Oaxaca, and Yucatan

4.ENERGY TRANSITION PATHWAYS DEVELOPED FOR THE STUDY

The co-benefits assessment takes a policy-directed scenario approach, connecting projections to existing policy environments and learning by contrasting the socioeconomic performance of various potential energy transition pathways in Mexico.

The reference policy pathways, as the scenarios are called in this context, have been developed and selected in consultation with federal and state government organizations, building on prior consultation with national experts and knowledge partners from science and research. The development of reference policy pathways has been guided by two design principles:

- Connectivity and comparability with Mexico's official climate and energy policies, strategies, or roadmaps (existing or considered) to ensure the political relevance and usability of the assessment results.
- Suitability as calculation basis for scientifically sound, quantitative assessments of socio-economic impacts.

Following this rationale, two contrasting reference policy pathways were specified as the basis for co-benefits assessments for the period 2020 to 2050:

a. Current policy pathway (MLTE), building on Mexico's LTE and drawing on the Mexican National Program for the Development of the Electricity Sector (Prodesen) of 2019, elaborated by SENER (SENER, 2019, Table 2).

b. Zero Carbon Transition pathway (ZCT), building on Prodesen, but with a more ambitious decarbonization of Mexico's energy sector and stronger deployment of renewable energies.

Table 2 Prodesen 2019 - 2033: key reference numbers

Capacity additions	Solar PV and wind power additions are 20.6 GW and 13.2 GW respectively, representing over 33.8 GW of new capacity installed by 2033.
New clean energy additions	39.3 GW of new clean energy capacity installed by 2033 (under the Planning Scenario).
Total clean energy installed capacity	64.6 GW of total clean energy installed capacity by 2033.
Average annual growth in electricity demand	Planning Scenario from Prodesen 2019 – 2033, 3.1% annual growth between 2019 and 2033.
Load factors	The approach considers historic trends for DG and caps capacity at 28 GW. The trend to 2033 is exponential rather than linear.
Retirement of plants	No retirement of plants in Prodesen 2019–2033 and natural retirement of plants are considered after 2033. 76,85 MW in MLTE and 79,85 in ZCT by 2049.

Sener, 2019.

CURRENT POLICY PATHWAY: MLTE SCENARIO BUILDING ON PRODESEN 2019

This pathway aims for the 2050 target of 50% clean electricity generation, stemming from the government's 2016 Transition Strategy to Promote the Use of Cleaner Technologies and Fuels mandated by the LTE (DOF, 2015). The scenario uses additions included in Prodesen 2019 (see Table 2). When building the MLTE scenario to 2050, different assumptions must be applied from 2034 to 2050, since Prodesen only considers the energy planning of the country to 2033.

The projection from 2034 to 2050 consists of an estimation that normalizes the MLTE scenario to meet a 50% share of clean electricity generation by 2050. In order to reach this clean energy goal, the MLTE scenario projects capacity additions and retirements of power plants from year the year 2034 up to 2049, considering an annual 2,200 MW increase in wind power capacity starting in 2035 and adding a total of 35,200 MW up to 2049.

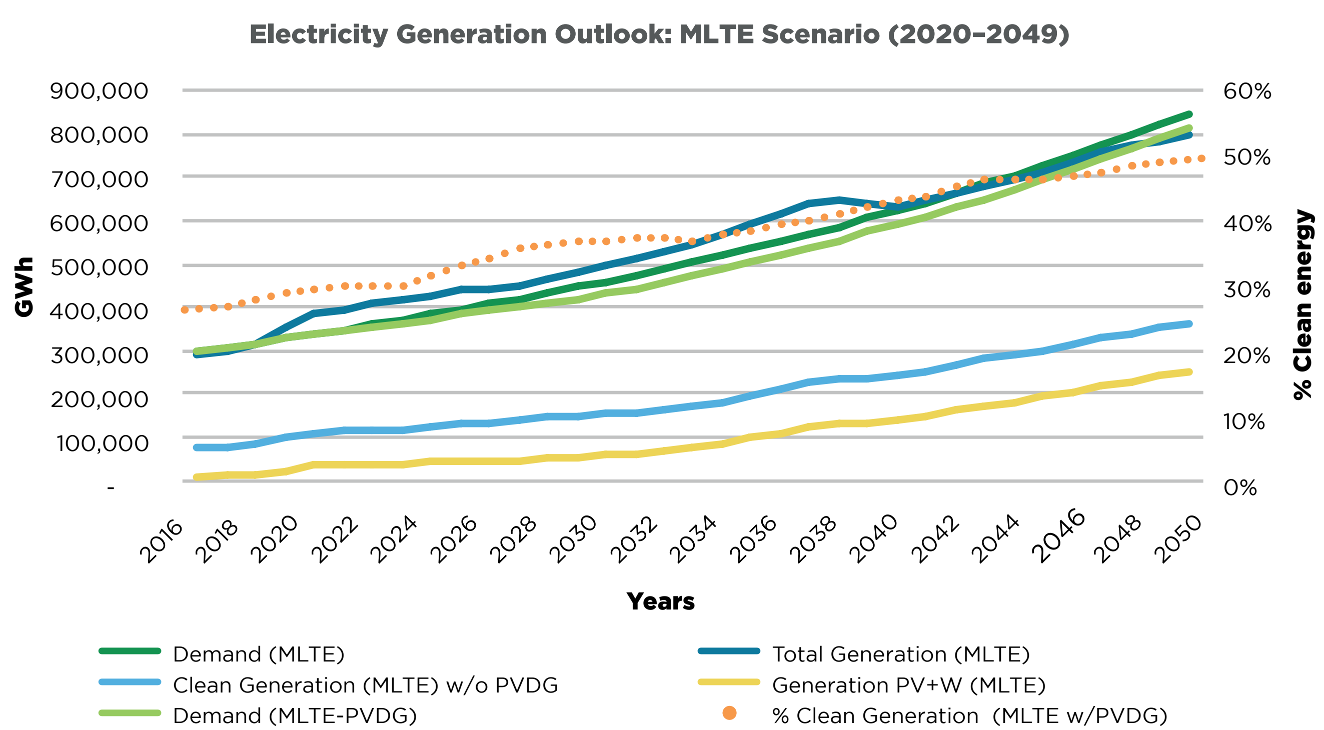
Similarly, 4,500 MW of PV power capacity per year was added between 2034 and 2036, and 6,000 MW per year until 2050 (97,500 MW total). Additional renewable sources were added for the 2034–2050 period to account for the retirement of clean energy power plants projected by Prodesen (2019) such as hydropower, geothermal, bioenergy, and efficient cogeneration, adding up to 9,864 MW by 2049. Moreover, combined cycle power capacity was added at a rate of 2,200 MW per year between 2034 and 2049, thereby adding 37,400 MW by the end of the period (cf. Figure 3). Building on expected power demand, the capacity of the General Distribution Network, with its pivotal role in boosting distributed renewable energy generation, is estimated in 28 GW across the country.

ROOM FOR MORE: ZERO CARBON TRANSITION (ZCT) SCENARIO

A more ambitious decarbonization scenario with higher renewable energy deployment was developed in order to quantify its potential co-benefits. The ZCT scenario represents a normalized projection towards generating at least 75% of electricity (GWh) from clean energy sources by 2050.

Achieving a higher clean energy generation target of 75% by 2050 would require substantial capacity additions of renewable energy as well as retirements of conventional power plants. In addition, the ZCT scenario substitutes decommissioned conventional power capacity with clean energy sources. Similarly to the MLTE scenario, the annual increase in wind power capacity is kept at 2,200 MW, starting in 2035 and adding a total of 35,200 MW up to 2050. In contrast, PV power capacity is ramped up

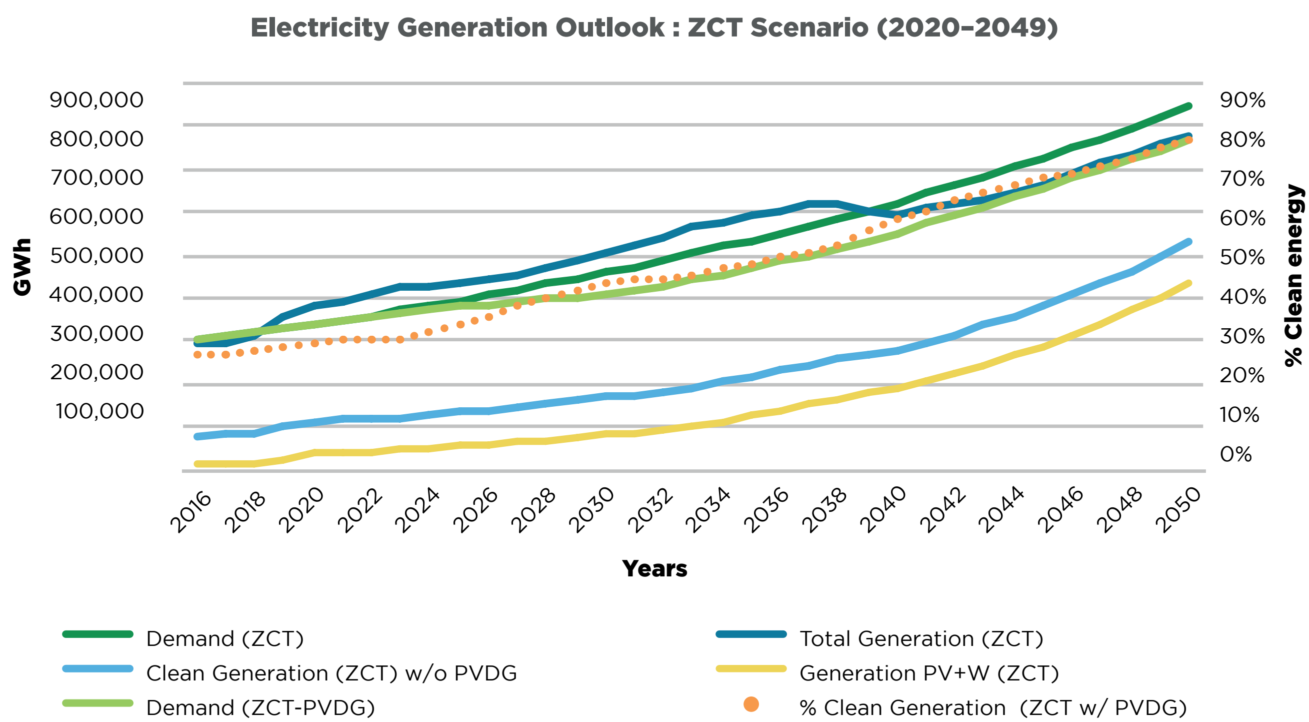
Figure 3 Electricity generation outlook under the MLTE pathway. Considering wind power (W), solar photovoltaic (PV), and PV distributed generation (PVDG)



as early as 2021, increasing from 1,860 MW to 19,790 MW by 2049, averaging almost 7,500 MW additional PV capacity annually, totaling an additional 224,000 MW of installed capacity by 2049. Other renewable sources remain the same as in the MLTE scenario for the 2034–2050 period. Moreover, the power capacity additions from combined cycle plants are substantially reduced from the period 2035–2049, down to 705 MW compared with 33,000 MW under the MLTE scenario (cf. Figure 4).

Compared to MLTE, in terms of installed capacity (GW), the ZCT scenario additionally increases the share of renewable energy in the power sector by more than 27% by 2030 and by more than 84% by the year 2050. For reasons of comparability, both scenarios assume average power demand growth of 3.1% annually. Losses of installed capacity from decommissioning conventional power plants are transferred mainly to solar PV capacity additions.

Figure 4. Electricity generation outlook under the Zero Carbon Transition (ZCT) pathway. Considering wind power (W), solar photovoltaic (PV), and PV distributed generation (PVDG)



5. SOCIAL AND ECONOMIC CO-BENEFITS OF MEXICO'S ENERGY TRANSITION

The co-benefits assessment for Mexico focuses on three high-priority areas, which have been identified with government partners and relevant stakeholder groups as potential social and economic opportunities connected to the country's energy transition (see Table 1):

- Saving costs and generating income in public buildings (hospitals and schools) with renewable energy and energy efficiency measures.
- Saving costs and generating income for local communities with renewable energy.
- Employment opportunities and future skills through renewable energy.

In this chapter the reader is introduced to the political context for these three co-benefits and the case studies along with the assessment methodology. Subsequently, the assessment results are presented and detailed quantification is provided for each of the co-benefits. Each co-benefit subchapter concludes with policy options to unlock the identified co-benefits, building from the qualitative analyses resulting from the Enabling Policy Workshops (cf. Chapter 3) with representatives from national and sub-national governmental organizations.

5.1 GENERATING SAVINGS AND INCOMES IN PUBLIC BUILDINGS

5.1.1 Understanding the context of energy cost savings in public buildings by scaling up energy efficiency and renewables

Introducing energy efficiency measures is important not only for reducing electricity consumption of public buildings and related public expenditures. They also help to reduce load on the electricity system, which is particularly important in times of peak demand. The installation of on-site solar PV electricity generation capacities is contributing to this goal and can in addition generate income during periods of low demand.

At 6.7 TWh, the annual electricity consumption of Mexico's schools is similar to that of the country´s hotel sector (6.6 TWh). Hospitals in Mexico consume considerably more electricity, at 17 TWh annually, even exceeding the electricity consumption of all office buildings in Mexico at 15 TWh (Conuee, 2019). The energy efficiency measures presented in this chapter offer economic and remunerative means to reduce energy-related public expenditures, which, compared to the identified cost saving potential, are far from being fully exploited.

Besides freeing resources for schools and hospitals to invest in the quality of their public service, in a broader picture, with the substantial scale of energy cost saving opportunities in public buildings, the presented measures can also make important contributions to achieving the objectives set by the NDP, such as reducing unnecessary public spending in order to alleviate Mexico's budget deficit and to free government resources for social welfare programs (DOF, 2019a, 2019c).

In view of Mexico's commitments to combat global warming, the study findings show that scaling up energy efficiency and distributed renewable energy generation in public buildings provides the government with strong leverages to meet the GHG emission reduction goals set in the NDC.

5.1.2 Assessment methodology and case studies

Two cities were selected for in-depth co-benefit assessment of public schools and hospitals: Mexico City and La Paz. The cases were selected for their high energy demand and due to their differences in electricity costs and tariffs, in energy intensity, annual average solar radiation level, and climatic differences. Mexico City has a mild climate throughout the year, while La Paz has an arid climate and greater intensity of electricity consumption (cf. Box 5 and Box 6).

Assessing two cities located in different regions and with dissimilar climatic characteristics allows comparison of energy intensity and the potential savings available through energy efficiency and PV projects installed on hospital and school roofs. In a second step, the results of the case studies were extrapolated to the national level to estimate the potentials for energy and cost savings and GHG mitigation for Mexico as a whole.

To assess the energy demands and respective energy and cost saving potentials, schools and hospitals were classified according to their energy demand profiles. Energy demand profiles were derived from existing research literature and official sources[7] as well as an extensive analysis of existing energy demand diagnoses of public schools and hospitals. In a second step, energy demand profiles were reviewed, verified, updated with missing information, and corrected for anomalies through qualitative inquiries and interviews with operational staff at hospitals, schools, and in the building sector.

Through this multi-stage, multi-source enquiry, a comprehensive data set on energy demand and energy saving profiles of public schools and hospitals was developed, which will form a valuable knowledge base for future studies.

The first part of the analysis quantifies the identified energy efficiency measures and the renewable energy PV by tiers of analysis (see Table 3, or the complete list in annex Table 2). The objective is to assign an investment cost to each measure and tier. The second part of the quantitative analysis quantifies the electricity consumptions, costs savings, and mitigation potential of the samples gathered for hospitals and public schools. The analysis is conducted at a micro level by property, providing an estimate at the macro-city level. The results of the case studies are extrapolated to a national-level analysis, building on official statistics concerning the total number of public schools and hospitals, by city and at the national level[8].

