REPORT

NEW CLIMATE INSTITUTE

UNDERSTANDING FINANCE NEEDS FOR A JUST TRANSITION OF THE MEXICAN POWER SECTOR

Discussion Paper

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UNDERSTANDING FINANCE NEEDS FOR A JUST TRANSITION OF THE MEXICAN POWER SECTOR

Discussion paper

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Disclaimer

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SUMMARY

The people-centred just transition of the power sector requires investments and actions along many dimensions. This includes the phase-out of fossil fuel-based infrastructure, the development of new clean infrastructure as well as the transition of workers, communities, and regions in a just manner. Equally important is the development of institutional frameworks, policies and capacity to support the planning and build-up of clean infrastructure. In particular, emerging and developing economies rely on international financial support to successfully transition their economies. A detailed understanding of investment and finance needs is essential to inform government planning and to support emerging climate finance partnerships for countries' transition efforts. Against this backdrop, this report discusses approaches to estimate and, where possible, quantify the investment and finance needs in the context of the power sector transition in Mexico. Mexico's heavy reliance on fossil gas and its dependence on energy imports make it particularly vulnerable to energy security risks, which resonates with other emerging economies seeking to navigate the energy transition in a just manner. While the global discourse on just energy transition is currently centred around the phase-out of coal, this report focuses on the implications of an early phase-out of fossil gas, given its relevance in the Mexican power system.

The investment and finance needs for the power sector transition vary significantly in scale and type across different dimensions, making their assessment complex. While finance needs for infrastructure investments are easier to estimate, those for the just transition of workers and regions, or the development of political and financial institutions cannot be as easily quantified. In particular, estimating finance needs for the just transition requires intensive stakeholder engagement and deep understanding of local contexts, which is beyond the scope of this report. Even in cases where estimating finance needs appears more straightforward, such calculations still rely on significant assumptions that are influenced by political processes. Estimating support needs hence essentially remains a political process. The calculations and discussion laid out in this paper are merely an attempt to provide transparency regarding the factors, assumptions and decisions that need to be considered in such processes.

Fig. S1

Overview of just transition elements in the power sector

Infrastructure: Clean build-up

New renewable energy
New power storage solutions
New and upgraded grid connections
Energy efficiency measures
System management / balancing
New manufacturing for components

Just social transition

Support to retiring workforce
Reskilling / training programmes
Economic diversification from coal
Relocation support
Community investments
Education and skilling new workforce

Infrastructure: Fossil phase-out

Early retirement of fossil fuel based power plants
Restricted operation of fossil fuel based power plants
Reduced fossil fuel production
Decommissioning of plants / mines
Repurposing or remediation of sites

Institutional capacity

Sector planning and delivery
Project permitting / licensing
Monitoring progress
New policy development
Public engagement and awareness

Source: Produced by authors.
Note: Elements that are greyed out have not been discussed in this publication.

While there is not yet a nationally agreed-upon net zero emissions target and pathway in Mexico, civil society organisations have produced sectoral roadmaps aiming for net zero emissions by 2060 to advance the national discourse around decarbonisation (Iniciativa Climática de México (ICM), 2023). To complement this discourse, the analysis in this paper considers a more ambitious transition using an internationally developed scenario; It targets alignment with the Paris Agreement and net zero emissions by 2050 (Teske et al., 2023), a timeline recommended for the world to stay within the 1.5-degree limit (IEA, 2023a). Under such a scenario, Mexico would have to gradually phase out its current fossil gas capacity, including retiring some plants before the end of their technical lifetime. Such phase-out would potentially require the compensation of power plant owners for the early retirement of their plants as well as for the transition of workers. The implications of this in the context of fossil gas has so far received little to no attention internationally, let alone in Mexico. This paper can in that sense serve as an initial contribution to an emerging discourse both in Mexico and internationally.

Overview of results

The most significant investment needs for the just energy transition stem from the build-up of new renewable energy generation infrastructure, followed by grid expansion and the early retirement of fossil gas fired power plants. Our calculations suggest that the build-up of new renewable energy generation infrastructure would require around $180 bln USD between 2023 and 2030, as well as between 2030 and 2040. For the period from 2040 to 2050, the required amount is reduced to about half. Investment needs for grid build-up range from $10 to $160 bln USD between 2023 and 2030, but the absence of more detailed grid build-up plans makes it difficult to produce reliable figures. For the phase-out and early retirement of fossil gas-fired power plants, we estimate that economic compensation needs range from negative values (indicating an economic gain from replacing existing fossil gas fired power plants with new renewables) to around $9 bln USD. The exact amount of finance needed is highly dependent on the approach used to calculate economic impacts and any associated compensation claims. Ensuring a just transition for communities and for coal and fossil gas workers requires taking a country and region-specific approach. Reliable figures cannot be determined without deeper contextual analysis and stakeholder engagement. The same holds for the development of appropriate institutional capacity and policy frameworks, which are not discussed in this paper.

Compensation for early retirement of fossil gas-fired power plants

The early retirement of fossil gas plants in line with net-zero pathways triggers the question of compensation payments towards the power plant owner. While the overall concept of compensating fossil fuel-based power plants remains disputed, the problem can be approached from two different angles. First, a power plant view can be taken, whereby the financial compensation aims at ensuring the initial investment is recovered. This requires finding the breakeven year of the plant, which is often before the end of its technical lifetime, as well as access to plant specific, often proprietary data. Second a company view can be taken, where the transition of the business models of the company operating the plant is in the focus. This requires the identification of alternate business opportunities that produce a similar return on investment.

Data availability and accessibility is a major hurdle in estimating financial compensation needs at the power plant level, but using simplified methods can lead to a significant overestimation of compensation needs. We compare two methods: A plant-based capital recovery method which looks at individual power plant economics more closely to determine the breakeven point, and a simplified capital recovery method which assumes the breakeven to be at the end of the technical lifetime **(see → Fig. S1)**. Our results show that using simplified approaches can send the wrong signals regarding the scale of compensation needed – in our case about four times more than the plant-based capital recovery method.

Turning the focus towards the company level can help reduce compensation needs, as the low cost of renewables allow for an economically sustainable transition of business models. We compare the electricity generation costs of new renewable energy, in terms of their levelized cost of electricity (LCOE), with cost of operating already existing fossil gas plant, in terms of their long-range marginal cost (LRMC) **(see → Fig. S1)**. If the LCOE of renewables is lower than the LRMC of fossil gas, it would allow companies to switch their business models and refocus on renewables without worsening their economic situation. Our analysis suggests that such an approach can result in reduced, or even negative financial compensation needs. Such approach is highly sensitive to uncertainties around the future development of fossil gas prices – using a lower fossil gas price would lead to a similar level of financial compensation needs as the simplified capital recovery method suggests. But existing indications of either stagnating or increasing fossil gas prices, combined with a tendency to underestimate cost developments of renewables in the past, could result in significantly reduced or even eliminated financial compensation needs, while in parallel fostering the build-out of renewables (Cronin et al., 2015).

Fig. S2

Compensation needs under different methods for calculating fossil gas phase out over the time period 2023 to 2050

Note: Discount rate of 8.4% used for the graph on the right-hand side.
Source: Author's own calculations.

To further minimise the overall need for compensation payments, Mexico could make important policy decisions that drive the energy transition. This is particularly relevant to the design of the electricity markets and planned fossil gas power capacity additions which, if realized, would lead to increased needs for early retirements. A power market design that remunerates plant owners for flexible operation, such as through capacity markets, could allow existing fossil gas-fired power plants to operate at reduced capacity while remaining profitable. This approach presents an appealing strategy to further diminish the role of fossil gas plants without the need for separate remuneration schemes. At the same time, Mexico should aim to redirect investments from planned new fossil gas-fired power plants towards renewables. Our analysis shows that renewables can generate electricity at significantly lower costs. In addition, such a shift would decrease Mexico's vulnerability to price hikes, as seen during the recent global energy crisis, given the country's heavy dependence on fossil gas imports.