Table 3: Energy savings and generation options for schools and hospitals: Tiers of analysis. Complete list in annex Table 2.

Tier of analysis	Description of the Tier	Example measures
Tier 1	**zero to low-cost energy efficiency investments**	Turn off lighting and use natural light, Clustering of lighting circuits, Install photocells to control lighting in hallways
Tier 2	**medium-level energy efficiency investments**	Install movement sensors, Natural dome-style lighting, More efficient elevators
Tier 3	**combined investment in PV self-generation and medium-level energy efficiency measures**	In addition to Tier 2 measures: Installation of PV system interconnected to the grid, Exterior solar panel illumination

Box 5 Case snapshot: Mexico City

CASE SNAPSHOT: MEXICO CITY

- **Mexico City consumes approximately 6.3% of Mexico's national electricity consumption (Sener, 2017).**
- **More than 72% of the population of Mexico City (i.e., approximately 6.4 million people) are affiliated with a State Public Health Institute (INEGI, 2015).**
- **Mexico City is the most densely populated city in Mexico (approximately 6,000 inhabitants per km^2) (INEGI, 2015).**

Mexico City consumed 12.6 TWh during 2017, accounting for almost 6.3% of national electricity consumption (Sener, 2017). Being a highly densified area with reduced accessible space for the installation of renewables, its potential for renewables lies in solar PVDG (BID, 2019). However, Mexico City can also reduce electricity consumption through implementing energy efficiency measures, thereby providing cost savings for consumers. The Climate Action Program of Mexico City estimated that electricity consumption was responsible for 31% of the city's GHG emissions in 2012 (Gobierno de la Ciudad de México, 2014). The program has the goal of reducing CO_2 emissions of Mexico City by 30% by 2020 (Gobierno de la Ciudad de México, 2014).

Mexico City has engaged in multiple efforts to increase energy efficiency and awareness. In addition to multiple multilateral projects, the Mexico City Government has begun energy reconversion activities, which helped to reduce electricity consumption and inefficient energy use in public buildings (Gobierno de la Ciudad de México, 2018). The exploratory phase of Co-benefits Mexico identified a significant number of existing energy diagnoses conducted in the city, which enabled the Co-benefits study on public buildings to be carried out.

7 Sources of reviewed documentation: Secretary of Energy (Sener), Secretary of Public Education (SEP), National Institute of Geography and Statistics (INEGI), National Institute of Administration and Appraisals of National Assets (INDAABIN), Federal Electricity Commission (CFE), National Commission for the Efficient Use of Energy (Conuee), Trust for the Saving of Electric Energy (FIDE), Secretary of the Environment of Mexico City (Sedema).

8 Hospitals: Ministry of Health (Salud), Mexican Institute for Social Security (IMSS), Institute for Social Security and Services for State Workers (ISSSTE), Petróleos Mexicanos (PEMEX), Ministry of National Defense (SEDENA) and Ministry of the Navy (SEMAR). Schools: Ministry of Public Education (SEP).

Box 6 Case snapshot: Baja California Sur

CASE SNAPSHOT: BAJA CALIFORNIA SUR

- **From 2016 to 2017, Baja California Sur experienced an 11% increase in average marginal local electricity prices (MLP).**
- **In 2017/18, Baja California Sur had a total of 1,237 secondary schools and 181,000 students. (INEGI, 2017).**
- **More than 91% of Baja California Sur climate is categorized as being very dry with abundant space for solar PV technology.**

The Baja California Sur electricity network covers the area from Loreto to Los Cabos, it is an electrical system isolated from the National Interconnected System (SIN) and it consists of the Mulegé and Baja California Sur interconnected systems. Electricity generation in Baja California Sur is dominated by fossil fuel sources and high dependence on fossil fuel imports (Sener, 2019). In addition, from 2016 to 2017 Baja California Sur had the greatest increase in marginal local electricity prices (MLP) nationwide. The reasons are increasing fuel prices; power plants being unavailable due to emergency conditions or inspections; decreased availability of natural gas and the consequent increased use of other, more expensive, fossil fuels such as fuel oil and diesel (Sener, 2018b).

The National Atlas of Areas with high Potential for Clean Energy (AZEL) identifies Baja California Sur as one of the states with the greatest solar PV energy capacity potential.[9] The state also has the highest economic and population growth nationally, due to its rising tourism and services sector, resulting in an accelerated escalation of the state's energy demand (Sener/GEIC, 2016 INEGI, 2015). Examples of the region's rapid development include the population of Los Cabos, which increased from 164,000 inhabitants in 2005 to 288,000 inhabitants in the last census of 2015 (INEGI, 2015). Baja California Sur faces the challenge of guaranteeing energy security while sustaining its dynamic economic growth. In the third quarter of 2019 alone, 25 shutdowns were registered in the federal state.

9 Federal states with higher solar PV energy potential (2016): Durango, Chihuahua, Baja California Sur, and the State of Mexico.

5.1.3 Results of the co-benefits assessment

Generating savings and income through energy efficiency measures and renewable energy in public hospitals and schools was assessed for Mexico City and the city of La Paz in the state of Baja California Sur. The results of these case studies were extrapolated to the national level to estimate the potentials for energy and energy cost savings as well as GHG mitigation for Mexico.

The results are presented, starting with the national perspective in order to provide a panorama on the possible economic co-benefits of giving public hospitals and schools a stronger role in Mexico's energy transition. Subsequently, the state-specific results are presented for Mexico City and the city of La Paz.

Table 4 Classifications for public hospitals and schools.

Hospitals: Classification	Schools: Classification
Level 1: First Level of attention: Family Medicine Units (IMSS), Health Centers (Salud), and Family Clinics (ISSSTE), where primary health care is provided.	Level 1: Elementary schools (including Conafe, Genera, and Indigenous schools)
Level 2: General, Regional, Integral, Community, Pediatric, Gyneco-Obstetrics or Maternal and Child Hospitals, as well as Federal Hospitals (specialized diagnoses, therapeutic, and rehabilitation treatments).	Level 2: Secondary schools (including General and Community schools, schools for migrants, schools for workers, technical and remote schools "Telesecundarias")
Level 3: Highly specialized hospitals with advanced technology, where low prevalence, high risk diseases and more complex cases are treated (National Medical Centers, High-Specialty Medical Units, National Institutes of Health and Regional High-Specialty Hospitals).	

Source: own classification

NATIONAL-LEVEL RESULTS FOR PUBLIC HOSPITALS

Public hospitals in Mexico are managed by different public institutions: The largest number of hospitals (743; 63%) is managed under the auspices of the Ministry of Health (Salud). A further 256 hospitals (22%) are managed by the Mexican Institute for Social Security (IMSS), while the hospital network of the Institute for Social Security and Services for State Workers (ISSSTE) oversees 105 hospitals (9%). Smaller numbers of hospitals are managed by Petróleos Mexicanos (PEMEX), the Ministry of National Defense (SEDENA), and the Mexican Navy (SEMAR).

Given the diversity and small size of level 1 units and the corresponding low energy saving potential, the assessment focused on level 2 and level 3 hospitals (cf. Table 4), accounting for 1,182 public hospitals nationally.

The analysis indicates that public hospitals in Mexico can reduce their energy expenditures by more than 2.3 billion pesos annually. This figure is comparable to the 2019 budget for the Integral Development Program for People with Disabilities (2.55 billion pesos, DOF, 2018), and could support more than 150,000 citizens with disabilities every year.

With a payback period of about two years, investments in medium-level energy efficiency measures (Tier 2), such as motion detectors for lighting or increasing sun shields to reduce cooling demand, result in an estimated GHG mitigation potential of nearly 265,000 tCO_2e annually.

By investing in combined medium-level energy efficiency measures and PV self-generation (Tier 3) the estimated economic benefit can be more than doubled to 2.25 billion pesos, additionally mitigating an estimated 628,454 tCO_2e annually (Table 5).

A low-cost energy efficiency strategy for public hospitals in Mexico, based on low to zero energy-efficiency investments, such as reducing the operating hours of lighting equipment (Tier 1), could mitigate 4,764 tCO_2e per year and enable annual energy cost savings of 13.6 million pesos.

NATIONAL-LEVEL RESULTS FOR PUBLIC SCHOOLS

The analysis of energy expenditure savings in public schools includes 111,672 public schools nationwide, comprising 77,523 elementary schools and 34,149 secondary schools. Public schools in Mexico are managed by the Mexican Ministry of Education (SEP), the elementary schools are divided between the National Commission for Educational Promotion (CONAFE) model schools, general elementary schools, and indigenous schools. There are six types of secondary schools in Mexico: community school, general secondary schools, migrant schools, schools for workers, technical and the virtual format of "Telesecundaria" school (SEP, 2019).

The results show that public schools in Mexico can save nearly 2 billion pesos per year through implementing medium-level energy efficiency measures (Tier 2) such as motion detectors for lighting or high-efficiency air conditioning systems. With an estimated overall investment of around 2.6 billion pesos, the estimated payback period of this investment is a little more than one year. Through these measures electricity consumption in public schools can be reduced by almost 25%, with associated GHG mitigation potential of more than 470,000 tCO_2e annually (Table 6).

By introducing combined investment in PV self-generation and medium-level energy efficiency investments (Tier 3), public schools in Mexico can make a leap towards decarbonization and unleash a GHG mitigation potential of 1.2 million tCO_2e annually, with an estimated payback period on the investment of five years. Estimated cost savings of 4.3 billion pesos represent almost 20% of the requested 2020 budget for the national social program of Youth building the future, and could support almost 100,000 young Mexicans every year (see Box 1; DOF 2018, 2019b).

Public schools in Mexico can reduce their energy consumption by more than 7% simply by introducing low- to zero-cost energy efficiency measures (Tier 1), such as disabling the standby mode of electronic appliances and enabling the energy-saving mode for computers. The annual cost savings of around 822 million pesos are slightly lower than the funds of the Program of Direct Support

Table 5 National results for public hospitals: Costs savings, energy savings, and mitigation potential

Type of public hospital	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(million pesos/ year)*	Investment *(million pesos)*	Payback Period *(years)*	Mitigation potential *(tonCO_2e/year)*
National Federal Hospitals	Tier 1	9.04	13.69	0.16	0.01	4,764
	Tier 2	503.33	918.19	1,831.58	1.99	265,253
	Tier 3	1,192.52	2,255.85	5,357.71	2.38	628,454
Total		**1,201.56**	**2,269.54**	**5,357.87**	**2.36**	**633,218**

Table 6 National results for public schools: Costs savings, energy savings, and mitigation potential

Type of public school	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(million pesos/ year)*	Investment *(million pesos)*	Payback period *(years)*	Mitigation potential *(tCO_2e/year)*
Elementary and Secondary	Tier 1	333.76	822	5.5	0.006	193,643
	Tier 2	811.16	1,997	2,596.4	1.300	470,626
	Tier 3	1,752.86	4,315	21,667.7	5.021	533,817
Total		**2,086.62**	**5,137**	**21,673.2**	**4.219**	**1,197,821**

to Schools,[10] which had a budget of 1 billion pesos in 2019 (SEP, 2019). In addition to the annual energy cost savings, these measures can mitigate more than 193,000 tCO_2e annually (Table 6).

If public schools in Mexico implement Tier 3 measures by installing solar PV and medium- and high-energy-efficiency measures, Mexico can save around 1,752 MWh of energy every year, representing energy cost savings of 4.3 billion pesos. Under this scenario, the return on investment period is around five years (Table 6).

MEXICO CITY: POTENTIAL SAVINGS FOR PUBLIC HOSPITALS

The analysis of energy consumption, related costs, and carbon emissions for public hospitals located in Mexico City includes 101 hospitals (71 federal, 30 state-managed by Salud).

A low-cost energy efficiency strategy for public hospitals in Mexico City, based on low to zero energy efficiency investments, such as reducing the operating hours of lighting equipment (Tier 1), could mitigate around 400 tCO_2e per year and provide annual energy cost savings of 1.15 million pesos. In total, potential annual costs savings for Mexico City add up to more than 95 million pesos per year from electricity costs savings, corresponding to energy savings of more than 46,000 MWh per year, with an annual GHG mitigation potential of nearly 25,000 tCO_2e (Table 7).

The results show that federal hospitals in Mexico City can save nearly 60 million pesos per year through implementing medium-level energy efficiency measures (Tier 2) such as motion detectors for illumination or high-efficiency air condition systems. With an estimated overall investment of around 105 million pesos, the estimated payback period is less than two years. Through these measures electricity consumption in federal hospitals can be reduced by more than 28,000 MWh annually with a GHG mitigation potential of more than 14,000 tCO_2e annually. For state-managed hospitals, investments in Tier 2 measures are economically viable, but have a longer payback period of around 4 years and 4 months.

While combined investment in PV self-generation and medium-level energy efficiency investments (Tier 3) for federal hospitals pay off after around four years and then yield an annual economic benefit of 82 million pesos, under the current policy environment, Tier 3 investments for Salud hospitals will be environmentally beneficial but with a considerably longer payback period (Table 6).

Table 7 Analysis results: Mexico City hospitals

Type of public hospital	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(pesos/year)*	Investment *(pesos)*	Payback period *(years)*	Mitigation potential *(tCO_2e/year)*
Federal (71 Hospitals)	Tier 1	543.41	822,405	9,610	0.01	286.38
	Tier 2	28,224.57	57,310,867	105,694,526	1.84	14,874.35
	Tier 3	39,460.74	82,706,271	313,936,841	3.80	20,785.27
Salud (30 Hospitals)	Tier 1	206.88	322,654	4,061	0.01	109.03
	Tier 2	3,233.09	5,997,452	26,007,097	4.34	1,703.84
	Tier 3	6,164.14	11,829,904	150,058,777	12.68	3,248.50
Total		**46,375.17**	**95,681,234**	**464,009,289**	**4.85**	**24,429.18**

10 Program of Direct Support to Schools: This program generates conditions that allow public schools of basic education to strengthen their management autonomy and supports actions for decision-making in favor of quality, equity, and inclusion of the educational service.

Furthermore, the analysis identified potential fossil fuel savings from introducing solar water heaters in Mexico City hospitals, representing annual savings of nearly 92,000 liters of diesel and more than 70,000 liters of liquefied petroleum gas (LPG). These fossil fuel savings represent an annual economic benefit of 2.6 million pesos[11].

MEXICO CITY: POTENTIAL SAVINGS FOR PUBLIC SCHOOLS

The analysis of energy expenditure savings in Mexico City public schools comprises 1,982 elementary and 831 secondary schools.[12]

A low-cost energy efficiency strategy for public schools in Mexico City, based on low to zero energy efficiency investments (Tier 1), could mitigate around 4,900 tCO_2e per year and enable annual energy cost savings of 21 million pesos. In total, potential annual costs savings for public schools in Mexico City add up to more than 145 million pesos per year from electricity costs savings, corresponding to energy savings of more than 50,000 MWh per year, with an annual GHG mitigation potential of 30,000 tCO_2e (Table 8).

The results show that public schools in Mexico City can save nearly 65 million pesos per year by implementing medium-level energy efficiency measures (Tier 2) such as motion detectors for illumination or high-efficiency air condition systems. With an estimated overall investment of around 150 million pesos, the estimated payback period of this investment is 2 years and 4 months. Through these measures electricity consumption in public schools can be reduced by more than 20,000 MWh annually with a GHG mitigation potential of more than 11,000 tCO_2e annually.

With combined investment in PV self-generation and medium-level energy efficiency investments (Tier 3) energy savings for public schools in Mexico City can be more than doubled to around 44,000 MWh, with a payback period for related investments of five years.

LA PAZ, BAJA CALIFORNIA SUR: POTENTIAL SAVINGS FOR PUBLIC HOSPITALS

The analysis of energy consumption, related costs, and carbon emissions for public hospitals located in La Paz, comprises a total of 27 hospitals.

A low-cost energy efficiency strategy for public hospitals in La Paz, based on low to zero energy efficiency investments (Tier 1), could mitigate around 88 tCO_2e per year and enable annual energy cost savings of 323,000 pesos. In total, potential annual costs savings for La Paz add up to more than 1 million pesos per year from electricity costs savings, corresponding to energy savings of more than 250 MWh per year, with an annual GHG mitigation potential of 226 tCO_2e (Table 9).

Table 8 Analysis results: Mexico City schools

Type of public school	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(pesos/year)*	Investment *(pesos)*	Payback period *(years)*	Mitigation potential *(tCO_2e/year)*
Elementary and Secondary	Tier 1	8,403.56	21,384,801	138,473	0.0	4,881.02
	Tier 2	20,414.96	65,448,693	152,401,462	2.3	11,843.93
	Tier 3	44,130.78	123,868,490	632,621,027	5.1	25,275.69
Total		**52,534.34**	**145,253,291**	**632,759,500**	**4.4**	**30,156.71**

Table 9. Analysis results: La Paz, Baja California Sur hospitals

Type of public hospital	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(pesos/year)*	Investment *(pesos)*	Payback period *(years)*	Mitigation potential *(tCO_2e /year)*
State	Tier 1	98	323,000	6,400	0.02	88
	Tier 2	128	396,000	252,000	0.6	116
	Tier 3	156	707,000	3,731,823	5.3	138
Total		**254**	**1,030,000**	**3,738,223**	**3.6**	**226**

11 Energy prices retrieved in August 2017, Bloomberg energy prices.

12 In addition to public schools, there are currently 1,145 private elementary schools and 530 private secondary schools registered in Mexico City.

The results show that public hospitals in La Paz can save nearly 400,000 pesos per year through implementing medium-level energy efficiency measures (Tier 2). With an estimated overall investment of around 250,000 pesos, the estimated payback period of this investment is less than one year. Through these measures, electricity consumption in public hospitals can be reduced by 128 MWh annually with a GHG mitigation potential of 116 tCO_2e annually.

Combined investment in PV self-generation and medium-level energy efficiency investments (Tier 3) for public hospitals pays off after around five years and then yields an annual economic benefit of around 700,000 pesos.

LA PAZ, BAJA CALIFORNIA SUR: POTENTIAL SAVINGS FOR PUBLIC SCHOOLS

The analysis of energy expenditure savings in public schools for La Paz includes 534 public elementary and secondary schools.

A low-cost energy efficiency strategy for public schools in La Paz, based on low to zero energy efficiency investments (Tier 1), could mitigate around 115 tCO_2e per year and enable annual energy cost savings of around 450,000 pesos. In total, potential annual costs savings for public schools in La Paz add up to more than 1.2 million pesos per year from electricity costs savings, corresponding to energy savings of 346 MWh per year, with an annual GHG mitigation potential of 300 tCO_2e (Table 10).

The results show that public schools in La Paz can save nearly 560,000 pesos per year by implementing medium-level energy efficiency measures (Tier 2). With an estimated overall investment of 355,000 pesos, the estimated payback period of this investment is less than 1 year. Through these measures electricity consumption in public schools can be reduced by more than 128 MWh annually with a GHG mitigation potential of more than 116 tCO_2e.

With combined investment in PV self-generation and medium-level energy efficiency investments (Tier 3) annual energy savings for public schools in La Paz can be increased to 217 MWh, with a GHG mitigation potential of more than 194 tCO_2e annually, however at a considerable longer payback period of this investment of 8.5 years (Table 10).

5.1.4 Creating an enabling environment to unlock co-benefits

The analysis shows that public energy expenditures in schools and hospitals can be reduced by up to 6.5 billion pesos annually by applying various measures for energy saving and renewable energy generation (approximately 2.2 billion pesos for hospitals and 4.3 billion pesos for schools).

Besides freeing resources for schools and hospitals to invest in the quality of their public services, the substantial potential energy cost savings also offer opportunities for the federal and state governments to reinvest these savings into programs for socioeconomic development.

The following policy options were identified, together with representatives from national and sub-national governmental organizations (cf. Chapter 3), as the basis for further discussion on providing an enabling environment to unlock the identified co-benefits:

Policy options at the national level

POLICY OPTION #1

Encouraging public buildings as role models for energy and cost savings by including them in Mexico's NDC — In light of their high GHG mitigation potential, public buildings can play an important role in the national mitigation strategy. Mitigation targets based on energy efficiency measures in public buildings could be further specified in revising Mexico's NDC. Public buildings could thereby become role models for energy and cost saving and incentivize subsequent initiatives among private building owners.

POLICY OPTION #2

Incentive scheme for public schools and hospitals to create financial benefits from savings — Although schools and hospitals can achieve substantial savings in energy costs and contribute to GHG reductions at almost zero cost, these entities do not yet directly benefit from the energy cost savings, resulting in little or no incentive to implement energy efficiency measures. Public hospitals and schools are not responsible for paying their electricity costs, thereby having little incentive to implement energy efficiency measures. By exploring new payment schemes, the Ministry of Finance, in coordination with state governments, can provide additional incentives for public school and

Table 10 Analysis results: La Paz, Baja California Sur schools

Type of public school	Tier of EE & RE	Energy savings potential *(MWh/year)*	Energy cost savings potential *(pesos/year)*	Investment *(pesos)*	Payback period *(years)*	Mitigation potential *(tCO_2e /year)*
Elementary and Secondary	Tier 1	129	454,000	6,995	0,0	115
	Tier 2	164	559,000	355,727	0,6	147
	Tier 3	217	750,000	6,355,574	8,5	194
Total		**346**	**1,204,000**	**6,362,569**	**5,3**	**309**

hospital administrations to engage in energy and energy cost saving measures.

POLICY OPTION #3

Budget-neutral programs to cover upfront investments in energy saving — Despite the attractive return on investment of energy efficiency measures, institutional budgets might not cover the initial investment costs, which can represent an important barrier to their implementation. Climate finance programs and public/private partnerships can facilitate investments by schools and hospitals in energy saving measures and enable them to benefit from cost savings. The substantial GHG mitigation potential of combined solar energy / energy saving measures can be used as an additional argument to roll out upfront investment programs.

Policy options at the subnational level

POLICY OPTION #4

Combined energy saving & Education programs — Involving students in the planning and implementation of energy saving programs not only contributes to an applied school curriculum, it also serves as multiplier within the students' social environments and families. To this end, a share of the cost savings can be allocated to school community budgets to co-create innovative energy saving projects in schools, thereby adding another incentive, particularly for 'low-hanging fruit' improvements in energy efficiency.

Policy options at the national-subnational level

POLICY OPTION #5

Adding cost saving potential to existing monitoring schemes for energy usage — Strengthen existing efforts to monitor the energy demand and usage of public buildings. Data collection can be complemented by monitoring and disclosing connected cost saving potentials for the public sector. Additional surveys and detailed audits according to building types and climatic regions will further strengthen the information base and help to specify cost-saving opportunities.

5.2 GENERATING SAVINGS AND INCOMES FOR COMMUNITIES

5.2.1 Understanding the context of energy savings and income generation for local communities

Since its official introduction through the 2015 Energy Reform on the basis of the Mexican Power Industry Law of 2014, and driven by plummeting technology costs, solar PVDG is becoming increasingly attractive for Mexican prosumers[13]. By December 2018, around 85,000 net metering contracts nationwide together provided a total installed capacity of 570 MW distributed solar PV. In total, PVDG accounts for a generation capacity of 693 MW and is installed on around 95,000 solar roofs.[14]

The possibility for installing smaller-scale electricity generation capacities of up to 499 KW[15] and related small-scale investments allows new players such as businesses and households to invest in and benefit financially from renewable energy. PVDG provides economic benefits by reducing expenditure on grid electricity and by generating revenues through selling electricity, under the net billing and net metering schemes[16] (Figure 5).

Figure 5 Photovoltaic distributed generation schemes (PVDG) available in Mexico

Net Billing	HOUSE w/ solar panel	→	All solar PV energy produces is sold to the grid based on the current electricity rate per kWh	→	**GRID**
		←	All energy consumed is purchased from the grid at CFE rate	←	
Net Metering	HOUSE w/ solar panel	→	Energy not self-consumed is sold to the grid based on the current electricity rate per kWh	→	**GRID**
		←	Energy consumed beyond self consumption is purchased form the Grid at CFE rate	←	

13 Prosumers are households or organizations that sometimes produce surplus energy and feed it to the grid, whilst at other times they consume energy from the same grid, i.e., they are producers as well as consumers of electricity.

14 Source: Asociación Mexicana de Energía Solar (Asolmex) / https://pv-magazine-usa.com/2019/06/24/mexico-reaches-4-gw-milestone/

15 As defined by the Power Industry Law (2014).

16 Under the third existing interconnection scheme, wholesale, every MWh generated by the user is sold and there is no electricity consumption from the grid. Therefore, it cannot present energy cost savings -since no consumption costs exist- and is not part of the analysis.

Table 11 Federal electricity tariff schemes, Mexico (CFE, 2019)

Type of tariff	Tariff sector	Tariff scheme	Description	Subsidy level
Low voltage	Residential	DAC[17]	High domestic consumption	Low
	Commercial sector	PDBT	Low demand in low voltage	
		GDBT	High demand in low voltage	
Medium voltage	Industrial medium enterprise	GDMTH	High demand of medium hourly voltage	Medium / high
		GDMTO	High demand in medium ordinary voltage	
High voltage	Large industrial sector	DIST	Industrial demand in sub-transmission	
		DIT	Industrial demand in transmission	

The economic benefits of PVDG under the presented schemes are closely linked to electricity tariffs, which vary depending on the sector, the state where electricity is being consumed, as well as the extent to which the respective tariff is subsidized by the Federal Government (Table 11). For the high consumption residential and commercial sectors, where tariff schemes tend to be less subsidized, PVDG in many cases represents an economically interesting option. In contrast, industrial-sector tariffs normally attract subsidies and are therefore cheaper. However, the historical increase of these tariff schemes, projected in this study, suggest that net billing and net metering are increasingly economically viable in this sector.

As PVDG under the presented schemes reduces the amount of subsidized electricity purchased from the grid, the future scope of PVDG deployment in Mexico can also result in fiscal benefits — particularly given that total energy subsidies presently amount to approximately 130 billion pesos (GIZ, 2018).

In this respect the study results presented in this chapter provide evidence on the economic benefits for different consumer groups in different states and also insights into possible fiscal benefits in terms of freeing government resources for use in other priority programs, depending on the energy transition pathway chosen. The findings suggest that the government might consider further improving conditions for enabling PVDG in Mexico in order to increase economic benefits both for electricity consumers and fiscal planning.

Furthermore, as shown by international experiences such as Germany's energy transition, enabling new groups of smaller-scale investors can considerably accelerate the deployment of clean energy (cf. Helgenberger, 2016). Therefore, PVDG in Mexico can be an important driver towards meeting the goals set by the LTE as well as international commitments to reduce the carbon intensity of Mexico's energy sector.

5.2.2 Assessment methodology and case studies

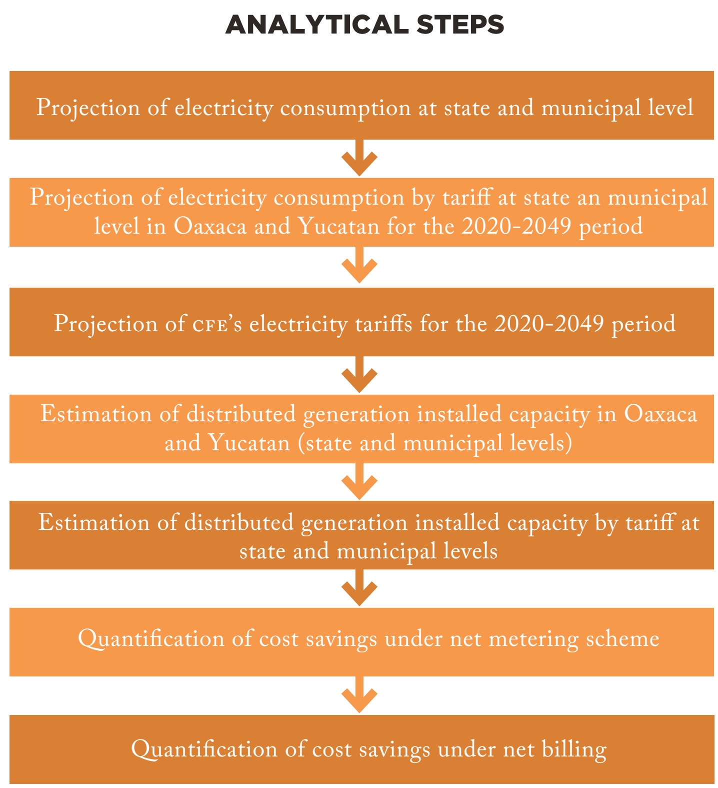
Cost savings were assessed in seven stages (Figure 6, detailed equations for each of these steps are presented in annex Table 3) for the states of Oaxaca and Yucatan at state and municipal level.

Both states are characterized by high solar PV potential, but differ in their electricity tariff rates as well as in terms of the proportions of their industrial, business, and commercial sectors.

Cost savings are quantified for the two contrasting energy transition pathways for the period 2020 to 2050: Current policy (MLTE), and Zero Carbon transition (ZCT).

For both scenarios and state-level case studies, the cumulative capacity of PVDG was projected. Energy cost savings were quantified for both the net metering and net billing schemes based on the state-specific federal electricity tariff schemes (Table 12) for Oaxaca and Yucatan.

Figure 6 Generating savings and incomes for communities: Steps of analysis



17 The DAC Tariff is part of the DB2 scheme (1, 1A, 1B, 1C, 1D, 1E, 1F, DAC). However, only the DAC tariff was assessed due to its potential benefits. The omitted tariffs are: Domestic consumption up to 150 kWh/month (DB1), Low-voltage agricultural irrigation (RABT), Public lighting in low voltage (APBT), Public lighting in medium voltage, and Medium voltage agricultural irrigation (RAMT).

Table 12 Projected cumulative capacity of solar PV distributed generation (PVDG) in Oaxaca and Yucatan by scenario (2020–2049)

Installed capacity of distributed generation photovoltaic energy (MW) by scenario

Level	2020–2024		2025–2029		2030–2034		2035–2039		2040–2044		2045–2049	
	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
Mexico (national level)	5.988	7.034	18.245	31.242	22.588	47.132	23.105	49.846	23.155	50.918	23.159	52.962
Oaxaca	127	143	539	814	859	1,702	919	1,966	926	2,019	926	2,081
Yucatan	578	654	2,460	3,713	3,921	7,772	4,197	8,971	4,226	9,214	4,228	9,500

Source: based on Sener 2019 and CRE 2019

Box 7 Case snapshot: Oaxaca

CASE SNAPSHOT: OAXACA

- Oaxaca generated 61% of Mexico´s wind power in 2017.
- Energy planning should integrate indigenous communities. In Oaxaca, there are more than 1,2 million people aged 3 years and older who speak an indigenous language (INEGI, 2015).
- Oaxaca has the most municipalities of all states in Mexico, at 570. Most municipalities located in the southeast of Oaxaca have moderate to excellent wind power class potentials (NREL, 2003).

The federal state of Oaxaca has the largest potential capacity for wind energy in Mexico (Sener, 2018a), with estimates ranging between 13 and 33 GW (Sener, 2018; NREL, 2003). In 2017, Oaxaca accounted for 56% of the installed capacity and 61% of the annual generation of wind energy in Mexico (Sener, 2018a). However, Oaxaca falls short of its potential capacity, and in 2017 had only installed 2.7 GW capacity (Sener, 2019). In addition, this potential could support all citizens of Oaxaca; however, 3.8% of the state population still lacks access to electricity (Sener, 2018b). In 2017, Oaxaca generated 8,427 MWh of electricity (2.6% of national electricity generation), ranking the 15th federal state in electricity generation (Sener, 2018b).