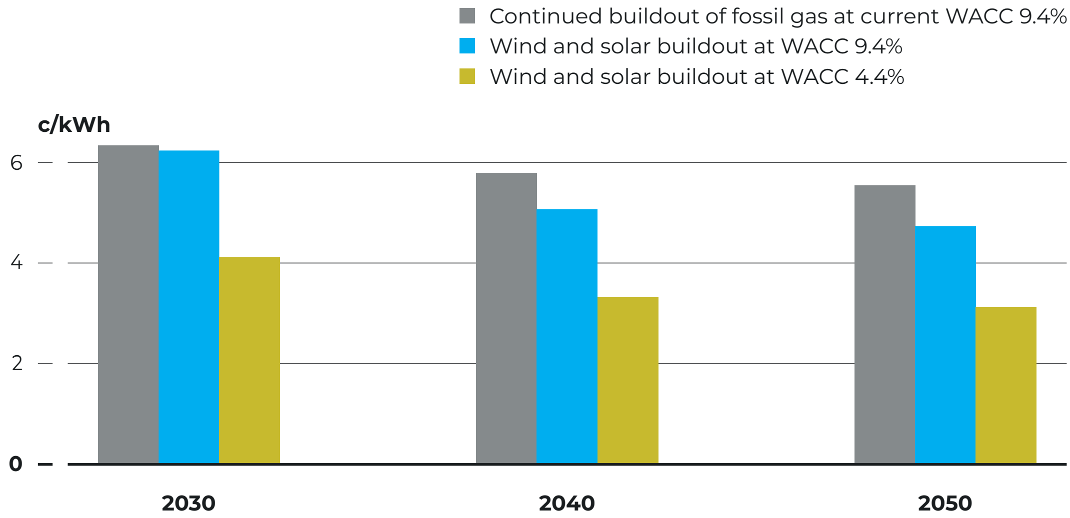
The approach chosen to assess compensation payments hold important political implications. While a simplified approach requires less input data, a more detailed and granular plant level approach can prevent windfall profits caused by potentially inflated compensation payments. It is recommended to follow a process that produces credible results accepted by all stakeholders involved. This ensures a high degree of buy-in from national stakeholders and the international community, which is especially important when seeking international financial support. Applying different approaches in parallel, such as those presented here, could provide a valuable basis and become a catalysts for political discussions and negotiations.

Clean energy build-up

Our analysis suggests that all new power plant capacity in Mexico should be entirely renewables-based, both from an economic as well as Paris Agreement compatibility perspective. Building new fossil gas- based power capacity in Mexico is also not needed to provide more flexibility, as the existing fleet provides sufficient flexibility to significantly increase the share of variable renewables. Our analysis finds that the average LCOE of wind and solar, if financed with interest rates achieved in Mexico in 2021, is more than 1 c/kWh cheaper than that of new fossil gas-fired power plants **(see → Fig. S3)**. If low-cost (concessional) financing is considered, the cost advantage of renewables would increase even further, increasing the gap to fossil gas by another 1 c/kWh to around 2 c/kWh on average. The build-out of renewable energy can also help reducing the substantial subsidies that the Mexican government currently provides to end consumers, which average at 9 c/kWh.

Fig. S3

Electricity generation costs for new build-out of capacity between 2030 and 2050, comparing fossil gas and a combination of solar and wind at different WACC levels



Note: Assuming a decreasing fossil gas price over time in line with IEA WEO Stated policy scenario (IEA, 2023e).
Source: Author's own calculations.

Under the previous auction scheme in Mexico, renewable energy experienced relatively low financing costs, with the weighted average cost of capital (WACC) reaching levels of 4.4%. Without a conducive policy framework, securing low cost financing for new renewables remains a major hurdle in Mexico. Regulatory risks are a major factor, and policy reforms can help minimise such risks (IEA, 2022). Greater certainty for investors could be created through measures such as the reactivation of the auction scheme, and the replacement of the current clean energy target with a series of concrete renewable energy targets, coupled with the removal of administrative hurdles. In addition to policy instruments, financial instruments such as guarantee funds could be considered to further reduce the financing costs of renewables.

Just social transition

As the needs for a just social transition is highly influenced by context specific aspects, there are no sophisticated methods applicable on a universal level. Countries and regions have adopted varied strategies, but international experiences highlight certain common elements. First, active engagement of affected stakeholders has been a key part of just transition efforts. Secondly, a combination of top down coordination and funding, coupled with bottom up identification and implementation of measures, has proven effective in supporting the transition of workers and communities. Thirdly, the regional context is crucial; Thus, supporting a socially just transition requires a tailored approach specific to each country and sub national region.

Estimating finance needs is challenging due to context-specificity. Funding needs for a region cannot be accurately gauged through desktop based exercises alone; further regional engagement and consideration for specific contexts are essential. While funds supporting regional transitions often follow pledge and review processes, initial finance needs could be estimated with stakeholder input, focussing on priority areas for intervention. Alternatively, a narrower focus could be placed on transitioning fossil fuel workers, for which estimating finance needs is more straightforward (Fearnehough et al., 2024). However, focussing solely on workers can raise equity concerns within countries, as some workers who have benefited from the exploitation of fossil resources may be prioritised over other disadvantaged groups. In other contexts, a sole focus on compensating or supporting workers in transition to new jobs has not proven effective without considering broader strategic transition efforts at the regional level.

Internationally, several types of funds have been established that could also be considered in Mexico. These include transition funds that focus on regional restructuring, social transition funds targeting vulnerable groups such as indigenous communities and/or compensation funds that directly address affected workers. Incorporating such funding into just transition plans at state and/or national levels would be essential to ensure the success of a socially just transition in Mexico.

Overall, it is important to advance the evidence base for just transition investment and finance needs in Mexico's energy sector and beyond. The further development of different approaches to estimate and quantify such needs lays an important foundation for political discourses in Mexico and internationally. It is critical to accompany such analytical efforts with deeper stakeholder engagement and political processes at both national and regional levels. A just transition can only be successful if all perspectives of those affected are considered and political compromises can be negotiated in a fair and transparent way.

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/\ 01 INTRODUCTION

Global economies need a deep transformation to reach net-zero carbon emissions by the end of the century in order to stay within the long-term goal agreed under the Paris Agreement (IPCC, 2023). The power sector, given its relatively readily available mitigation options compared to other sectors, is projected to see an even faster transition to net-zero emissions globally. The IEA suggests that in advanced economies the power sector needs to be fully decarbonised by 2035 whereas at the global level this should happen by 2040 (IEA, 2021). Countries that are mostly responsible for climate change historically have an obligation to transition faster, especially if equity considerations are considered (Hagemann, Outlaw and Röser, 2023). However, given the lack of action to date and limited remaining timeframe, science mandates that all countries now need to embark on a net zero pathway as quickly as possible to avoid the most disastrous and irreversible impacts of climate change. In line with this thinking, many countries, also in the Global South, have put forward net zero targets. In many cases these are not underpinned by concrete plans and actions on how they intend to achieve them. The gap between ambition and actual implementation is widening.

The transformation to net-zero emissions economies requires deep structural changes that are challenging on multiple levels. Technical solutions are required to reduce the dependency on fossil fuel resources. In the power sector clean technologies are readily available, but they are often not regarded as feasible alternatives in the national context. Several barriers still impede the rapid and scaled investments into clean energy technologies and infrastructure. In particular fossil rich countries face a significant barrier of how to deal with existing fossil infrastructure and the reliance of their economies on fossil resources and income. Beyond technical and economic considerations, transformations are about people, and any deep structural change is very challenging at the social level. Not only will the transition itself have impacts on communities but people need to be convinced of the necessity, benefits, and feasibility of the transformation for it to be durable and successful. The success of the power sector transition also relies on a policy environment that is conducive to change with political actors having the courage to think long term and act forward looking.

Such deep transformation requires unprecedented levels of investment. In particular for countries in the Global South, international finance and support are paramount to enable the clean energy transition. Despite climate finance commitments of advanced economies, the provision of international public finance put forward to date has not been sufficient – not even the goal of achieving 100bln USD by 2020 has been met (OECD, 2023). More recently plurilateral partnerships have emerged, such as the Just Energy Transition Partnerships (JETP), under which financial support packages are negotiated to drive just transition efforts in key economies in the Global South. These JETPs so far mainly focus on countries with major coal resources that are regarded as critical for the achievement of the global climate goals. The JETPs as well as other bi-and plurilateral energy and climate partnerships seek to bundle climate finance contributions for clear ambition commitments of the recipient country. While it is unclear whether these partnerships will be continued in this form, they initiate an important process towards a better understanding of just energy transition and associated support needs. Existing partnerships have mainly been the result of (political) negotiations between the parties involved with broad commitments as the starting point. Detailed investment planning of the scale of finance and type instruments and mechanisms needed for all parts of the just transition has often been missing, at least at the outset. At the same time a thorough evidence base on precisely these questions is critical to enable climate finance to be effectively channelled to the most relevant activities and to mobilise additional finance from diverse sources.

Against this backdrop, this report discusses approaches to mapping just transition finance needs in the power sector in Mexico. The report is mainly centred on questions related to the phase out of fossil infrastructure and build out of renewable energy systems. Methods for the quantification of compensation payments, with a focus on gas instead of coal, and renewable energy related infrastructure development are discussed and applied to the Mexican context. Specific approaches for better understanding and ultimately quantifying support needs for the just transition elements are considered more broadly. The important questions of policy reform and institutional capacities are not subject of this discussion paper as these, as well as a just transition framework, can only credibly be assessed on the basis of deeper consultation with stakeholders and more in-depth consideration of the regional characteristics and context.

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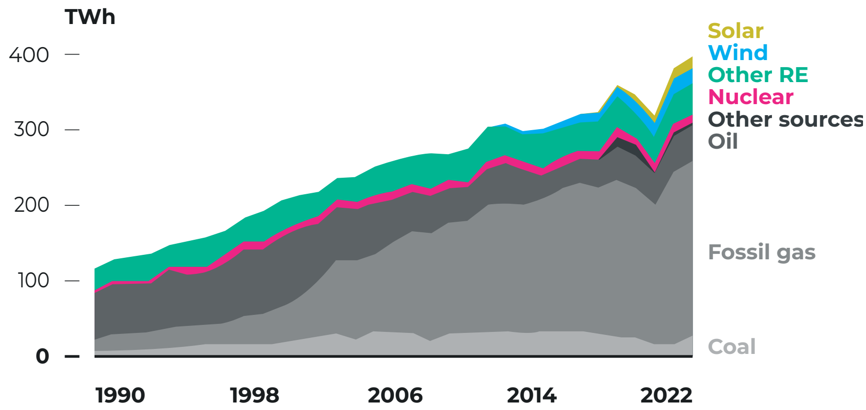
CONTEXT: THE MEXICAN POWER SECTOR AND JUST TRANSITIONS

Fig. 1

Evolution of electricity generation sources in Mexico since year 1990



Source: (IEA, 2023c).

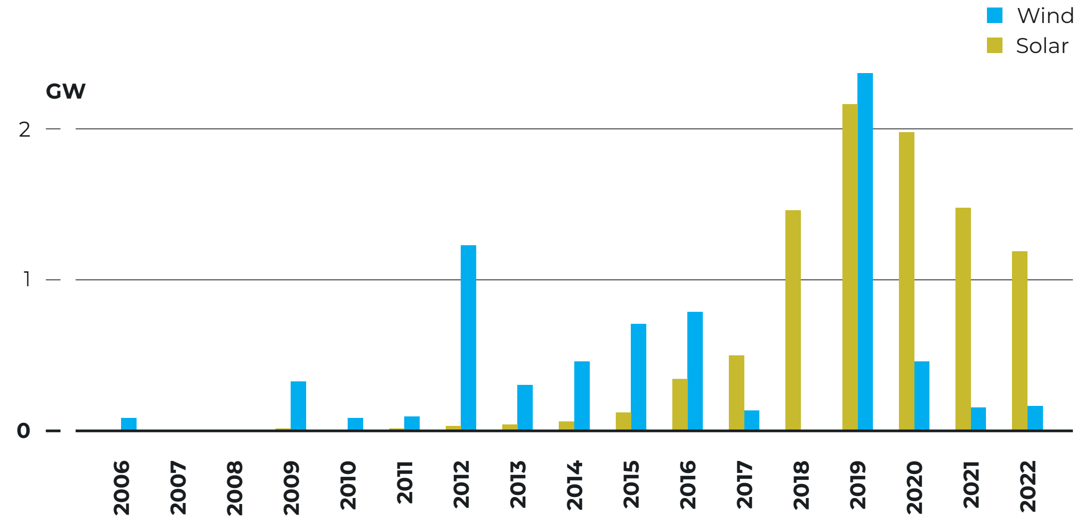
The Mexican power sector is currently heavily reliant on fossil fuels to serve the growing electricity needs of the country. While coal is only responsible for a small share (about 7%) of installed capacity, fossil gas and oil make up the majority (70%) of the capacity portfolio (IEA, 2023c). Since year 2000 electricity generation from fossil gas has been increasing steadily as depicted in → **Fig. 1**.

During the last decade, the installed capacity of variable renewables (wind and solar) rose from about 2% in 2013 to about 9% in 2022 in line with the share of electricity generation which rose from 1% to 9% (IEA, 2023c; Ember Climate, 2024). The 2013 energy reform, which liberalised the electricity market and introduced measures such as long term auction schemes, was a key driver behind the growth in wind and solar. In recent years however, energy policies are reverting that trend as key policies promoting renewables have been drawn back and have not been replaced by others. As a result, investments and corresponding installations in renewables (especially wind energy) have gone down since the cancellation of the long term energy auction scheme in 2019 **(see → Fig. 2)**.

In an attempt to bring the energy sector back into public ownership, other policies have been introduced which make it more difficult for independent power producers to enter the market. This resulted in the cancellation of many renewables projects that were in the pipeline. In total, 11.6 GW of wind and solar have been shelved, mothballed or cancelled so far (Global Energy Monitor, 2023). In 2021 for the first time in half a decade the share of renewables in the generation mix decreased (IEA, 2023c). Public investments in renewables are also low. Since the current administration came to power in 2020, few new renewable capacities have been built by the state-owned power utility CFE. Instead, public investments in new oil production and fossil gas plants signal a continued high political support for fossil fuels and as a result Mexico is planning to build nearly double the capacity in fossil gas (13.3 GW) than wind and solar (6.7 GW) (Global Energy Monitor, 2023). This shows that the current administration puts fossil resources at the centre of its economic policy and recovery strategy.

Fig. 2

Yearly installed wind and solar capacity in GW



Source: (Ember Climate, 2024).

Given the aging and relatively small coal fleet, phasing out coal can be considered a low hanging fruit in the Mexican context. However, although the government signed up to the Power Past Coal Alliance it has not taken any actions to phase out coal. On the contrary, the current government is planning to modernize existing plants. Different interest groups are pushing for a continuation of current coal mining operations. At the same time the negative impacts of these activities are significant, including coal mining related deaths and injuries caused by lax safety rules as well as pollution and ecosystem damage caused by illegal open-pit mining reducing access of vulnerable communities to clean water and other resources (Fonseca and Grados, 2021).

DECARBONISATION SCENARIOS

Identifying pathways to reaching net zero emissions is an essential starting point to understand the scale and speed of the transformation of the sector. In the absence of a nationally agreed pathway, decarbonisation studies can provide some insights in this regard. In this report we consider three scenarios which represent different levels of ambition and approaches to modelling **(see → Tab. 1)**. The '1.5 benchmark' scenario and the 'International pathway' scenario are both compatible with Mexico's contribution to limiting global warming to 1.5°C. However, as international desk studies they do not carefully consider political and social context and feasibility. In contrast, the third scenario, the 'Domestic pathway' scenario, is developed by national experts and aims to reach net zero emissions by 2060. While less ambitious it is more grounded in the political realities of the country.

Tab. 1

Overview of scenarios used in this report

Name	Type	Description	Aim
1.5 benchmarks	IAM top-down 1.5-compatible	Based on benchmark ranges identified from filtering 1.5°C compatible IAM scenarios. Developed by the Climate Action Tracker (CAT, 2023).	Highlights a globally 1.5 degree compatible least cost pathway for the power sector.
International scenario	Bottom-up 1.5 compatible	1.5°C compatible pathway developed by (Teske et al., 2023).	Demonstrates a technologically feasible pathway, taking account of the more complex interactions within the power sector.
Domestic scenario	Bottom-up Not 1.5 compatible	Net zero pathway developed by national experts (Iniciativa Climática de México (ICM), 2023).	Highlights a politically feasible/ highest plausible pathway towards net zero, taking account of current national circumstances.

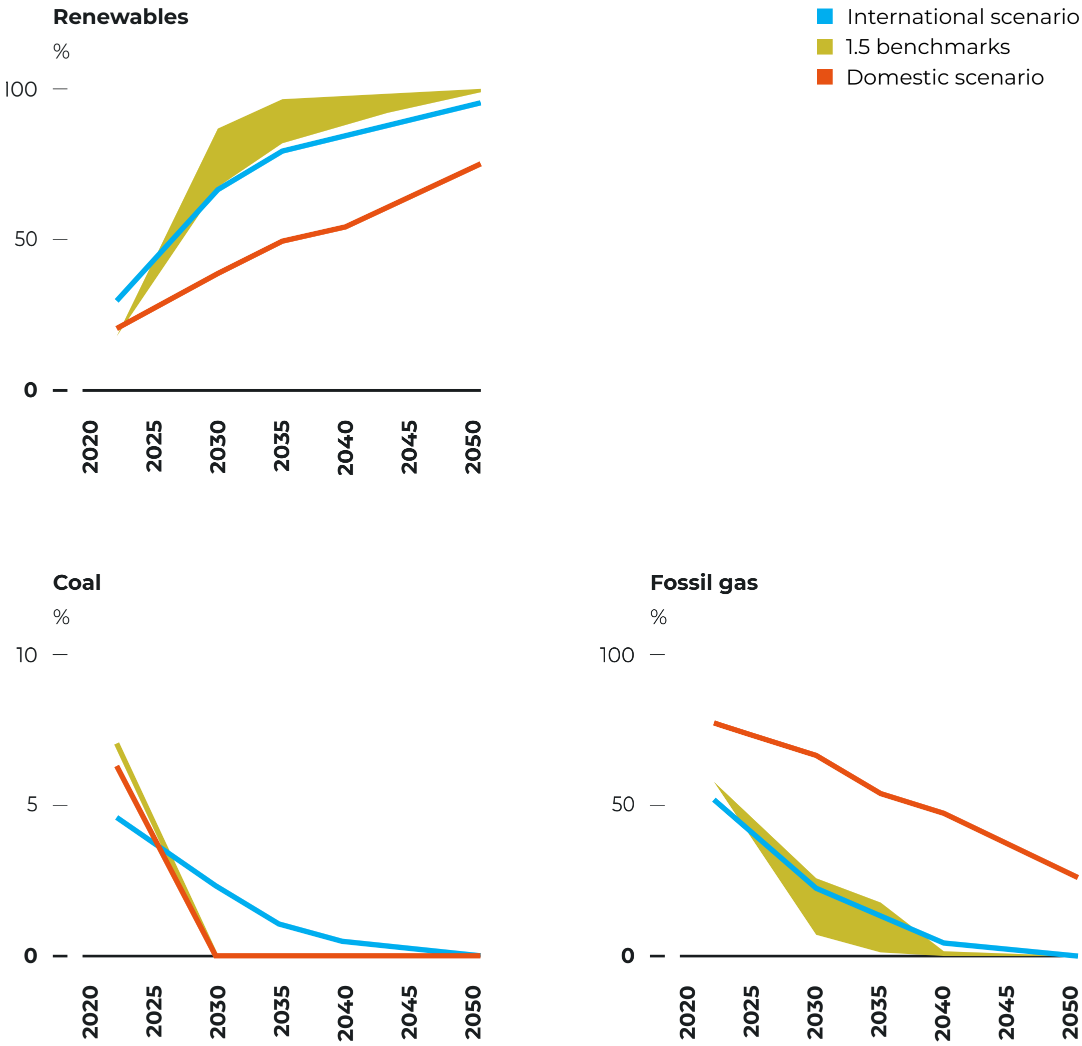
Tab. 1 shows a comparison of the three scenarios described above and the implications for phase out of coal and fossil gas as well as build-out of renewable energy-based power generation.