Co-benefits Mexico opted to elaborate studies in the federal state of Oaxaca with the objective of socializing and communicating the potential benefits of renewable energy by analyzing the potential savings and income that can be generated for families, businesses and municipalities of Oaxaca.

Box 8 Case snapshot: Yucatan

CASE SNAPSHOT: YUCATAN

- Yucatan's GDP grew 3.1% from 2016 to 2017.
- Yucatan has a population of approximately 2.1 million inhabitants in an area of 43,379 km^2 (approximately 61 inhabitants per km^2) (INEGI, 2015).
- The average annual temperature in Yucatan is 26°C with an average rainfall of 1,100 mm per year.

The federal state of Yucatan has an installed electricity generation capacity of 2,100 MW (Sener, 2018a), consisting mainly of thermoelectric plants and combined cycle gas turbine plants operated by the CFE and independent energy producers. However, the share of renewables has been constantly growing: solar PV installed capacity has increased 92% in the last 3 years, reaching an installed capacity of 32 MW[18]. In the state of Yucatan, approximately 78% of domestic, commercial, and industrial consumption is concentrated in five municipalities, with Merida accounting for 60% of total sales (CFE, 2018). To 2019, 2,356 solar PVDG projects were registered in Yucatan.

Co-benefits Mexico opted to explore the savings and benefits for the federal state of Yucatan and its communities participating in renewables using mechanisms already established in Mexican energy legislation. Additionally, other participation schemes for renewables applicable to Mexico are explored.

18 The solar PV installed capacity of Yucatan includes PVDG and large scale solar installed until October 2019.

Based on historical trend analyses of the last 10 years, tariffs are projected to increase by 4.9% annually for the high domestic consumption tariff and by 3.6% annually for industrial and commercial tariffs. Electricity consumption by tariff and energy cost savings / income generation from PVDG were calculated based on the projected electricity demands of Oaxaca and Yucatan states. Projected electricity demand until 2033 is based on regional forecasts of maximum demand estimated by Prodesen 2019–2033. For the 2034–2050 period, electricity demands for both states were based on an average annual growth rate of energy demand (AAGR) of 3.3% (Oaxaca) and 3.8% (Yucatan).

The analysis concludes by estimating the fiscal impact of reduced energy subsidy demands as well as estimated opportunity costs by state.

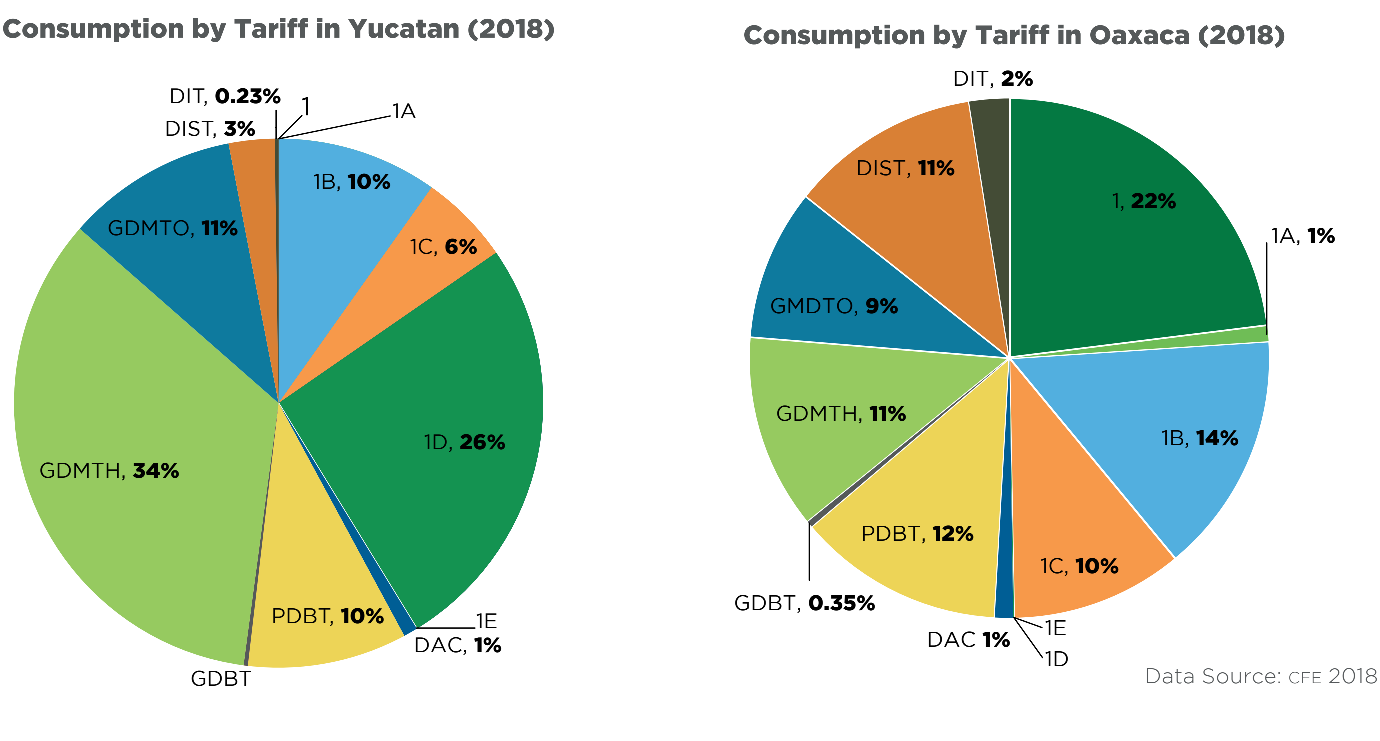
5.2.3 Results of the co-benefits assessment

Electricity consumption in Oaxaca is presently (2018) estimated to be 2,748 GWh, accounting for 1.3% of total national consumption. The High Domestic Consumption (DAC), Industrial Medium Enterprise (GDMTO), Large Industry (DIST), and Business sector tariffs account for 46% of Oaxaca's electricity consumption. Yucatan's electricity consumption in 2018 is estimated to be 3,623 GWh, accounting for 1.7% of total national consumption. The High Domestic Consumption, Industrial Medium Enterprise, Large Industry, and the Business sector tariffs account for 59% of Yucatan's total consumption.

OAXACA: ENERGY COST SAVINGS UNDER THE NET METERING AND NET BILLING SCHEMES

Independent of the energy transition pathway by 2030, cumulative energy cost savings under the net metering scheme across all sectors in Oaxaca will have surpassed 1 billion pesos, with the commercial sector as the main beneficiary, achieving more than 50% of these cost savings.

Figure 7 Electricity consumption by tariff: federal states of Oaxaca and Yucatan



Data Source: CFE 2018

Starting from 2030, the ambitious decarbonization pathway (ZCT) leads to significantly higher economic benefits compared to the current policy pathway (MLTE). By 2040, cumulative cost savings for all analyzed sectors in Oaxaca under the ZCT pathway would be 63% greater than those achieved through the current policy pathway, exceeding 7 billion pesos, which is estimated to more than double by 2050 to 17.7 billion pesos. This would exceed the economic benefits of the current policy pathway by more than 80%, again with the commercial sector as main beneficiary achieving cost savings of almost 10 billion pesos (for detailed sectoral numbers, see Table 13).

By the year 2030, under the current policy scenario, domestic, commercial, medium enterprise and large industry consumers in Oaxaca can expect economic benefits of 546 million pesos resulting from the net billing scheme. These benefits can be increased by more than 9% to 600 million pesos under an ZCT. With cumulative savings of 1.4 billion pesos by the year 2040 under the ZCT pathway, consumers in Oaxaca's net billing scheme will see an additional 45% savings compared to MLTE, under which economic benefits will amount to 682 million pesos (Table 14).

However, under the tariff structure assumed for the analysis, the ZCT pathway particularly benefits domestic and medium enterprise consumers, whereas commercial and large industry consumers see greater economic benefit under the current policy environment.

OAXACA: PRIORITY MUNICIPALITIES FOR PVDG DEPLOYMENT

Electricity consumption in Oaxaca's domestic, commercial, and industrial sectors reached 2,747 GWh. The municipalities of Oaxaca de Juarez (10.5%), San Juan Bautista Tuxtepec (8.9%), Barrio de la Soledad (8%), Salina Cruz (4.9%), and Santa María Huatulco (3.9%) account for 36% of the state's total consumption (CFE, 2018).

Independent of the energy transition pathway by 2030 energy cost savings under the net metering scheme across all analyzed municipalities in Oaxaca are estimated to cumulate to 500 million pesos, with the municipalities of Oaxaca de Juarez , San Juan Bautista Tuxtepec and El Barrio de la Soledad as main beneficiaries, achieving around 80% of these cost savings.

Starting from 2030, the ambitious ZCT leads to significantly higher economic benefits compared MLTE. By 2040, cumulative cost savings for all analyzed municipalities in Oaxaca under the ZCT pathway are almost 50% greater than savings achieved through the current policy pathway, exceeding 3.3 billion pesos. This figure can be expected to more than double by 2050 to 8.5 billion pesos, thereby exceeding the economic benefits of the current policy pathway by 65%. The main beneficiaries are the municipalities of Oaxaca de Juarez and El Barrio de la Soledad,

Table 13 Oaxaca: Estimated energy cost savings (in million pesos by tariff) under net metering scheme (2020–2049)

Period	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
	Domestic		Commercial		Medium enterprise		Large industry	
2020–2024	9	11	70	79	23	19	18	21
2025–2029	69	79	484	553	189	145	144	163
2030–2034	114	209	758	1,406	327	401	245	449
2035–2039	153	310	969	1,985	450	603	333	675
2040–2044	197	410	1,188	2,490	582	793	428	889
2045–2049	322	670	1,444	3,124	737	1,034	539	1,159
Total	**865**	**1,688**	**4,912**	**9,637**	**2,308**	**2,994**	**1,707**	**3,356**

Source: own calculations based on data from Sener 2019 and CFE 2018

Table 14 Oaxaca: Estimated energy cost savings (in million pesos by tariff) under net billing scheme (2020–2049)

Period	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
	Domestic		Commercial		Medium enterprise		Large Industry	
2020–2024	2	2	38	44	61	71	41	47
2025–2029	12	14	135	158	270	257	147	171
2030–2034	15	28	171	331	279	537	185	358
2035–2039	15	33	179	382	291	620	194	413
2040–2044	15	34	180	392	292	637	195	424
2045–2049	15	35	180	404	292	657	195	437
Total	**75**	**146**	**889**	**1,710**	**1,435**	**2,778**	**955**	**1,850**

Source: own calculations based on data from Sener, 2019 and CFE, 2018.

Table 15 Oaxaca: Estimated energy cost savings (in million pesos by municipality and scenario) under net metering scheme (2020–2049)

Period	Oaxaca de Juarez		San Juan Bautista Tuxtepec		El Barrio de la Soledad		Salina Cruz		Santa María Huatulco	
	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
2020–2024	23	22	12	11	13	13	6	6	7	7
2025–2029	166	161	88	86	103	101	43	42	51	50
2030–2034	281	422	155	232	184	275	75	112	89	133
2035–2039	359	610	203	344	242	412	96	164	115	195
2040–2044	447	780	258	450	310	540	121	212	145	253
2045–2049	509	996	324	583	390	702	151	272	182	327
Total	**1,785**	**2,991**	**1,039**	**1,706**	**1,242**	**2,042**	**493**	**807**	**588**	**965**

Source: own calculations based on data from Sener, 2019, CFE and CRE, 2018.

Table 16 Oaxaca: Estimated energy cost savings (in million pesos by municipality and scenario) under net billing scheme (2020–2049)

Period	Oaxaca de Juarez		San Juan Bautista Tuxtepec		El Barrio de la Soledad		Salina Cruz		Santa María Huatulco	
	mlte	zct	mlte	zct	mlte	zct	mlte	zct	mlte	zct
2020–2024	14	14	12	12	17	17	5	5	6	6
2025–2029	83	80	73	70	101	97	29	28	35	34
2030–2034	112	168	98	147	137	204	40	59	48	71
2035–2039	114	193	100	169	139	235	40	68	48	82
2040–2044	114	199	100	174	139	242	40	70	48	84
2045–2049	114	205	100	179	139	249	40	72	48	87
Total	**552**	**858**	**483**	**751**	**672**	**1,045**	**195**	**304**	**233**	**363**

Source: own calculations based on data from Sener, 2019, CFE, CRE, and Cenace, 2018.

which account for 55% of cumulative cost savings (for detailed municipal data, see Table 15).

Independent of the energy transition pathway, by the year 2030, analyzed municipalities in Oaxaca are expected to see cumulative savings of more than 350 million pesos resulting from the net billing scheme. With the exception of Oaxaca de Juarez , the economic benefits estimated for the municipalities correspond to cost savings under the net metering scheme. Comparison between both schemes indicates that by 2030, with around 185 million pesos in total savings, consumers in Oaxaca de Juarez double benefits from the net metering scheme compared with the net billing scheme (for detailed municipality numbers, see Table 16).

Starting from 2030 also for the net billing scheme, ZCT leads to significantly higher economic benefits compared to MLTE. By 2040, cumulative savings under the ZCT pathway will exceed the economic benefits of MLTE by 40%, achieving cumulative savings of 1.7 billion pesos.

In order to identify tariffs with the highest cost saving potential for the analyzed municipalities of Oaxaca, the tariffs with the highest cost savings under the net metering or net billing schemes were analyzed. With the exception of Oaxaca de Juarez, under the net billing scheme, average annual energy cost savings, calculated as a share of total costs, remains the same in both scenarios. The calculations indicate that the greatest potential energy cost savings are in the municipality of *El Barrio de la Soledad*, under the DIST Tariff for both the net metering and net billing schemes, with potential savings of 95% and 97% of annual average costs (Table 17).

YUCATAN: ENERGY COST SAVINGS UNDER THE NET METERING AND NET BILLING SCHEMES

By the year 2030, under the current policy pathway scenario, domestic, commercial, medium enterprise, and large industry consu-

Table 17 Oaxaca: Annual average cost savings under compensation schemes by municipality and scenario (2020–2024)

Municipality	Tariff with greatest cost savings under the net metering scheme	Annual average cost savings (%) under the net metering scheme	Tariff with greatest cost savings under the net billing scheme	% annual average cost savings under the net billing scheme
Oaxaca de Juarez	PDBT (Commercial)	70%	PDBT (Commercial)	35% (MLTE)/ 38% (ZCT)
San Juan Bautista Tuxtepec	PDBT (Commercial)	38%	DIT (Large Industry)	34%
El Barrio de la Soledad	DIST (Large Industry)	95%	DIST (Large Industry)	97%
Salina Cruz	PDBT (Commercial)	53%	GDMTH (Medium Enterprise)	54%
Santa María Huatulco	PDBT (Commercial)	41%	GDMTH (Medium Enterprise)	62%

Source: own calculations based on data from Sener, 2019, CFE, CRE, and Cenace, 2018.

Table 18 Yucatan: Estimated energy cost savings (in million pesos by tariff and scenario) under net metering scheme (2020–2049)

Period	Domestic		Commercial		Medium enterprise		Large Industry	
	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
2020–2024	18	40	271	307	385	437	22	25
2025–2029	98	293	1,407	2,137	2,163	3,293	128	194
2030–2034	199	780	2,732	5,429	4,450	8,849	266	529
2035–2039	274	1,157	3,578	7,652	6,102	13,051	368	787
2040-2044	355	1,526	4,396	9,589	7,767	16,942	471	1,028
2045–2049	560	2,495	5,347	12,022	9,713	21,839	593	1,332
Total	**1,503**	**6,291**	**17,731**	**37,135**	**30,581**	**64,411**	**1,848**	**3,896**

Source: own calculations based on data from Sener 2019 and CFE 2018.