The international studies suggest that fossil fuels need to be completely phased out from Mexico's power generation mix by 2050 in order to stay in line with the Paris Agreement. While several international studies indicate that coal should be phased out in the near term (by 2030), fossil gas upon which the Mexican power sector is significantly more reliant, needs to be phased out between 2040 and 2050 to stay in line with a pathway compatible with the Paris Agreement (CAT, 2023; Teske et al., 2023). Such a change will require rapid scaling up of renewables to replace fossil fuel based capacity and to satisfy an increasing demand for electricity following the electrification of end use sectors. The share of renewables should reach almost 70% by 2030 and between 95% and 100% by 2050 according to these international studies. The "Domestic" scenario allows for longer use of fossil gas which is not even phased out in 2060.

Some common aspects of the three pathways for the Mexican electricity sector are the early complete phase out of coal based power generation, and the relatively rapid scale-up of renewable energy. The most significant disagreement across the three scenarios revolves around how fast the sector can reach net-zero emissions, i.e., how fast fossil fuel based power generation can be phased out. This is strongly linked to the expected future of fossil gas-based power generation in the country. While the 'International pathway' scenario and the '1.5 benchmark' scenario both see a complete phase out of fossil gas (between 2040-2050 and by 2050 respectively), the 'Domestic pathway' scenario sees a continued strong role for fossil gas in the next couple of decades, still representing a quarter of electricity generation in 2050 **(see → Fig. 3)**.

Fig. 3

Comparison of three scenarios for Mexico's power sector



Source: The "1.5 benchmark" scenario (CAT, 2023), the "International" scenario (Teske et al., 2023), and the "Domestic" scenario (Iniciativa Climática de México (ICM), 2023).

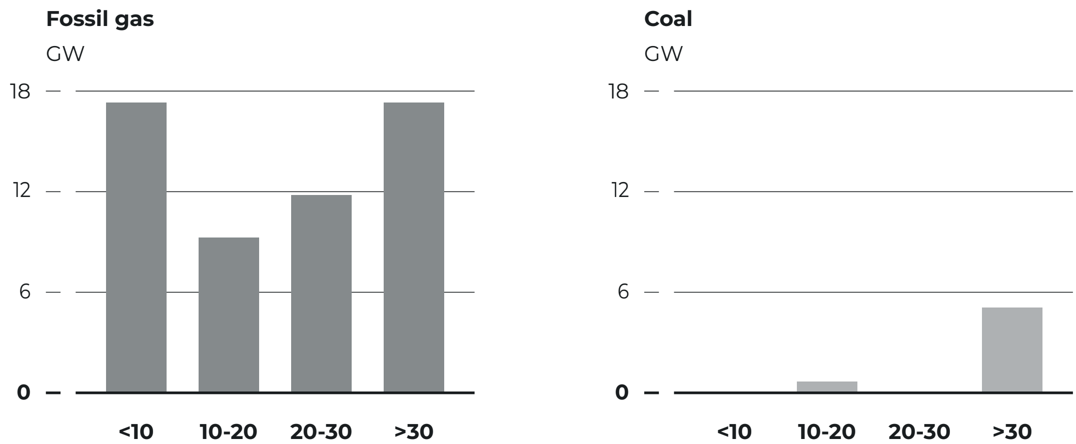
The key reasons behind the different gas phase out timelines are the expectations on what is considered politically and technically feasible. Pathways developed by domestic experts tend to focus more on political feasibility considering aspects such as the current political circumstances in Mexico, length of permitting processes or the institutional inertia with which policies have been implemented in the past. The international pathways build on the experience at the global level. This includes progress in the cost-competitiveness of renewable energy technologies in recent years, examples of policy and technology development effectively changing the pace significantly and effectively overcoming barriers, such as can be observed in the aftermath to the global gas crisis in Europe and other places (European Commission, 2022; Velten et al., 2023). Especially in developing countries this results in more optimistic uptake scenarios for renewables in the future.

THE NEED FOR EARLY RETIREMENT

Mexico's power sector's high dependency on fossil gas is the main challenge to decarbonising the power sector. The Mexican coal fleet is far from negligible and needs to be addressed, but it is relatively old and with no new coal capacity in the pipeline there is a low risk of the creation of substantial amount of stranded assets. Most of the existing coal capacity will have reached the end of its technical lifetime around 2030. In contrast, the significantly larger fossil gas fleet is relatively young, and has grown again in the last 10 years **(see → Fig. 4)**. In addition, Mexico currently uses fuel oil as a byproduct from its refinery activities as fuel in some of its thermal power stations. The phase out of fuel oil also needs to be discussed, however is considered less of a challenge as changes to refinery technology are expected to result in much lower availability of fuel oil in future.

Fig. 4

Age distribution of the currently operating coal and fossil gas based power generation fleets in Mexico



Source: Author's analysis based on database provided by ICM underlying their Net Zero pathway (Iniciativa Climática de México (ICM), 2023).

In addition to the existing fossil gas generation capacity, another 9-13 GW of new fossil gas capacity corresponding to 15%-30% of the current fleet is in the pipeline and planned to come online in the near future. In order to decarbonise the power sector in line with the goals of the Paris Agreement, already parts of the existing fleet would have to be retired early. International studies suggest that this would apply to about 35% of the currently operating fossil gas-based power capacity.

The size of the existing fossil gas fleet is significantly different across data sources which leads to this broad range.

Box 1

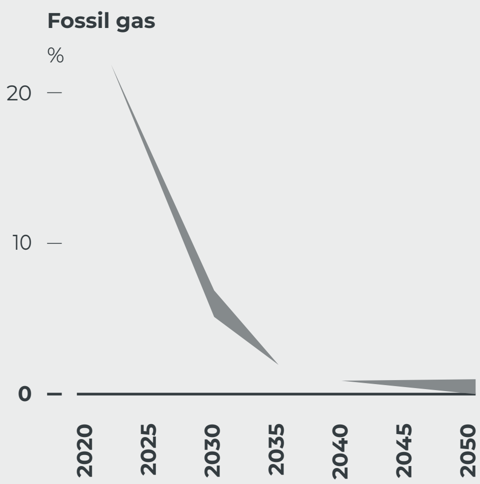
The role of fossil gas in a 1.5-compatible future for the Mexican power sector

While stopping financing coal has made good progress in recent years as development finance institutions and private sector asset owners largely have shifted away from providing direct finance to coal, that is not the case for fossil gas (Marquardt and Kachi, 2021). Despite being a fossil fuel, fossil gas has for quite some time been shielded from more serious phase out discussion and instead has been largely regarded as “bridging/transitioning fuel”. This has been motivated by the arguments of fossil gas being a less carbon intensive fuel than coal, the flexible operation of fossil gas power plant and, in some countries, relatively low costs also compared to renewables. In recent years, however, there is a growing consensus among climate change/policy experts that there are several reasons as to why the expansion of fossil gas-based electricity generation is not compatible with the Paris agreement. This discussion refers to aspects such as the long lifetime of the infrastructure and technology leading to carbon lock-in, and the steadily increasing cost competitiveness of renewables (Marquardt and Kachi, 2021). According to 1.5 compatible benchmarks, the share of fossil gas in the global electricity sector should reach 2% by 2035, 1% by 2040, and between 0-1% by 2050, compared to current levels of about 22% **(see → Fig. 5)** (CAT, 2023). In parallel the energy crisis caused by the Russian invasion of the Ukraine, has caused major economies, especially the EU, to reconsider the role of fossil gas and to speed up its phase out – the REPowerEU plan laid out several measures to replace gas in the power plant mix significantly in the next years (European Commission, 2022)