Table 19 Yucatan: Estimated energy cost savings (in million pesos by tariff and scenario) under net billing scheme (2020–2049)

Period	Domestic		Commercial		Medium enterprise		Large Industry	
	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
2020–2024	10	12	183	214	822	962	56	65
2025–2029	44	67	511	772	2,293	3,462	155	234
2030–2034	71	140	815	1,615	3,656	7,246	247	490
2035–2039	76	162	872	1,864	3,913	8,364	265	566
2040–2044	76	166	878	1,915	3,940	8,590	266	581
2045–2049	76	171	879	1,974	3,942	8,857	267	599
Total	**354**	**718**	**4,138**	**8,355**	**18,566**	**37,482**	**1,256**	**2,535**

Source: own calculations based on data from Sener 2019, CFE, CRE, and Cenace 2018.

mers in Yucatan will benefit by 4.5 billion pesos under the net metering scheme. These benefits can be increased by 50% to 6.7 billion pesos under ZCT, with commercial and medium enterprises being the main beneficiaries, achieving more than 90% of the cumulative cost savings (for detailed sectoral data, see Table 18).

By the year 2040, cumulative savings under the ZCT pathway will exceed the economic benefits of MLTE by an additional 150%, achieving cumulative savings of 45 billion pesos, with commercial and medium enterprise sectors benefiting by 15 billion and 25 billion pesos respectively.

By the year 2030, under the current policy environment, domestic, commercial, medium enterprise, and large industry consumers in Yucatan are expected to see cumulative economic benefits of 4 billion pesos resulting from the net billing scheme. These benefits can be increased by more than 40% to 5.8 billion pesos under ZCT. By the year 2040, cumulative savings under the ZCT pathway will be almost double that of the MLTE, achieving cumulative savings of more than 26 billion pesos, of which 20 billion pesos will accrue to Yucatan's commercial sector (for detailed sectoral data, see Table 19).

YUCATAN: PRIORITY MUNICIPALITIES FOR PVDG DEPLOYMENT

In the state of Yucatan approximately 78% of domestic, commercial, and industrial[19] consumption is concentrated in five municipalities: Merida (60%), Uman (8%), Progreso (4%), Hunucma (3%), and Kanasin (2%) (CFE, 2018).

By the year 2030, the analyzed municipalities in Yucatan are estimated to cumulate 5 billion pesos from distributed PV generation through the net metering scheme under ZCT, thereby exceeding savings under the current policy pathway (MLTE) by almost 50%. Under the net metering scheme, consumers in Merida municipality will be the main beneficiaries of distributed PV generation, attracting 3.7 billion pesos of the cumulative savings (for detailed municipal data, see Table 20).

By the year 2040, consumers in Merida will benefit from 25 billion pesos cumulative savings through net metering of distributed PV generation under the ZCT pathway. Under the ZCT pathway, total savings in the analyzed municipalities are estimated at 35 billion pesos, thereby doubling the economic benefits expected with MLTE.

By 2030, under the ZCT pathway, the net metering scheme for distributed PV generation provides estimated cumulative savings of 4.3 billion pesos within the analyzed municipalities. Consumers in Merida municipality are again the main beneficiaries of distributed PV generation, accounting for 3 billion pesos of the cumulative savings (for detailed municipal data, see Table 21).

By the year 2040, cumulative savings through net billing of distributed PV generation under the ZCT pathway will exceed 20 billion pesos, thereby almost doubling economic benefits of distributed PV generation expected under MLTE.

In order to identify tariffs with the highest potential cost savings for the analyzed municipalities of Yucatan, tariffs with the highest cost savings under the net metering and net billing schemes were analyzed. Average annual energy cost savings, calculated as shares of total costs, remain the same in both scenarios. The calculations indicate that the greatest potential energy cost savings are found in the municipality of Kanasin under the PDBT (commercial) tariff for net metering, with an opportunity to save 84% of average annual costs. Meanwhile, consumers in the municipality of Uman on the GDMTH (medium enterprise) net billing tariff can potentially save 91% of annual average costs (Table 22).

Table 20 Yucatan: Estimated energy cost savings (in million pesos by municipality and scenario) under net metering scheme (2020–2049)

Period	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
	Merida		Uman		Progreso		Hunucman		Kanasin	
2020–2024	287	326	13	15	22	25	20	23	9	11
2025–2029	2,253	3,427	374	569	194	295	142	215	58	88
2030–2034	4,539	9,022	764	1,518	392	780	291	580	114	227
2035–2039	6,126	13,101	1,042	2,228	533	1,139	400	856	152	325
2040–2044	5,230	11,408	239	522	407	887	408	889	157	342
2045–2049	6,424	14,445	1,980	4,452	665	1,496	752	1,690	97	218
Total	**24,859**	**51,729**	**4,411**	**9,304**	**2,213**	**4,622**	**2,012**	**4,253**	**587**	**1,210**

Source: own calculations based on data from Sener 2019, CFE, CRE, and Cenace, 2018.

19 The calculations considered consumption registered in the tariff sectors 1, 1A–1D, DAC, PDBT, GDBT, GDTMH, GDTMO, DIST, and DIT.

Table 21 Yucatan: Estimated cost savings (in million pesos by municipality and scenario) under net billing scheme (2020–2049)

Period	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT	MLTE	ZCT
	Merida		Uman		Progreso		Hunucma		Kanasin	
2020–2024	408	461	86	97	33	38	35	40	7	8
2025–2029	1,739	2,616	365	552	142	214	149	225	30	45
2030–2034	2,677	5,132	560	1,071	218	420	228	437	47	92
2035–2039	2,961	6,300	623	1,333	242	516	254	544	51	110
2040–2044	2,981	6,469	628	1,369	243	530	256	558	52	113
2045–2049	2,983	6,670	628	1,411	243	547	256	576	52	116
Total	**13,749**	**27,648**	**2,890**	**5,833**	**1,121**	**2,265**	**1,178**	**2,380**	**239**	**484**

Source: own calculations based on data from Sener 2019, CFE, CRE and Cenace, 2018

Table 22 Yucatan: Annual average cost savings under compensation schemes (by municipality and scenario) (2020–2024)

Municipality	Tariff with greatest cost savings under the net metering scheme	Annual average cost savings (%) under net metering scheme	Tariff with the highest cost savings under net billing scheme	% annual average cost savings under net billing scheme
Merida	PDBT (Commercial)	55%	GDMTH (Medium enterprise)	60%
Uman	PDBT (Commercial)	48%	GDMTH (Medium enterprise)	91%
Progreso	PDBT (Commercial)	42%	GDMTH (Medium enterprise)	67%
Hunucma	DIST (Large industry)	78%	DIST (Large industry)	71%
Kanasin	PDBT (Commercial)	84%	PDBT (Commercial)	48%

Source: own calculations based on data from Sener 2019, CFE, CRE, and Cenace, 2018.

FISCAL IMPACTS AND SAVINGS IN THE GOVERNMENT BUDGET THROUGH INCREASING THE SHARE OF PVDG

Amounting to more than 100 billion pesos annually, electricity subsidies for residential tariffs (1 to 1F) accounted for the bulk of electricity tariff subsidies in Mexico (agricultural tariffs: 14.6 billion pesos, large industries: 13 billion pesos; GIZ, 2018).

Building on the electricity tariffs approved by CRE in 2018 for each region and consumer type as well as the Distributed Nodes Prices (DNP), this study assesses the opportunity cost for CFE across the country (see Figure 8). In terms of regional comparisons, *Peninsular, Northern Mexico Valley, Southeast, East, and South Center* were identified as regions accounting for the highest opportunity costs in view of CFE rates and DNP. In the case of the Peninsular region, the greatest differences were found for the Medium Enterprise (GDMTO) and Large Industry (DIST) sectors.

Opportunity costs for CFE in the SIN regions amount up to 45.5 billion pesos. Of this, the Peninsular region has the highest opportunity cost at approximately 3.9 billion pesos. In terms of sectoral comparison, the medium enterprise / industrial sector (GDMTH, GDMTO tariffs) accounted for the highest opportunity cost for CFE at approximately 25.5 billion pesos. To put these potential savings into a national context, the national budget of the Youth building the future project was 40 billion pesos for 2019 (DOF, 2018a).

The results illustrate the potential savings in energy costs and the opportunity for the Federal Government to actively reduce subsidies by promoting PVDG in regions with the highest potential savings in energy costs.

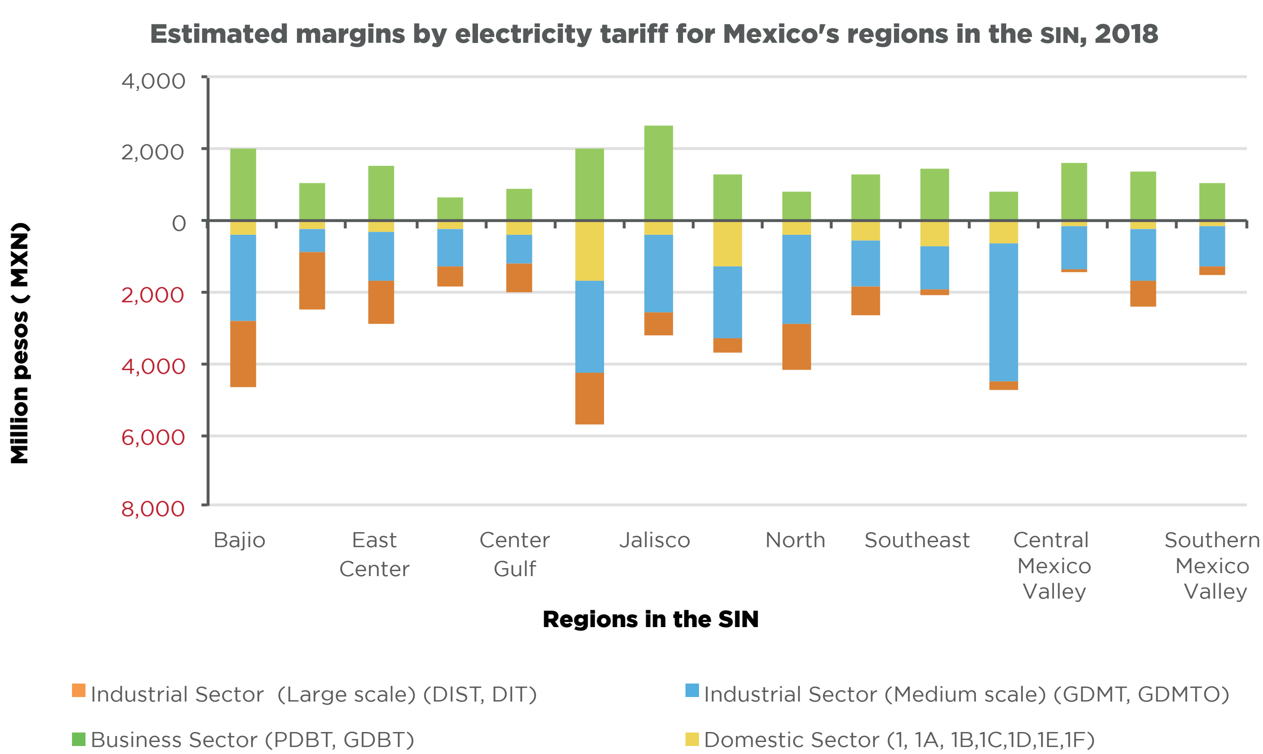
EXPLORING ADDITIONAL COMMUNITY-ORIENTED MECHANISMS FOR FINANCING DG OF RENEWABLE ENERGY

The co-benefits assessment of creating savings and incomes for communities analyzed the potential economic benefits of two prevailing existing schemes, net metering and net billing.

In a broader understanding of economic participation and community ownership of renewable energy generation, it is worth exploring additional mechanisms that are in the process of implementation or applied in other countries. Particularly in view of accelerating the deployment of clean energy to meet the goals set by the LTE and international commitments to reduce the carbon intensity of Mexico's energy sector, economic participation, and ownership by new groups of smaller-scale investors can be an important driver (cf. section 5.2.1). In this sense, the following four mechanisms can also be considered as options to further align Mexico's energy policy with the government's mission laid out in the current NDP (2019–2024):

1. **Community shares** issued by energy cooperatives and Registered Community Benefit Funds. In contrast to common shares, community shares are non-transferable and cannot be sold or traded. Shareholders can withdraw their share capital subject to specific terms and conditions defined beforehand by the issuer. The value of the share is fixed and is not subject to speculation, although share value can be reduced if the cooperative or benefit society experiences financial difficulties. If the issuer is registered to receive tax deductible donations, the share can serve as a form of tax relief.
2. **Mini Bonds** are a form of debt with fixed interest rate and term, after which they must be repaid. They can be made transferable and traded on a secondary market, meaning they can be more liquid than some other types of investment.
3. **Revenue-based financing (RbF),** also known as royalty-based financing, is a mechanism whereby companies agree to share a percentage of future revenue in exchange of capital. Under this scheme owners retain full ownership and control of their business. Moreover, the scheme allows for monthly payments to fluctuate according to revenue generation.
4. **Co-investment in communal off-grid solar.** The co-investment in off-grid solar for communities consists of pooling human and financial capital to facilitate the installation of off-grid PV systems in communities.

Figure 8 Estimated margins by electricity tariff for Mexico´s regions in the SIN, 2018 (Source: own calculations based on data from Cenace 2019 and CFE 2018)



5.2.4 Creating an enabling environment to unlock the co-benefits

The study has quantified the potential cost savings and income generation provided by PVDG for different electricity consumer groups under the tariff schemes employed in Oaxaca and Yucatan. The results show that under an ambitious decarbonization pathway, by 2030, economic benefits for consumers amount to almost 2 billion pesos in Oaxaca and more than 12 billion pesos in Yucatan. By the year 2040, these economic benefits are expected to exceed 10 billion pesos for electricity consumers in Oaxaca and 70 billion pesos in Yucatan.

Different government institutions can further improve the enabling environment in order to foster PVDG and increase economic benefits for local communities beyond the two analyzed states. Building on the Enabling Policy Workshops (cf. Chapter 3) with representatives from national and sub-national governmental organizations, the following policy options were developed to unlock the identified co-benefits:

Policy options at the national level

POLICY OPTION #1

Reinvesting government subsidies in developing a community oriented renewable energy industry — CFE, together with the Ministry of Finance, can programmatically reduce subsidies to medium and large industry in order to encourage investment in renewable energy and energy efficiency measures, while simultaneously increasing economic benefits for affected consumers. Such a reinvestment program can be designed to be socially just for affected consumer groups and can gradually release federal budgets to address other investments prioritized in the social and economic program of the NDP (see Box 1 in Chapter 1).

POLICY OPTION #2

Tendering and licensing procedures to foster local economic participation in renewable energy projects — Tendering and licensing procedures can be revised to include regulations for project developers, mandating developers and implementers ensuring financial participation from large-scale renewable energy projects (e.g., through levies for community funds) and inviting local shareholding and revenue-creation energy regulatory institutions to create a framework that fosters local economic benefits and local community support.

Policy options at the subnational level

POLICY OPTION #3

Communication program on local economic opportunities — The states can direct an assertive communication strategy and research-based campaign to identified end-users in municipalities and regions, communicating the potential savings, income generation, and multiple co-benefits of renewables and energy efficiency measures. Ongoing communication with the Agrarian Attorney General Office, which serves as the legal representative of *ejidos*[20] and communally owned land, would help to improve the relationships with local communities and include them in project implementation and economic participation.