While Mexico produces fossil gas domestically, its production has decreased significantly (by about 50%) in the last decade (CSIS, 2024). Domestic production is not expected to increase in the near- to medium term due to

Fig. 5

Paris-compatible benchmarks (2030, 2035, 2040, and 2050) for the share of fossil gas in the global electricity sector

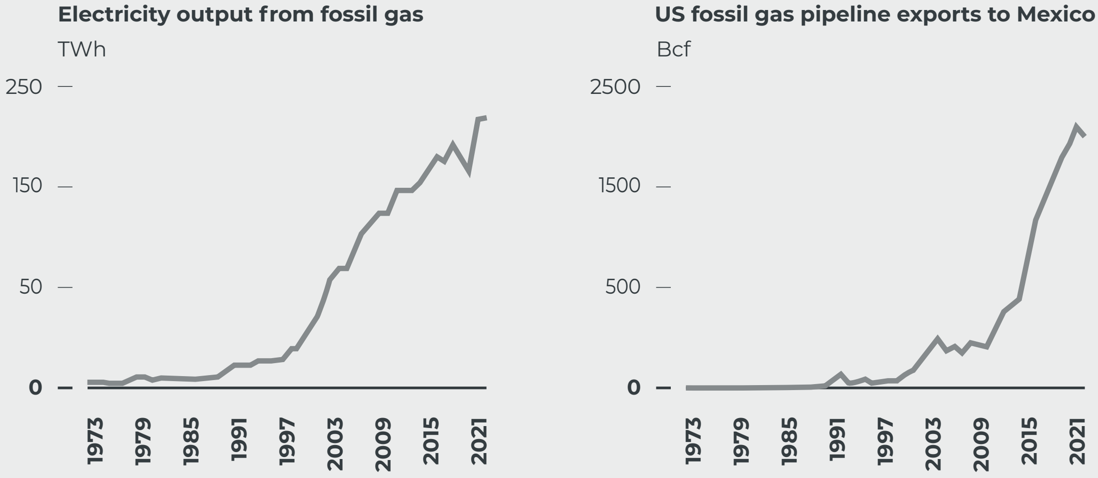


Source: (CAT, 2023).

Fig. 6

Left: Electricity generation from fossil gas in Mexico

Right: Annual exports of fossil gas from the US to Mexico



Source: Left: (IEA, 2023c); Right: (US EIA, 2023).

financial challenges, among others (Diego, Rivota and Joseph, 2023). At the same time, the demand for fossil gas is steadily increasing, mainly driven by the power sector **(see → Fig. 6)**. As the domestic upstream oil and gas sector is also a significant consumer of fossil gas this has led to the current situation where the domestic supply and demand gap is filled by imported fossil gas **(see → Fig. 6)**. Mexico has a growing dependence on fossil gas imported from the United States (US), which delivered 69% of Mexican fossil gas demand in 2022, with almost all imports (99%) originating from Texas (Secretaría de Energía (SENER), 2023).

With the fossil gas-based power plant pipeline growing – currently 10 new plants together corresponding to about 6.5 GW are planned to be operational by 2027 – the fossil gas demand is expected to continue to grow. As of May 2023, the Mexican government labels some fossil gas plants as “clean” meaning that their capacity contributes to the national clean energy target (Reuters, 2023). In addition to an expanded fossil gas based electricity capacity, the building of several new LNG export terminals, which will be reliant on US fossil gas in order to pay off, further increases the competition for US fossil gas in Mexico. Furthermore, LNG exporters will face intense competition under a decarbonisation scenario – the IEA estimates that under its Net Zero Energy (NZE) scenario 70% of LNG export project under construction would struggle to recover their invested capital (IEA, 2023b).

Based on this, several reports expect US fossil gas prices to increase in the near to medium term (US EIA, 2012). Locked into a US fossil gas dependence by expanding the fossil gas based electricity generation thus, not only significantly weakens Mexico’s energy security, but also risks increasing electricity prices (Diego, Rivota and Joseph, 2023; S&P global, 2023) with significant impacts on consumers and social development.

The more ambitious the scenario, the steeper the phase out-curve and hence the higher the need for early retirement. → **Tab. 2** provides a comparison of the scale of early retirement required in the 'International' versus in the 'Domestic' scenario. As expected, the major difference is on the role of fossil gas. The 'International' scenario requires early retirement of 82 fossil gas plants representing 11 GW of installed capacity, while the 'Domestic' scenario sees no need for early retirement. In fact, the 'Domestic' scenario requires a build out of the current fossil gas fleet, allowing all the new fossil gas plants in the current pipeline to be built.

Tab. 2

Early retirement needs across fossil fuels in the "International" and "Domestic" scenarios

Scenario	Fossil gas	Coal
Teske 1.5 (international scenario)	11 GW (82 plants)	4 GW (2 plants)
ICM Net zero (domestic scenario)	0.0 GW (none)	4.8 GW (4 plants)

Against this backdrop, our analysis on finance needs for fossil phase out is focused on fossil gas rather than on coal. The approach will differ from the approach taken for coal as the economics of coal as well as just transition implications are different for fossil gas. While coal power plants are characterised by relatively high upfront investment and low fuel costs, fossil gas plants have the opposite characteristics, with relatively lower upfront investment but much higher fuel costs. The just transition discussion of coal phase out typically focuses on coal producing regions, in particular mining activities. The phase out of fossil gas will be centred more around questions of affordability, employment shifts related to plant operations, and broader questions of energy security. The latter is particularly relevant for a country like Mexico due to its high reliance on imported fossil gas.

JUST TRANSITION CONSIDERATIONS

There is generally a lack of discourse on a just transition for fossil gas phase out. This is problematic in several ways. Firstly, the international decarbonisation pathways presented above as well as other scientific evidence suggests that also fossil gas fired power plants need to be phased out before the end of their lifetime and hence might require a planned transition approach similar to coal. Secondly, the current discourse focused on the phase out of coal and the lack of a similar discourse around fossil gas can be interpreted in a way that fossil gas is here to stay for longer (Heffron and McCauley, 2022). And thirdly, the inflated financial sums currently discussed for coal phase out in various countries risk sending signals to the fossil gas industry that following as business as usual approach will only mean that they can also expect significant public support to cover any losses resulting from early retirement in the future.

The discourse on just transition of the energy sector in Mexico is generally fledgling and framed as an abstract concept at the national level. Whilst social justice issues are considered in the current energy system, governance strategies related to employment, regional development, and effective implementation of human rights law are generally missing. At the local level initial efforts and discussions on just transition aspects are happening. For instance, miner collectives have started to pro-actively ask for a just-transition, realizing the adverse impacts coal has on their regions. This could serve as a starting point for a broader discourse (Fonseca and Grados, 2021).

It is important to note that this report only covers the power sector, not upstream or downstream fossil fuel related activities. This is especially relevant when considering the just transition impacts of the sector, which can be a lot more significant for fossil fuel extraction sectors (Saha et al., 2023). However, while Mexico was historically a country with significant fossil gas resources, today's fossil gas used in power plants is mainly imported. As highlighted above **(see → Box 1)**, almost 70% of fossil gas demand for power generation in 2022 was met from imports. Unlike coal, oil and fossil gas extraction are decoupled from power plant operations.

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UNDERSTANDING JUST TRANSITION FINANCE AND INVESTMENT NEEDS

Fig. 7

Overview of just transition elements in the power sector

Infrastructure: Clean build-up

New renewable energy
New power storage solutions
New and upgraded grid connections
Energy efficiency measures
System management / balancing
New manufacturing for components

Just social transition

Support to retiring workforce
Reskilling / training programmes
Economic diversification from coal
Relocation support
Community investments
Education and skilling new workforce

Infrastructure: Fossil phase-out

Early retirement of fossil fuel based power plants
Restricted operation of fossil fuel based power plants
Reduced fossil fuel production
Decommissioning of plants / mines
Repurposing or remediation of sites

Institutional capacity

Sector planning and delivery
Project permitting / licensing
Monitoring progress
New policy development
Public engagement and awareness

Source: Produced by authors.
Note: Elements that are greyed out have not been discussed in this publication.

The decarbonisation of Mexico's power sector will require significant finance and investment and a holistic approach to enable the transformation across all the dimensions for a just energy transition. It **(see → Fig. 7)** outlines the key dimensions of a just transition in the power sector which can serve as a framework for assessing finance and investment needs. Following a short description of each of these dimensions we will discuss in more detail how finance needs can be determined, and which factors need to be considered. The focus here will be on the infrastructure dimensions – fossil phase out and clean build up – as well as more briefly the just social transition elements. Institutional capacity is not covered in this paper.