POLICY OPTION #4

State programs to foster local shareholding and revenue creation in renewable energy projects — State governments can additionally foster local shareholding by introducing state programs to cover upfront investments for municipalities, small businesses, and households to co-invest in local renewable energy projects. These would be refinanced over time by local shareholders through a specified share of attained revenues from these projects.

Policy options at the national-subnational level

POLICY OPTION #5

Technical guidelines to facilitate PVDG — The CRE can incentivize small projects by increasing the maximum limit on DG from 499 kW to at least 1 MW in circuits or areas where there is installed capacity. Guidelines that facilitate collective DG, considering a collective scheme for net metering in different entry PoIs within the same price area, or at least within the same distribution circuit, can create additional support. This option could be accompanied by a capacity building program to increase the participation of small projects and foster income generation at the sub-national and regional level.

5.3 GENERATING FUTURE-ORIENTED EMPLOYMENT AND SKILL DEVELOPMENT

5.3.1 Understanding the context of employment and skill development in the renewable energy sector

In 2017, around 70,000 persons were employed in Mexico's renewable energy industry (IRENA, 2018). Since then, employment numbers are likely to have grown further, given the rapid growth of new wind and solar photovoltaic installations across the country, representing 45% of newly installed capacity (Sener, 2019). In 2018, Mexico quadrupled its solar PV capacity to reach 2.5 GW (IRENA, 2019). Still, in terms of overall employment, Mexico's renewable energy industry is relatively small compa-

20 Land subject to a special regime of social ownership in land tenure; such personality is constitutionally recognized and its patrimony is specially protected (Ley Agraria, 2014).

red to other industries such as the automotive and construction sector (INEGI, 2019).

Employment in the emerging renewable energy industry and economy-wide spillover effects can become important contributors to achieving the social agenda set out by the Federal Government. As the NDP suggests, creating quality employment opportunities in the country is closely connected with skill requirements along the industrial value chain and training capacities for future-oriented skills (see Box 1 in Chapter 1). So far, knowledge gaps exist not only in terms of estimating potential employment opportunities in the renewable energy industry in Mexico, but also in terms of better understanding the skill requirements of this emerging industry and the expected demand for vocational training.

Lastly, the fact that the renewable energy industry is still emerging in Mexico implies that if the government seeks to further develop the renewable energy value chain in the country, this development should be accompanied by a suitable policy environment. In this regard, international examples on introducing local content or manufacturing requirements, or adapting the "Youth building the future" program for the renewable energy sector, might provide useful impulses.

5.3.2 Assessment methodology

Employment impacts were quantified using the International Jobs and Economic Development Impacts (I-JEDI) model developed by the National Renewable Energy Laboratory (NREL) (NREL, 2016, see Box 10), adapted for Mexico. To specify the model for the Mexican context, country-specific input data was derived from existing literature. In a second step, this data was reviewed, verified, updated with missing information, and corrected for anomalies through qualitative inquiries, interviews, and regional workshops in Oaxaca and Yucatan. Furthermore, interviews were used to estimate the skill needs by disaggregating the value chain of renewable energy employment.

In the course of the national and regional workshops (cf. Chapter 3), policy options were developed to unlock the identified employment opportunities.

Within its comparative approach, the co-benefits assessment for employment considers two contrasting pathways for the future development of the power sector in Mexico from 2020 to 2050: MLTE pathway, building on Mexico's LTE, and the ZCT pathway, utilizing the same early base as the Prodesen, but projected to a greater ambition and penetration of renewable energies (see Chapter 3).

The study focused on the gross employment impacts of solar PV and wind power for Mexico. However, the presented data also enables comparison of differing employment effects across all main electricity generation capacities, including hydro, coal, and gas power (CCGT). As neither of the analyzed pathways foresee substitution effects on planned generation capacity from natural gas by solar before 2035 (ZCT) and 2045 (MLTE), the assessment focused on the gross employment effects of renewable energy additions during this time. Policy planning beyond these horizons will need to take into account substitution effects between natural gas and renewable energy generation.

This study analyzes employment impacts in terms of job years, i.e., full-time equivalent (FTE) units per annum. This approach accounts for part-time and full-time workers in a comparable way. One job is equivalent to one job year, with the total number of jobs indicating the total number of people employed during a specific year. Gross employment effects are categorized along three types of employment effects: direct, indirect, and induced employment (IRENA, 2019, see Box 9).

5.3.3 Results of the co-benefits assessment

Estimating employment opportunities for different power sector pathways

The achievement of MLTE would create more than 375,000 direct and indirect job years by 2030 and more than 1 million direct and indirect job years by 2050. A shift from the MLTE to the ZCT pathway would create 77% more new job years in the power sector by 2030, amounting to more than 290,000 new direct and indirect job years. Until the year 2050, job additions in the ZCT pathway will almost double compared to MLTE pathway, adding more than 912,000 new direct and indirect job years (Figure 9).

In the short run, the renewables industry can add more than 322,000 direct and indirect job years by 2024 under (MLTE. A shift from the MLTE to the ZCT pathway would create 17% more new job years in the power sector by 2024, adding more than 54,000 new direct and indirect job years (Figure 9).

Box 9 Analyzed types of employment effects

DIRECT, INDIRECT, AND INDUCED EMPLOYMENT

Direct – Direct project development expenditures; example: PV installers

Indirect – Spinoff economic activity & supply chain effects; example: Steel workers

Induced – Expenditures by direct & indirect workers; example: Hotels, airlines

Box 10 International Jobs and Economic Development Impacts (I-JEDI) model

I-JEDI IN A NUTSHELL

- Jobs and economic development impacts
- User-friendly Excel-based tool
- Quantifies the economic impacts of building and operating large-scale renewable energy projects

The I-JEDImodel estimates the economic impacts associated with the construction and operation of power plants, by characterizing these two phases in terms of domestic (in-country) and international expenditure. The model data are then used in a country-specific input–output (I–O) model to estimate employment, earnings, GDP, and gross output impacts. Total economic impacts are presented, as well as impacts per industrial sector. The model is used to estimate gross employment in the assessment, since it only considers the positive direct, indirect, and induced employment impacts of the value chain.

Source: NREL, 2016

Broad economy-wide employment impacts

Employment benefits in the installation and operation phases of renewable energy projects also lead to additional spillover effects in the wider economy. These induced employment impacts appear across different sectors and create employment e.g., in housing and service sectors such as transport and health services.

These economic spillover effects in the country, triggered by investments in wind and solar energy, can create more than 200,000 and 250,000 additional induced job years in the MLTE and ZCT scenarios respectively, in the period 2020–2024; and up to 255,000 and 475,000 additional induced jobs in the MLTE and ZCT scenarios respectively in the period 2024–2030 (Figure 10).

The employment opportunities created by the spillover effect of scaling up renewables in Mexico create between 39% and 41% additional job years in each period presented in Figure 10. A shift to the ZCT scenario can create a total of 640,000 job years by 2024 and a total of 3,200,000 job years by 2049, including direct, indirect, and induced jobs.

Comparing employment opportunities across energy technologies

In the construction phase, all renewable energy technologies outperform fossil power generation technologies, particularly wind power with more than 21 job years per installed MW and PVDG with around 9.5 job years per installed MW, compared to 5.5 job years for coal power and 1 job year for gas power (CCGT, see Figure 11).

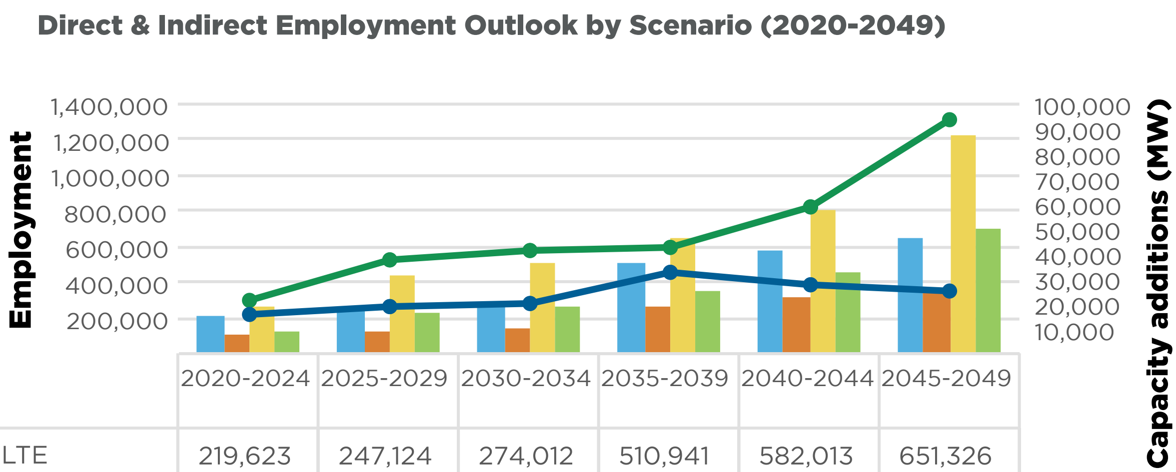
In the operation & maintenance (O&M) phase, solar PV and PVDG perform particularly well, albeit at a lower overall level, with around 0.4 job year per installed MW, compared to 0.14 job years for coal power, 0.08 for wind, and 0.05 job years for gas power (Figure 12).

The construction phase, together with O&M, creates around 45.74 job years per MW installed for wind power and around 18.14 job years per MW installed for solar PV power, compared to 11.3 job years per MW installed for coal power and around 3.61 job years per MW installed for gas power (Figure 11 and Figure 12).

Distribution of employment effects across the renewable energy value chain

Most of the direct and indirect jobs generated from renewables are related to construction, manufacturing, transportation and warehousing, finance, professional and business, and sales (Figure 13 and Figure 14). In order to assess the demand for various types of skills, the I-JEDImodel clustered the output results into sectors for both the construction and O&M phases.

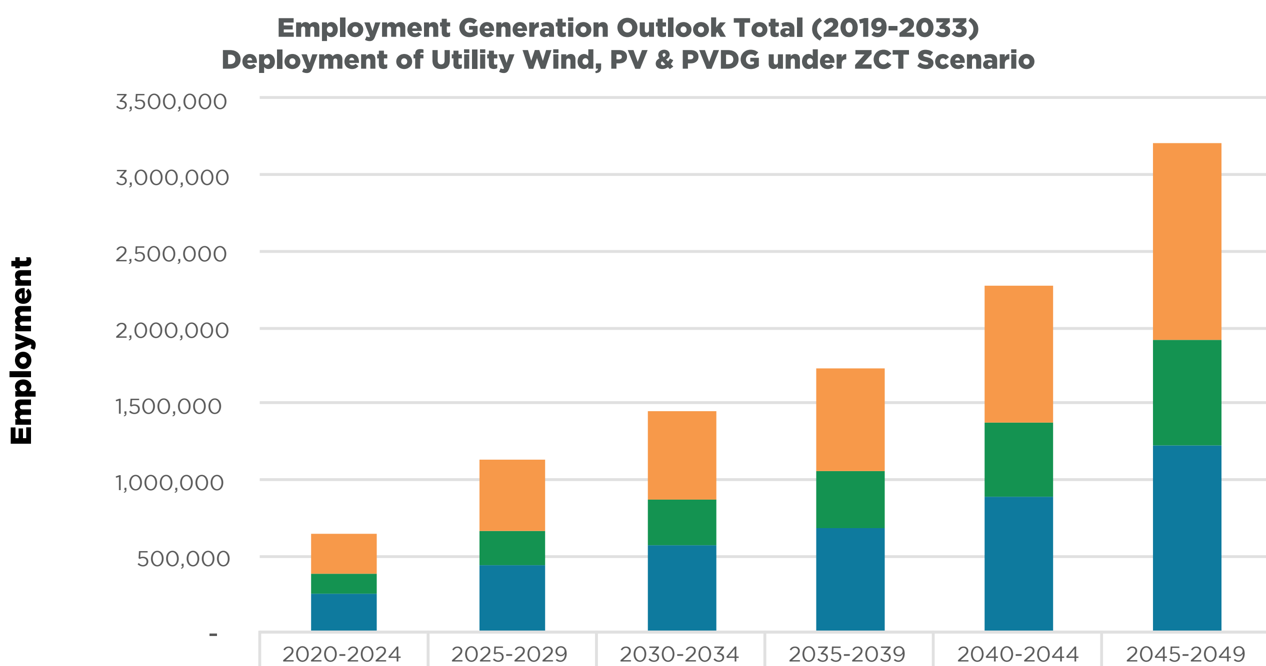
Figure 9 Direct and indirect employment outlook by scenario (2020–2049)



	2020-2024	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049
Direct MLTE	219,623	247,124	274,012	510,941	582,013	651,326
Indirect MLTE	103,268	129,427	141,499	261,351	310,336	359,474
Direct ZCT	262,412	438,187	503,115	650,008	802,887	1,228,468
Indirect ZCT	126,293	229,549	261,824	354,647	457,842	694,872
Additions ZCT (MW)	21,144	37,732	41,804	42,483	58,224	93,689
Additions MLTE (MW)	15,692	18,705	19,547	32,177	26,946	25,670

Job Years per Period

Figure 10 Deployment of utility wind, PV & PVDG under ZCT scenario

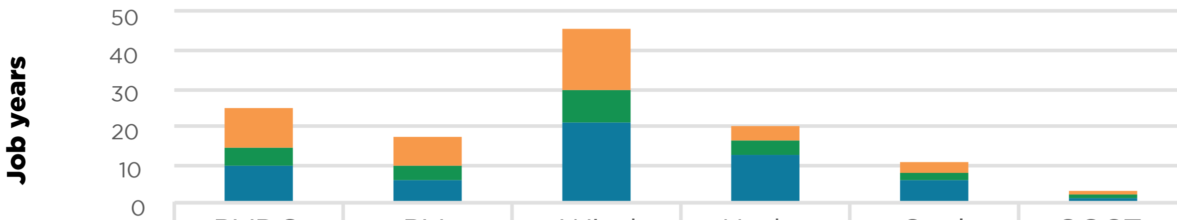


	2020-2024	2025-2029	2030-2034	2035-2039	2040-2044	2045-2049
Induced ZCT	254,464	471,038	579,773	670,486	890,794	1,282,019
Indirect ZCT	125,241	227,607	302,284	371,064	494,082	702,132
Direct ZCT	258,625	431,197	566,944	687,508	879,858	1,218,354

Job Years per Period

Figure 11 Employment generation by technology in the construction phase (per MW/yr)

Construction Employment Generation by Technology (per MW installed)

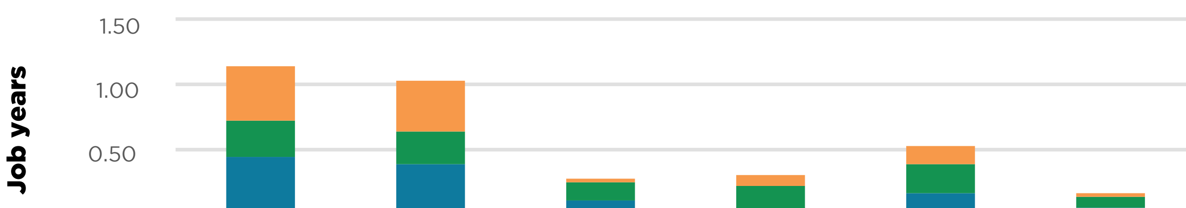


	PVDG	PV	Wind	Hydro	Coal	GGCT
Induced	11.07	7.83	15.89	4.16	2.58	1.07
Indirect	4.64	3.23	8.06	4.12	2.63	1.29
Direct	9.52	6.06	21.42	12.13	5.57	1.09

Technology

Figure 12 Employment Generation by technology in the operation & maintenance (O&M) phase (per MW/yr)

O&M Employment Generation by Technology (per MW/yr)



	PVDG	PV	Wind	Hydro	Coal	GGCT
Induced	0.42	0.38	0.00	0.06	0.13	0.03
Indirect	0.28	0.26	0.16	0.2	0.25	0.08
Direct	0.45	0.38	0.08	0.02	0.14	0.05

Technology

Between 2020 and 2034, the construction phase will create the most jobs in finance, professional, and business services, followed by jobs required for construction. More than 38% of the indirect jobs will be created in finance, professional, and business services. Meanwhile, 29% of direct jobs will be created in the transportation and warehousing sector (Figure 13).

Between 2020 and 2034, the O&M phase will also create the most jobs in finance, professional, and business services, followed by jobs in construction. More than 59% of jobs will be created between sales, and in finance, professional, and business services (Figure 14).

Availability and demand of skilled labor in Mexico

The comparison of the available labor force (number of graduates) with future job demands in the renewable energy sector shows that Mexico's current education system and number of university graduates can meet the increasing labor demand for most of the assessed productive sectors. Between 2020 and 2034, there will be more than 113,000 job years required, whereas in 2018 there were more than 366,000 enrolled students and 57,000 other graduates (Figure 15).

A gap ratio is estimated, dividing the total job demand for each sector by the 10% of graduates (2018) and 10% of enrolled students in relevant programs. There are enough enrolled students to cover the future yearly demand for jobs in all knowledge areas. However, there is a skill gap for most knowledge areas when examining 2018 graduates (i.e., when the gap ratio is 1) (Figure 15).

The skill gap could be easily eliminated by promoting a higher ratio of graduated versus enrolled students. Nonetheless, it is important to highlight that the assessment was not elaborated based on job localization, and it will therefore be important to match graduates and employment locations throughout the country. Additional analyses can provide further evidence on geographical distribution effects, in order to tailor skill development and capacity building to regional demands. In conclusion, there are enough young people interested in enrolling in undergraduate programs relevant for the deployment of renewable energy to fulfil the employment requirements over the next 14 years (ANUIES, 2019).

Figure 13 Distribution of employment effects across the renewable energy value chain

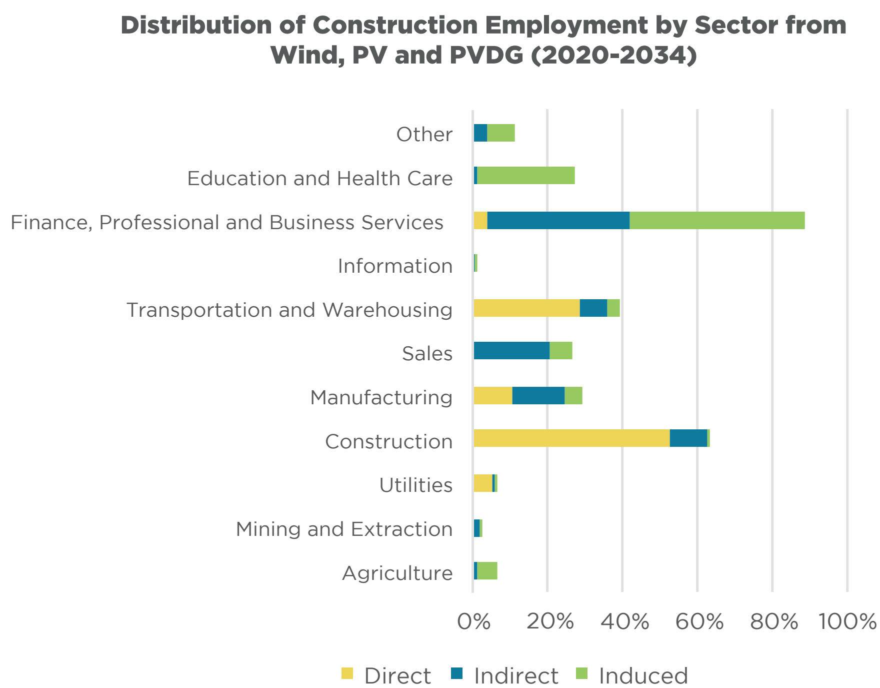


Figure 14 Distribution of employment effects across the renewable energy value chain

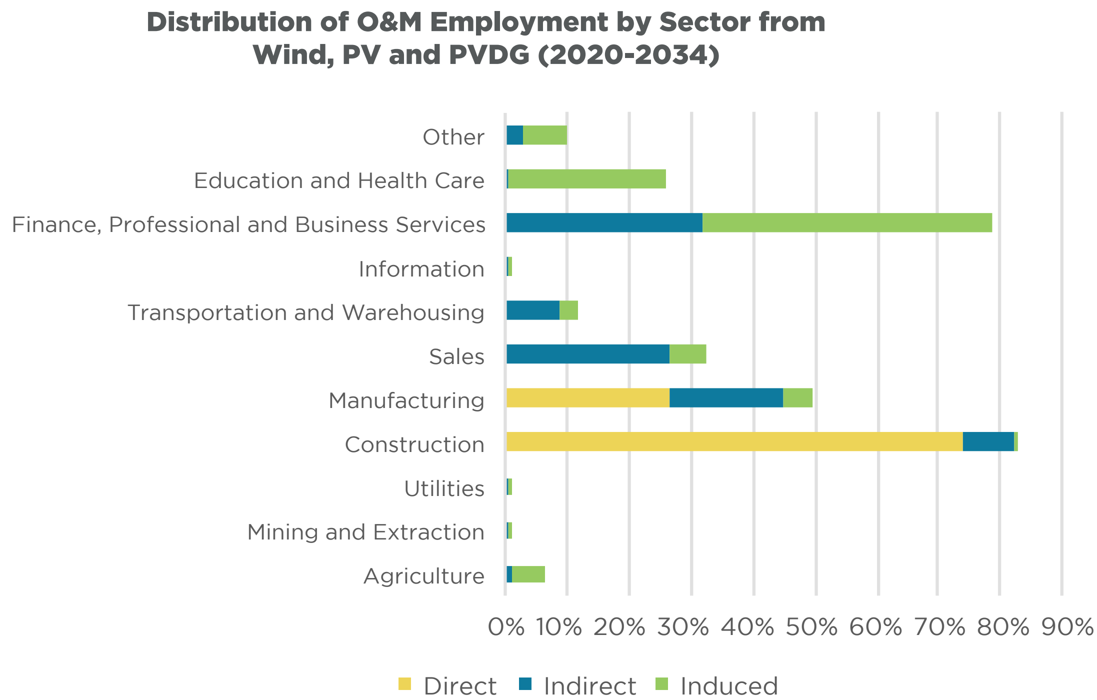
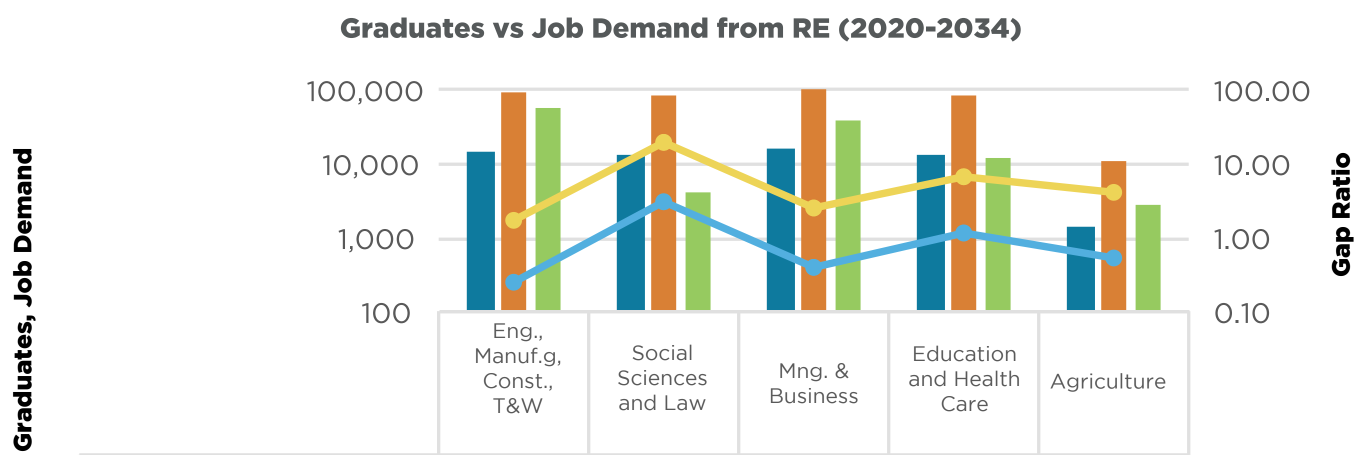


Figure 15 Availability and demand of skilled labor in Mexico



	Eng., Manuf.g, Const., T&W	Social Sciences and Law	Mng. & Business	Education and Health Care	Agriculture
10% Graduates 2018	13,968	12,652	15,564	13,748	1,456
10% Enrolled 2018	95,957	80,315	97,821	81,389	10,913
Job Demand per Year (2020-2034)	55,804	4,159	38,796	12,273	2,666
Grads. Vs Demand	0.25	3.04	0.40	1.12	0.55
Enroll. vs. Demand	1.72	19.31	2.52	6.63	4.09

Graduate Programs

5.3.4 Creating an enabling environment to unlock co-benefits

Within the term of the NDP (2019–2024) under the LTE policy environment, more than 320,000 job years (direct and indirect) can be expected in the power sector. A shift ZCT would increase this number with an additional 17% of new job years in the power sector by 2024. As the data suggests, employment in the emerging renewable energy industry and economy-wide spillover effects can contribute to achieving the social agenda of creating quality employment opportunities in the country, as set out by the government's NDP.

The federal and state governments can consider options to accompany the development of the emerging domestic renewable energy value chain in order to spark socio-economic benefits in the country and develop future-oriented skills among the Mexican workforce. Building on the Enabling Policy Workshops (cf. Chapter 3) with representatives from national and sub-national governmental entities, the following policy options were developed:

Policy options at the national level

POLICY OPTION #1

Job creation through the accomplishment of climate and energy targets — By fully implementing the targets set in the LTE, Mexico will have created more than 375,000 direct and indirect job years by 2030 and more than 1 million direct and indirect job years by 2050.

POLICY OPTION #2

Achieving employment through renewable energy — In the construction phase, all renewable energy technologies outperform fossil power generation technologies, particularly wind power with more than 21 job years per installed MW, and PVDG with around 9.5 job years per installed MW, compared to 5.5 job years for coal power and 1 job year for gas power (CCGT). In the O&M phase, solar PV and PVDG perform particularly well, albeit at a lower overall level, with around 0.4 job years per installed MW, compared to 0.14 job years for coal power, 0.08 for wind, and 0.05 job years for gas power.

POLICY OPTION #3

"Youth building the future" program on renewable energy — Targeting companies in the renewable energy industry to join forces with successful governmental welfare programs to attract young talent to the emerging industry and sending a strong message on the growing relevance of this sector. Additionally, public/private participation mechanisms can be explored, through which renewable energy projects can directly contribute to these programs.

POLICY OPTION #4

Introducing local content requirements — Tendering and licensing procedures can be revised to include regulations on using local technology components, thereby strengthening domestic industrial development and jobs (direct and indirect) across the renewable energy value chain. Additional requirements concerning local community employment can foster local employment impacts and contribute to social and economic community development. However, the design phase of these measures should investigate and consider positive as well as negative cost effects of local content and manufacturing.

Policy options at the subnational level

POLICY OPTION #5

Have the right job in the right place — The skill gap assessment shows that Mexico can cover most of the skill demand for the renewable energy sector on a national basis. However, skilled labor must be localized so that the employment needs generated by the construction and O&M of projects can be met. States with large potential for PV and wind power deployment should engage more with the private sector and educational and training institutions in order to identify the skills, and knowledge required by the renewables industry along the supply chain. States should review their undergraduate programs accordingly, in order to better prepare students for joining the renewables industry.

Policy options at the national-subnational level

POLICY OPTION #6

Future energy transition partnerships — Advancements in renewable energy and sustainability not only come from established players. Sparking local innovations through contests among students and young developers — and creating renewable energy laboratories for these target groups, private companies, start-ups, and universities — can facilitate the recognition of renewable energy as a future-oriented industry in Mexico.

6. THE WAY FORWARD: CO-BENEFITS AS FACILITATORS OF SUSTAINABLE DEVELOPMENT IN MEXICO

NATIONAL DEVELOPMENT PLAN: REGIONAL JUST TRANSITION DIALOGUES TO DELIVER SOCIAL BENEFITS

Mexico's energy transition, putting renewable energy and energy efficiency at the center of its electricity supply, is opening the door for future-oriented employment, new income sources for local communities, and releasing resources for public schools and hospitals. The study has shown that while current government policy — namely the LTE and Prodesen — can be expected to generate substantial benefits for the people of Mexico, there is room for more: With a more ambitious energy decarbonization pathway, these social and economic benefits can be increased considerably. With these opportunities at hand, it becomes apparent that renewable energy and energy efficiency can be cornerstones in achieving the social promises of the NDP, as has already been suggested by the Mexican Government (see Box 3 Mexico's key energy and climate policies: legal framework and established goals / DOF, 2019a).

While awareness of the social opportunities connected to the energy transition has increased in the public discourse, recent experiences in Mexican states such as Oaxaca show that sensitivity is also increasing — that social promises are met and opportunities for local communities are being delivered. As the data in this report clearly indicates, Mexico's energy transition can facilitate the government's pledge for social justice and equality. However, the numbers also come with the responsibility to lay out an enabling political environment to ensure that the identified opportunities are actually delivered to citizens and local communities.

In line with the NDP, state governments and local community leaders can spearhead community-centered energy planning to unlock local benefits, anticipating conflicts and creating political and economic ownership of these projects among citizens. Recent international experiences, such as the successful regional Just Transition Dialogues on South Africa's energy future, can be used as impulses for shaping Mexico's energy transition.

Policy Opportunity: **Just Energy Transition Dialogues –** launching a dialogue series (federal and regional level) with representatives of local communities and businesses, local policy makers, and implementers, to address local opportunities as well as concerns, and jointly identifying options to maximize the social benefits of renewable energy and energy efficiency projects. This can be an important step in aligning Mexico's energy transition with the NDP and the government's mission to achieve greater well-being for everyone.

MAKING THE PARIS AGREEMENT A SUCCESS FOR THE PLANET AND THE PEOPLE OF MEXICO

Mexico, alongside 187 other countries,[21] has ratified the Paris Agreement and committed to the global goal of substantially decreasing GHG emissions in order to restrict the average global temperature increase to well below 2°C, and to continue efforts to limit it to 1.5°C. This endeavor implies to complete the decarbonization of all major sectors of the economy by 2050, including the energy sector (IPCC, 2018). Mexico has aligned its international commitment in its NDC, with milestones formulated in the LTE (Federal Government of Mexico, 2015), which foresees a *partial decarbonization* of the energy sector, by achieving 35% and 50% of electricity generation from clean energy sources by 2024 and 2050 respectively.

As this report, alongside other recent studies, shows, decarbonization of the energy sector can open up an array of new social and economic co-benefits (cf. Oficina de la Presidencia & GIZ, 2019; GIZ, 2018b). By introducing schemes in which saved energy costs are reinvested in improving infrastructure and services of public schools and hospitals, and by educating the engineers of the new energy world, the federal and state governments of

21 Date of retrieval, 22.10.2019: https://unfccc.int/process/the-paris-agreement/status-of-ratification

Mexico can shape the enabling environment to unlock these development opportunities for people and local communities.

Besides global climate action, worldwide social and economic opportunities for welfare and prosperity have become the main drivers of continuously increasing investments in renewable energy and energy efficiency. By ratcheting up Mexico's energy transition and making the NDC a declaration of opportunity for current and future generations in Mexico, the government can both deliver on its social promise and strengthen the country's frontrunner position in global climate action.