Phase-out of fossil fuel infrastructure, in essence, early retirement of fossil generation and reduced electricity output is required as existing power plants are replaced by renewable energy sources. Both factors reduce the income of existing power plant operators and thus affect the economics of the power plants. In addition, an earlier phase out of existing plants can also lead to temporarily increased electricity generation costs as investments in new renewable power plants are undertaken before otherwise necessary. Financial support may be needed to ensure that power plant operators receive a fair compensation for shutting down the plants before the end of their lifetime. The difficult question is to determine what is fair in this context. Once the power plants are shut-down, they need to be decommissioned and the brown-field site needs to be remediated and potentially repurposed. Regions affected need to receive financial support to achieve this. Finally, fossil fuel power plants often directly rely on fossil resource extraction within the same country and the impact of the reduced fossil extraction activities could also be compensated for.

The decarbonisation of the power sector requires the **build-up of new infrastructure**. Initially the build up of renewable energy sources will be required coupled with additional investments into the grid infrastructure in order to connect dispersed sources to the grid, typically in locations that are different from existing power plants. In these initial stages the renewable energy sources can operate in conjuncture with existing power plants; especially gas fired power plants that can be operated flexibly, and the grid infrastructure largely remains the same. As the energy transition progresses, the investments into new infrastructure shifts. While investments into renewable energy continue to be relevant, additional investments are needed to provide other system services such as non fossil based flexibility sources or smart grid/ grid digitalisation technologies. A major barrier to investment in renewables, which have reached cost parity with fossil fuel sources in many countries in the world, is the cost of financing and hence the need for de-risking such investments.

A **just social transition** needs to parallel the technical transition away from fossil power plants as their phase out leads to structural changes not only affecting workers in the fossil fuel industries but also the income of sub-national regions. In particular vulnerable groups may be affected by the transition. These changes will not only be negative, as the build up of new technologies will create new (employment) opportunities, and a transition away from burning fossil fuels will have significant positive health impacts. While research suggest that at a macro-economic level these positive changes will outweigh the negatives, the impacts might be geographically and demographically dispersed. For instance, regions that lose their income from fossil fuel activities will not automatically benefit from new green jobs. This calls for regionally focused programmes supporting the structural changes needed. The finance needs associated with the social transition can arise from the need to retrain and temporarily support workers into shifting into retirement or new jobs but also the development of structural, regional development programmes. Due to temporarily higher electricity costs caused by new generation technologies and the premature phase out of existing ones, financing could also support the impact these have on vulnerable groups. Significant institutional capacity is needed at various governance levels to ensure the just social transition is implemented effectively.

Finally, the transition needs to be organised and managed by institutions at various governance levels, requiring increased **institutional capacity**. A major success factor for the uptake of renewable energy sources in different countries in the world has been the development of institutional support structures such as renewable energy support policies. At the same time the transition needs to be managed requiring robust long term planning and target setting (REN21, 2023). These processes may need additional capacities and competencies at different institutional levels within government but also within other organisations that are involved in the management of the transition. Finally, organisations operating in the sector that will be significantly affected by the transition, such as utilities, regulators, and market operators, may require institutional support in developing, implementing, and monitoring progress of new regulations, amongst other things. While many of these institutional capacities may come from re-allocating existing capacities, there will likely be a need for additional capacities as for a transition period both the fossil fuel based and the decarbonised system need to co-exist.

In the following approaches to assessing finance and support needs in the different transition dimensions will be discussed.

3.1 INFRASTRUCTURE – FOSSIL GAS PHASE OUT

The assessment of finance needs for the early phase out of fossil gas fired power plants focuses on the potential need for compensating operators. This will require careful consideration as to whether and how power plant operators should be compensated for potential financial losses incurred by the premature phase out of their plants.

Power plant investments are undertaken based on forecasted assumptions on how the plants will be operated. These assumptions include an expected lifetime of the plant, a timeframe for the recovery of the upfront investments, and an expected profit margin. Early retirement – retirement ahead of the expected (technical) lifetime – changes the initial economic expectations as the plant operates a shorter than expected time and generates less revenues than expected. In addition, on a contractual level, many private operators have signed fixed long term power purchase agreements (PPAs) which guarantee a fixed income over a pre-determined period. Shutting down the plants before the end of these contracts would require contractual changes and/ or potentially some form of financial compensation or buy out. These aspects need to be considered when calculating the financial losses incurred by power plant operators as a result of the phase-out of their power plants at the plant level. In addition, a number of other factors need to be considered in the calculation:

- **Data availability** – Data availability is a major issue when it comes to understanding the economics of power plants as most data is proprietary and not accessible to the public. While in some instances some plant specific data might be collected by regulators (US EIA, 2024), who sometimes publish aggregated data, plant level data relevant to the financial health of a power plant, is rarely accessible to the public. Private companies will likely not be willing to provide this data, as it may undermine their competitiveness. This creates an uneven playing field when it comes to the negotiation with power plant operators over a potential financial compensation which fossil fuel power plant operators might use to maximise their own profits.

- **Contractual agreements** – Contractual arrangements under which power plant operators operate can differ significantly and range from long term PPAs lasting as long as 25 years or longer under a "take or pay regime" to market participation. Linking compensation payments to contractual obligations would therefore provide a significant disadvantage to those operators that have chosen to operate under shorter term contracts or in the electricity market. More so one could argue that systems that operate with long term PPAs for fossil fuel power operators were set up or continued against scientific evidence as policymakers could have foreseen associated transition risks.

- **Type of power plant** – Gas and coal fired power plants have significantly different characteristics. Gas fired power plants have lower upfront costs given their generally smaller in size, they have higher running costs and generally a shorter technical lifetime (Schloemer et al., 2014). This translates into reduced compensation needs for two reasons: Lower upfront costs and short timespans before breakeven is reached, and significant contractual differences between how the different type of plants are operated. Contracts signed by coal fired power plant operators for instance tend to be largely long term PPAs; and almost all coal fired power plants in the world are shielded from competition (Bodnar et al., 2021). Gas fired power plants in contrast tend to operate under shorter PPAs and/or participate directly in the electricity market. Releasing gas plants from contractual obligations should hence be more straightforward for gas fired power plants. Lastly, fossil gas fired power plants, especially in Latin America, are often relatively young meaning that, despite generally lower technical lifetimes, they often have significant lifetime remaining.

- **The policy and market regime** – The design of electricity markets, as well as policies and regulations can affect the economics of fossil fuel power plants directly or indirectly. As the transition progresses, schemes that put a price on carbon such as emission trading schemes (ETS) or carbon taxes are likely to play an increasing role in many jurisdictions around the world. The number of CO_2 price schemes globally has already increased manifold in recent years (Worldbank, 2023). In addition, environmental regulations have caused the cost of fossil fuel generation to go up over the years. Indirectly, support policies for renewables also impact the economics of power plants as their push into the market reduces the dispatch of fossil fuels. All of this has and will change the economics of fossil fuel power plants. At the same time electricity markets, especially in liberalised power markets, have adjusted to accommodate these new realities. As renewables are pushing into the power systems in many parts of the world, their characteristics (no fuel costs, only upfront costs) often provide them priority dispatch (e.g., in the merit order), displacing fossil fuel power sources. However, given the intermittent nature of the most relevant renewable energy technologies, wind and solar, fossil fuel plants still play a significant role in providing system flexibility and balance. Assuming the long-term full decarbonisation of the sector, this is a transitional effect, and fossil fuel plants will eventually be replaced by clean flexibility sources (such as energy storage technologies or demand side management). In the meantime, especially fossil gas power plants are often pushed out, due to their relatively high fuel costs compared to coal. To accommodate these changes, new business models such as capacity markets, have been developed in many countries which pay operators on the basis of providing back up capacity rather than power and thus enable the continued operation of these plants under changing conditions (ACER, 2023). This has important implications for potential compensation payments, as under such scenario operators would likely not need separate financial compensation or only to a limited extent given these new income streams (Carvalho, Rexon; Hittinger, Eric; Williams, 2021).

In addition to plant level considerations, several additional factors have an impact on how much compensation should be paid and is justified for early retirement of a fossil-based power plant.

- **Historic role of fossil fuels** – The impact the combustion of fossil fuels has on the climate has been known since long before most operating fossil fuel power plants were built, and it can be argued that investors should have taken the risk of sunk investments into account at the time of making the investment decision. In this sense, power plant owners were acting financially imprudent when failing to consider transition risks of a potential early phase-out of fossil fuels given their clearly identified role in the international climate governance system. In simple words, they could have seen it coming. The acknowledgement of global man-made climate change and its link to the burning of fossil fuels goes back to the Club of Rome in 1982 (The Club of Rome, no date). While under Kyoto in 1997, commitments were largely focused on developed countries, the signing of the Paris Agreement in 2015 made clear that, to stay within the science driven, politically agreed global temperature level of 1.5°C/ 2°C, action by all countries will be required. Against this background, at a minimum, investors in fossil fuel plants should have considered the possibility of an early phase out (and potentially associated sunk investments) since this date. Any compensation could thus be viewed as rewarding imprudent investment decisions and hence needs to be considered under aspects of fairness, especially given limited financial resources.

→ **Power plant compensation versus utility compensation** – Looking at the compensation of utilities instead of individual power plants opens up new opportunities for how a compensation can be structured in a manner that reduces the costs to society. Instead of looking only at one asset, the focus can be shifted to the portfolio of assets that a utility owns, also including renewable energy. This becomes especially important when considering the availability of resources to invest into new assets which is a major problem that utilities commonly face (see for instance (Reuters, 2017)). In the US, securitisation bonds are one example where utilities are able to free up financial resources through refinancing their fossil fuel power plants that are then in turn invested into renewable energy and just transition efforts. In return, the utilities are retiring fossil fuel plants before the end of their technical lifetime (Fong, Christian; Mardell, 2021). This approach is especially attractive when considering that building new renewable power plants is increasingly cheaper than operating existing fossil fuel plants in many parts of the world (Carbon Tracker Initiative, 2018). In these cases, utilities might be open to retire existing plants earlier, as it puts them in an overall better economic position. Industry led initiatives have started to implement tools that help utilities identify when new renewables become cheaper than running existing fossil fuel plants (Carbon Tracker, 2024).

3.1.1 THREE METHODS TO QUANTIFY COMPENSATION NEEDS FOR EARLY PHASE OUT OF FOSSIL GAS POWER GENERATION

The calculation of potential financial compensation for the early retirement of fossil gas power generation assets is not trivial and does not lend itself to simple solutions. We developed three quantification methods with the following guiding questions in mind, reflecting the aspects discussed above:

- → To what extent is a phase out driven by the need to reduce global emissions or by other factors, such as economics or environmental/ health concerns? For instance, should a running fossil gas power plant be financially compensated if it is already cheaper to install new renewable power plants and generate electricity with these, as is increasingly the case (Gray et al., 2020)?
- → Should compensation be considered at the plant or at the utility level? For instance, at the utility level a portfolio of projects, including renewable sources, could be considered and thereby compensating the early phase out of fossils with a phase in of renewables.
- → If considering plant level, has the plant already broken even, and if not, will it do so before it needs to be retired early according to Paris-aligned pathways?

Using quantification methods with the aim to try and answer these questions can provide an improved understanding of the financial implications associated with the phase out of fossil gas power plants and the scale of potential compensation payments. The different methods discussed here all have their individual drawbacks, and none of them should be used without a process for stakeholder consideration and/or can deliver reliable results without access to often proprietary data.

→ **Tab. 3** provides an overview of the three different approaches analysed here, including their key advantages and disadvantages. The three methods are discussed in further detail below and tested from the perspective of the Mexican power sector and the particular challenges related to the phase out of fossil gas fired power plants. It is important to emphasise that any calculation, regardless of the method used, can only provide an order of magnitude. The aim here is therefore much rather to discuss the implications different approaches have which can then be used as a basis for consultation with affected stakeholders. → **Tab. 3** provide an overview of the three methods:

Method	Aim	Advantages	Disadvantages
1. Plant-based capital recovery	Identify the year in which the plant achieves an acceptable internal rate of return (IRR) or breaks even based on plant specific data.	Reveals the actual financial status of the plant.	Requires access to historical and often confidential data.
		Clearly determines whether compensation can be justified.	The lack of access to appropriate data makes the process reliant on a range of assumptions.
2. Simplified capital recovery	Establish the "generic" capital recovery (i.e. assuming that the plant only breaks-even at the end of its technical lifetime of typically 25 years).	Can be calculated even if access to confidential data is limited.	Results in overestimated compensation needs as fossil gas plants typically break even within 9 to 17 years (Carvalho, Rexon; Hittinger, Eric; Williams, 2021).
3. Compensation estimation based on generation costs	Estimate how much compensation (or in this case incentive) power plant owners need to make replacing existing fossil gas plants with new renewables financially attractive.	Reduced need for often confidential data as no assumptions needed on the capital recovery of existing power plants.	Does not provide a plant based overview on the capital recovery need of individual power plants, but can be useful for utility wide compensation.
		Looks at the energy utility more holistically.	

Tab. 3

Overview of methods to estimate compensation payments

The aspects discussed above are impacted differently by the methods presented here, which has important implications on how to interpret the results. Generally, many of the aspects are difficult to integrate into quantitative analysis and require a qualitative assessment and valuation:

→ **Availability of data to undertake analysis** – Data availability remains a problem across all methods as plant specific data provides the most accurate results. However, some methods (Methods 2 and 3) require less detailed modelling of the power plant stock, reducing the overall data requirements.

→ **Consideration of contractual agreements of power plants** – Contractual agreements are not considered in any of the approaches presented. This is an explicit choice as we argue above that they should not be the basis for estimating compensation amounts. We instead focus on the economics of the powerplants, independent of contractual arrangements.

→ **Suitability of analysis for gas fired power plants** – As gas fired power plants tend to have lower upfront costs and higher running costs than coal fired power plants, the payback periods are generally lower than for coal fired power plants. Assuming a payback over the technical lifetime (Method 2) thus overestimates the compensation needed. A more detailed understanding of the capital recovery at a plant level (Method 1) can avoid this. In addition, the relatively higher running costs of gas-fired power plants also mean that new renewables are more likely able to replace them on the basis of a comparison between their long-run marginal cost (LRMC) and the levelized cost of electricity (LCOE) of new renewables (Method 3).

→ **Role of changing policy (e.g., CO_2 prices) and market environment (e.g., capacity markets)** – None of the methods take account of policies affecting the operation and economics of power plants, as no such policies exist in Mexico (at least at a level that would impact the calculations). If policies such as CO_2 pricing mechanisms or environmental regulations were to be considered, the compensation amounts would likely be reduced for all three methods. Capacity markets affect the reduced/ curtailed operation of power plants, which is not considered here.

→ **Considerations of the historical roles of fossil fuels in climate** – None of the methodologies consider that plant owners should have taken account of the climate impact of fossil fuels in their planning. If considered, this could lead to a further reduction in the compensation amounts for all methods.

→ **Suitability for plant level versus utility level compensation analysis** – The first two methods are suited for plant level compensation (Method 1 and 2), and the third for utility level restructuring/ compensation (Method 3).

A more detailed discussion of each method as well as results in the Mexican context is outlined in the following sections.

Method 1 - Compensation estimation based on plant based capital recovery

On the basis that compensation payment for early retirement should recover initial upfront investments , i.e., avoid making a loss, this first method estimates when the investment broke, or will break even and relates this to a Paris compatible phase-out schedule. According to this method, once an investment has broken even and only generates profits, a compensation payment would not be justified. If the investment in contrast has not yet fully recovered its upfront capital costs (including an acceptable profit), the compensation would equal the expected revenue required to recover the capital costs between the year of early retirement and the technical lifetime of the plant. This break-even year is calculated here by determining the point in time when the power plant has reached a certain, acceptable internal rate of return (IRR). The IRR is a commonly used tool in the financial world to determine the return of an investment and represents the interest rate of an investment with a net present value (NPV) of zero.

Including interest on debt and an acceptable revenue on the investment (IRR)

While this method seems rather straightforward, it is highly difficult to pursue in practice as it requires a reconstruction of the financial feasibility of the investment decision. Calculating the break-even year of a plant requires access to plant-specific

Tab. 4

Overview of assumptions made for plant-based capital recovery method (Method 1)

Item	Input data / assumption
Capacity factors, year of operation start and investment costs (CAPEX)	Plant specific values as reported in the 'Domestic' scenario (Iniciativa Climática de México (ICM), 2023).
	For capacity factor - if not available use of average future value from the "International" scenario (Teske et al., 2023).
Fuel costs/gas price development	EIA historic figures for export to Mexico and forecasts for wholesale gas price until 2050 (US EIA, 2023b, 2023a).
Electricity offtake prices	Average wholesale market prices for the years available (2016 – 2023) (Nexus Energia, 2023) – afterwards: average across years with available data adjusted for inflation changes benchmarked on US generation price forecast (US EIA, 2023b).
Internal Rate of return of investment (equity investor)	12% Average values for Mexico from (IEA, 2022).
Share of debt financing	65% Average values for Mexico from (IEA, 2022).
Interest rate of debt financing	8% Average values for Mexico from (IEA, 2022).
Duration of debt financing	17.5 years Average values for Mexico from (IEA, 2022).
Construction time (gas plants)	3 years (Schloemer et al., 2014).
Efficiency of power plant	EIA average values for the US reported efficiency for the last 10 years by technology (US EIA, 2023c).
Year of early shutdown	Based on 1.5-compatibility (Teske et al., 2023).

historical data, that in almost all cases, is confidential. This includes data such as specific electricity offtake prices, capex debt share, and cost of debt and equity **(see → Tab. 4)**. Approximations based on accessible data and/ or assumptions, however, can give some general indication. Such analysis can only be used at the aggregated level as the input data is too generic to deliver plant level results. Especially the revenue streams of power plants are generally difficult to decipher – while some plants might sell at the spot market, others operate under long term PPA arrangements. In Mexico there is no information available on the offtake electricity prices agreed in long term PPAs, and only the average offtake prices for electricity on the market can be used as an approximation. **→ Tab. 4** provides an overview of the main assumptions made for the detailed capital recovery calculations for the case of Mexico.