Policy Opportunity: Making co-benefits part of Mexico's NDC – Building on the introductory notion of Mexico's NDC to enable health and wellbeing co-benefits for the Mexican population, through the NDC revision process, the government can make use of the opportunity to include a 'Co-Benefits' section that specifies and communicates the social and economic co-benefits it seeks to leverage for the country, and how climate action can play an active role in the government's social policy.

ACTIVATING THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT FOR MEXICO

This report builds on mutual learning, across sectors and government departments, concerning development priorities, policy options, and connecting political agendas for the benefit of the Mexican people. Applying the co-benefits approach has proven to be an important facilitator for overcoming policy silos and transforming traditional conflicts of interest into new policy coalitions (see Chapter 3). Recent studies published by the Government of Mexico indicate that leveraging co-benefits also offers a promising approach beyond the energy sector, e.g., in transportation and improving energy efficiency in the industrial sector (cf. Oficina de la Presidencia & GIZ, 2019; GIZ, 2018b).

The co-benefits approach yields quantifiable impacts of policy interventions across sectors and allows the design of policy schemes that unlock social and economic opportunities. This report compiles a list of policy options in different sectors, to enable communities and citizens to directly benefit from renewable energy and energy efficiency, thereby serving multiple policy goals. On the other hand, the co-benefits approach allows sectoral policy schemes to be designed so that benefits in other sectors are promoted simultaneously. International experience shows, for example, how national climate protection legislation can provide industry and businesses with investment security and direction, thereby unleashing private investment to build up future-oriented industries and domestic employment.

The 2030 Agenda for Sustainable Development and the growing body of research on its implementation provides an analytic framework to identify the relevant co-benefits of sectoral policies and to design policy schemes to maximize cross-sectoral co-benefits, e.g., between climate pledges, energy policies, and the NDP. On the other hand, regional dialogues (such as the 2019 co-benefits workshops in Baja California, Oaxaca, Mexico City, and Yucatan) can play an important role in visualizing and applying the SDG for local communities.

Policy Opportunity: **Introducing a Co-Benefits Approach to Inter-Ministerial Working Groups—** Building on the insights and impulses of the suggested regional and national energy transition dialogues, inter-ministerial working groups (such as the Inter-ministerial Commission on Climate Change or the Advisory Board for the Energy Transition) can be mandated to incorporate considerations of social and economic opportunities for local communities and businesses into their policy work. With its 2030 Agenda Directorate and in view of the SDG, the Office of the Presidency can be an important facilitator in shaping cross-sectoral policy interventions.

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ANNEX

Annex Table 1 National and federal state government organizations and additional stakeholders involved in the study co-design and knowledge co-creation (in alphabetic order)

National Government	State Government	Additional Stakeholders
Centro Nacional de Control de Energía (Cenace)	Gobierno de la Ciudad de México	Agencia internacional de Energía (IEA)
Comisión Nacional para el Uso Eficiente de la Energía (Conuee)	Gobierno del Estado de Baja California Sur	Alianza por la Eficiencia Energética
Comisión Reguladora de Energía (CRE)	Gobierno del Estado de Campeche	Asociación de Empresas para el Ahorro de Energía en la Edificación A.C.
Instituto Nacional de Ecología y Cambio Climático (INECC)	Gobierno del Estado de Hidalgo	Asociación Mexicana de Energía Eólica (AMDEE)
Instituto Nacional de Electricidad y Energías Limpias (INEEL)	Gobierno del Estado de Jalisco	Centro Mario Molina
Presidencia de la República	Gobierno del Estado de Oaxaca	Gesellschaft für internationale Zusammenarbeit (GIZ)
Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)	Gobierno del Estado de Querétaro	Institute for Advanced Sustainability Studies (IASS)
Secretaría del Trabajo y Previsión Social (STPS)	Gobierno del Estado de Sonora	Iniciativa Climática de México (ICM)
	Gobierno del Estado de Yucatán	Instituto Nacional de la Infraestructura Educativa (Inifed)
		Ithaca Environmental
		Universidad Nacional Autónoma de México (UNAM)

Annex Table 2 Energy saving and generation options for schools and hospitals: Tiers of analysis

	Schools: Energy savings / generation options:	Hospitals: Energy savings / generation options:
Tier 1 – zero to low-cost energy efficiency investments	Disconnect the refrigerator at weekends Enable 'sleep' energy-saving mode for PC equipment Disconnect equipment to avoid ghost-consumption Turn off the lights when not used	Turn off lighting and use natural light Clustering of lighting circuits Install photocells to control lighting in hallways Reduce the operational hours of lighting equipment Install timers in water disposals Energy-saving mode
Tier 2 – medium-level energy efficiency investments	Update the standard illumination system for a more efficient version Implement an automated control system for exterior and hallway lighting Exchange air conditioning systems with high-efficiency equipment Request a change of electricity tariff from 2 to GDMTO[24] Substitute high-consumption electrical devices for high-efficiency versions	Install movement sensors Natural dome-lighting Substitute PC hardware Substitute electrical motors with high-efficiency motors Change electricity tariff from PDBT[25] to GDMTO Install capacity banks Replace conventional air conditioning equipment with high-efficiency equipment Replace package and chiller equipment Increase the area of parasols Install a shed area Install ice banks Control energy demand during peak times Install frequency variations Change electric transformers with more efficient models Incorporate addition charge from generation plants Cogeneration system More efficient elevators
Tier 3 – combined investment in PV self-generation and medium-level energy efficiency measures	*In addition to Tier 2 measures:* Installation of PV system interconnected to the grid	*In addition to Tier 2 measures:* Installation of PV system interconnected to the grid Exterior solar panel illumination

22 GDMTO: Ordinary rate for general service at medium voltage, with demand less than 100 kW.

23 PBDT: Ordinary rate for general service at low voltage, with demand less than 24 kW. Except for the services for which the rate is specifically set.

Annex Table 3 Generating savings and incomes for communities: Steps of analysis and analytic equations

No. equation	Equation	Variables	Source
1 Projection of electricity consumption at state and municipal level	**1.1. State level** $ECS_n=[(CAGR + 1)^n] * ECS_i$ **1.2. Municipal level** $ECM_n= [(CAGR+1)^n] *ECM_i$	ECS_i =Value, in MWh/year, of electricity consumption registered at **state level** in Oaxaca and Yucatan in 2018 (1): • Yucatan: 3,622,797.29 MW/year • Oaxaca: 2,747,443.49 MW/year ECM_i =Value, in MWh/year, of electricity consumption registered **by municipality** in Oaxaca and Yucatan in 2018(1). CAGR = Compound annual growth rate of electricity consumption in Oaxaca and Yucatan (2): • Yucatan: 3.8% • Oaxaca: 3.3% n = Number of years ECS_n = Estimated value, in MWh/year, of electricity consumption registered in Oaxaca and Yucatan or in "n" year. ECM_n = Estimated value, in MWh/year, of electricity consumption registered in the **municipality** in "n" year.	(1) (CFE, 2018) (2) Prodesen 2019–2033.
2. Projection of electricity consumption by tariff at state and municipal level in Oaxaca and Yucatan for the 2020–2049 period	**2.1. Estate level** $ECTS_{x,n}=[(CAGR+1)^n]*ECTS_{x,i}$ **2.2. Municipal level** $ECTM_{x,n}=[(CAGR+1)^n]*ECTM_{x,i}$	$ECTS_{x,n}$ = Value, in MWh/year, of electricity consumption registered in the "x" tariff, in "n" year at **state level** in Oaxaca and Yucatan. $ECTS_{x,i}$ = Value, in MWh/year, of electricity consumption registered in "x" tariff in 2018, at **state level** in Oaxaca and Yucatan. CAGR = Compound annual growth rate of electricity consumption in Oaxaca and Yucatan (2): • Yucatan: 3.8% • Oaxaca: 3.3% n = Number of years $ECTM_{x,n}$ = Value, in MWh/year, of electricity consumption registered in the "x" tariff, in "n" year **at municipal level** in Oaxaca and Yucatan. $ECTM_{x,i}$ = Value, in MWh/year, of electricity consumption registered in "x" tariff in 2018, **at municipal level**.	

No. equation	Equation	Variables	Source
3. Projection of CFE´s electricity tariffs for the 2020–2049 period	$TF_n=[(CAGR+1)^n]*T_i$	T_i = CFE´s tariff, in $MXN/MWh, registered in 2018 by sector and region (3). CAGR= Compound annual growth rate of the CFE´s tariffs (4): • Domestic (1–1F): 2.6% • DAC: 4.8% • Industrial (PDBT, GDBT, GDMTH, GDMTO, DIS, DIT): 3.6% n = Number of years TF_n: Estimated tariff, in $MXN/MWh, by sector in "$n$" year.	(3) (CFE, 2019) (4) (ABM, 2017)
4. Estimation of installed capacity of distributed generation in Oaxaca and Yucatan. **(State and municipal level)**	**4.1. State level** $DGS_n=DGN_n\times(\%DGS_i)$	DGS_n = Estimated distributed generation installed capacity (MW) at state level in "n" year under MLTE and ZCT scenarios. DGN_n = Estimated distributed generation installed capacity (MW) at national level in "n" year according to the MLTE and ZCT scenarios. $\%DGS_i$ = Percentage of distributed generation capacity installed at state level in 2018 (5): • Yucatan: 5% • Oaxaca: 1%	(5) (CRE, 2019)
	4.2. Municipal level $DGM_n=DGS_n\times(\%ECM_i)$	DGM_n = Estimated distributed generation installed capacity (MW) at **municipal level** in "n" year under MLTE and ZCT scenarios. DGS_n = Estimated distributed generation installed capacity (MW) at **state level** in "n" year under MLTE and ZCT scenarios. $\%ECM_i$ = Percentage of electricity consumption registered in the municipality in 2018 (6).	(6) (CFE, 2018)

No. equation	Equation	Variables	Source
5. Estimation of distributed generation installed capacity by tariff at state and municipal level	**5.1. State level** $DGTS_{x,n}=\%ECTS_{x,n}\times(DGS_n)$	$DGTS_{x,n}$ = Estimated distributed generation installed capacity (MW) at state level by tariff "x" in "*n*" year. $\%ECTS_{x,n}$ = Percentage of electricity consumption registered in "x" tariff, in "n" year, at state level in Oaxaca and Yucatan. DGS_n = Estimated distributed generation installed capacity (MW) **at state level** in "*n*" year under MLTE and ZCT scenarios.	
	5.2. Municipal level $DGTM_{x,n}=\%ECTM_{x,n}\times(DGM_n)$	$DGTM_{x,n}$ = Estimated distributed generation installed capacity (MW) **at municipal level** by tariff "x" in "*n*" year. $\%ECTM_{x,n}$ = Percentage of electricity consumption registered in "x" tariff, in "n" year, **at municipal level** in Oaxaca and Yucatan. DGM_n = Estimated distributed generation installed capacity (MW) **at municipal level** in "n" year under MLTE and ZCT scenarios.	

No. equation	Equation	Variables	Source
6. Quantification of cost savings under net metering scheme	**6.1. State level** $NMSS_{x,n}=(FBAUS_{x,n}-FNMS_{x,n})-(LCOE\times GS_{x,n})$ $\%NMSS_{x,n}=\frac{NMSS_{x,n}}{FBAUS_{x,n}}\times 100$ Where; $FNMS_{x,n}=CNTS_{x,n}\times TF_{n}$ $FBAUS_{x,n}=ECTS_{x,n}\times TF_{n}$ $CNTS_{x,n}=ECTS_{x,n}-GS_{x,n}$ $GS_{x,n}=DGTS_{x,n}\times SH\times FP$	$NMSS_{x,n}$ = Estimated cost savings under Net Met Metering scheme by tariff "x" in "n" year at state level. $FNMS_{x,n}$ = Billing in tariff "x" during "n" year under Net Metering scheme at state level. $FBAUS_{x,n}$ = Billing without Net Metering scheme in "x" tariff during "n" year at state level. LCOE = Levelized cost of energy (LCOE) = 0.80 $/kW $GS_{x,n}$ = Electricity generation by tariff "x" in the "n" year at state level. $CNTS_{x,n}$ = Net Energy Consumption in the "x" tariff in the "n" year at state level. SH = Hours of sun per year = 8,760 hrs FP = Average plant factor in Mexico: 17% (7)	(7) Prodesen 2018–2032 (Sener, 2018)
	6.2. Municipal level $NMSM_{x,n}=(FNMM_{x,n}-FBAUM_{x,n})-(LCOE\times GS_{x,n})$ $\%NMSS_{x,n}=\frac{NMSS_{x,n}}{FBAUS_{x,n}}\times 100$ Where; $FNMM_{x,n}=CNTM_{x,n}\times TF_{n}$ $FBAUM_{x,n}=ECTM_{x,n}\times TF_{n}$ $CNTM_{x,n}=ECTM_{x,n}-GM_{x,n}$ $GM_{x,n}=DGTM_{x,n}\times SH\times FP$	$NMSM_{x,}$ = Estimated cost savings under Net metering scheme by tariff "x" during "n" year at municipal level. $FNMM_{x,n}$ = Billing in tariff "x" during "n" year, under net metering scheme at municipal level. $FBAUM_{x,n}$ = Billing without net metering scheme in "x" tariff during "n" year at municipal level. LCOE = Levelized cost of energy (LCOE) = 0.80 $/kW $GM_{x,n}$ = Electricity generation by tariff "x" during "n" year at municipal level. $CNTM_{x,n}$ = Net energy consumption in "x" tariff during "n" year at municipal level. SH = Hours of sun per year = 8,760 hrs FP = Average plant factor in Mexico: 17% (7)	

No. equation	Equation	Variables	Source
7. Quantification of cost savings under net billing	**7.1. State level** $NBSS_{x,n}=FBAUS_{x,n}-FNWS_{x,n}$ $\%NBSS_{x,n}=\frac{NWSS_{x,n}}{FBAUS_{x,n}}\times 100$ Where; $FNBS_{x,n}=FBAUS_{x,n}-[FWS_{x,n}-(LCOE\times GS_{x,n})]$ $FWS_{x,n}=GS_{x,n}\times \overline{PML}_{y,n}$ (Wholesale)	$FWS_{x,n}$ = Wholesale of energy considering "x" tariff during "n" year, at state level. $\overline{PML}_{y,n}$ = Average PML in "y" node during "n" year (Assumes annual growth of 3.5%). Ticul (Yucatan) and Oaxaca (Oaxaca) nodes were assumed. $FNBS_{x,n}$ = Net billing in "x" tariff during "*n*" year at state level. $NBSS_{x,n}$ = Estimated cost savings under net billing scheme by tariff "x" during "*n*" year at state level. $\%NBSS_{x,n}$ = Percentage of estimated cost savings under net billing scheme by tariff "x" during "n" year at state level.	
	7.2. Municipal level $NBSM_{x,n}=FBAUM_{x,n}-FNWM_{x,n}$ $\%NBSM_{x,n}=\frac{NWSM_{x,n}}{FBAUM_{x,n}}\times 100$ Where; $FNBM_{x,n}=FBAUM_{x,n}-[FWM_{x,n}-(LCOE\times GM_{x,n})]$ $FWM_{x,n}=GM_{x,n}\times \overline{PML}_{y,n}$	$FWM_{x,n}$ = Wholesale of energy considering "x" tariff during "n" year at municipal level. $FNBM_{x,n}$ = Net billing in "x" tariff during "n" year at municipal level. $NBSM_{x,n}$ = Estimated cost savings under Net Billing scheme by tariff "x" during "n" year at municipal level. $\%NBSM_{x,n}$ = Percentage of estimated cost savings under net billing scheme by tariff "x" during "n" year at municipal level.	

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