Results

According to our analysis, a total of 82 fossil gas fired power plants need to shut down before the end of their expected technical lifetime in line with the "International" scenario **(→ Section 2)**. An overview of the results is highlighted in **→ Tab. 5**. A significant number of plants (45%), according to our calculations, are not in need of any compensation but instead break even before they would need to shut down. However, an even higher number (48%) does not break even at all. This reflects that these plants are likely operating under different conditions than those assumed here, especially with regards to the revenue generated from selling the electricity.

Our analysis assumes that all plants are selling their electricity at the average offtake price achieved in the Mexican electricity market **(see → Tab. 4)**. In reality, a significant number of plants are either bound to long term PPA contracts (for which there is no data available) and/ or generate electricity for self-consumption (captive plants). In either case the revenue generated by these plants is likely to be higher than what can be achieved in the electricity market, likely improving the financial situation of these plants and allowing them to break even before the end of their technical lifetime. For that reason, we have assumed that these plants break even at the end of their technical lifetime, in line with Method 2.

Powerplant group	Number of plants	Total installed capacity (GW)	Avg. comp (thsd USD/MW)	Total comp (bln USD)
Break-even before early phase out with IRR=12%	37	7.9	0	0
Break-even after early phase out and IRR=12%	6	1.6	226	0.4
Break-even at the end of technical lifetime	39	1.7	3532	1.7
All	**82**	**11.2**	**1237**	**2.1**

Note: Break-even at the end of technical lifetime: plant compensation figures taken from Method 2, incomplete or missing data resulted in Method 1 not producing results.

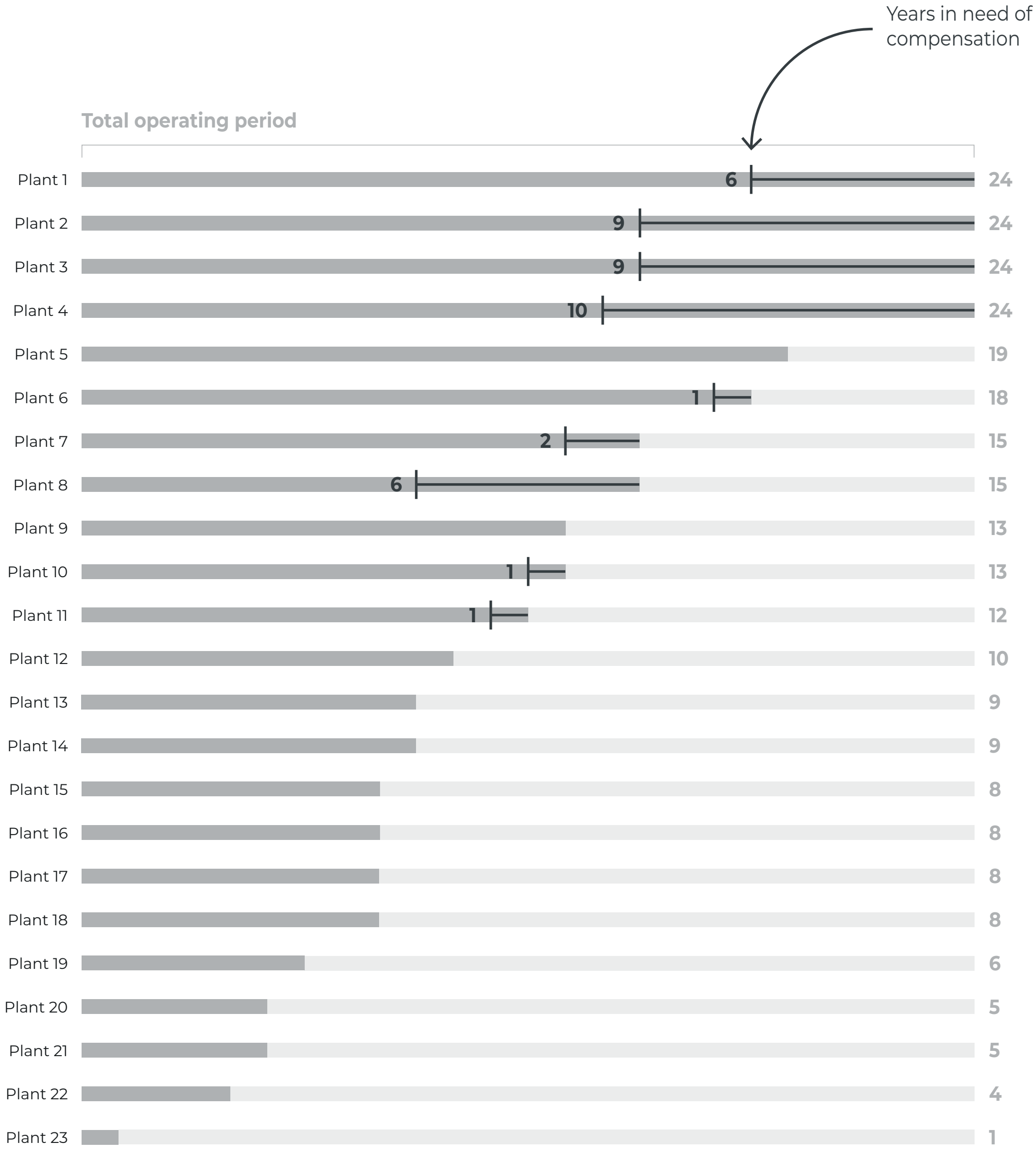
Tab. 5

Overview of results from compensation calculations under Method 1

The compensation amounts differ significantly from one plant to another, depending on plant specific characteristics including the size, type, and investment costs of the plant, but also the operating period that the plant would need to be compensated for **(see → Fig. 8)**. The average compensation amounts per MW are 15 times higher for plants that only break even at the end of the lifetime than for those breaking even earlier, and total compensation is almost 4 times higher **(see → Tab. 5)**. In addition to some plants not breaking even, there are also some plants that our analysis suggest break even in a rather short timeframe. This amplifies that the data situation is challenging and conclusions on individual plants cannot be drawn. On average our calculation, however, suggests that plants in Mexico might break even within a period of approximately 12 years, which is within the range reported by other sources of 9 to 17 years (Carvalho, Rexon; Hittinger, Eric; Williams, 2021), and hence generalised results are likely more robust.

Fig. 8

Method 1 - Operating period before fossil gas fired power plants in Mexico break-even and years in need of compensation for plants over 50 MW



Note: Plants have been made anonymous as the results from the calculations here cannot be used for individual plants due to a lack of data.
Source: Author's own calculations.

Method 2 - Simplified compensation estimation using capital recovery factors

Given the difficulties in estimating the break-even point of a fossil gas power plant, a simplified method can be considered. Instead of calculating the break-even point based on specific power plant data, one may assume that the initial investment costs only break-even at the end of the technical lifetime of a power plant. The calculations then rely on the use of a capital recovery factor, which spreads the initial investment costs over the technical lifetime of the power plant. This reduces the data needs significantly. In contrast to the approach used under Method 1, this would justify compensation payments for all plants that are retired before the end of their technical lifetime. However, fossil gas plants typically break even within the first 9 – 17 years of operation (Carvalho, Rexon; Hittinger, Eric; Williams, 2021), i.e ~10-15 years before the end of their usual technical lifetime . Therefore, this method will likely overestimate the compensation payments needed in comparison to Method1. In the case of Mexico, this effect is likely to be especially strong given the young age of some of the fossil gas-fired power plants in the fleet **(see → Section 2)**. **→ Tab. 6** provides an overview of the assumptions made using Method 2.

Tab. 6

Overview of assumptions made for the simplified capital recovery method (Method 2)

Item	Input data / assumption
Capacity factors, year of operation start and investment costs (CAPEX) (future)	Plant specific values as reported in the "Domestic" scenario (Iniciativa Climática de México (ICM), 2023).
	For capacity factor – if not available use of average future value from the "International" scenario (Teske et al., 2023).
	OPEX calculated as 1% of total value.
Gas price development	EIA historic figures for export to Mexico and forecasts for wholesale gas price until 2050 (US EIA, 2023b, 2023a).
Technical lifetime powerplant	25 years (Danish Energy Agency and Ministry of Energy and Mineral Resources of Indonesia, 2021).
WACC	8% average values for Mexico from (IEA, 2022).
Year of early shutdown	Scenario based (Teske et al., 2023).

Powerplant group	Number of plants (-) / share of total plants (%)	Total installed capacity (GW)	Avg. comp (thsd USD/MW)	Total comp (bln USD)
Break-even at the end of technical lifetime	82	11.1	1955	8

Note: Plant compensation figures taken from Method 2, incomplete or missing data resulted in Method 1 not producing results.

Tab. 7

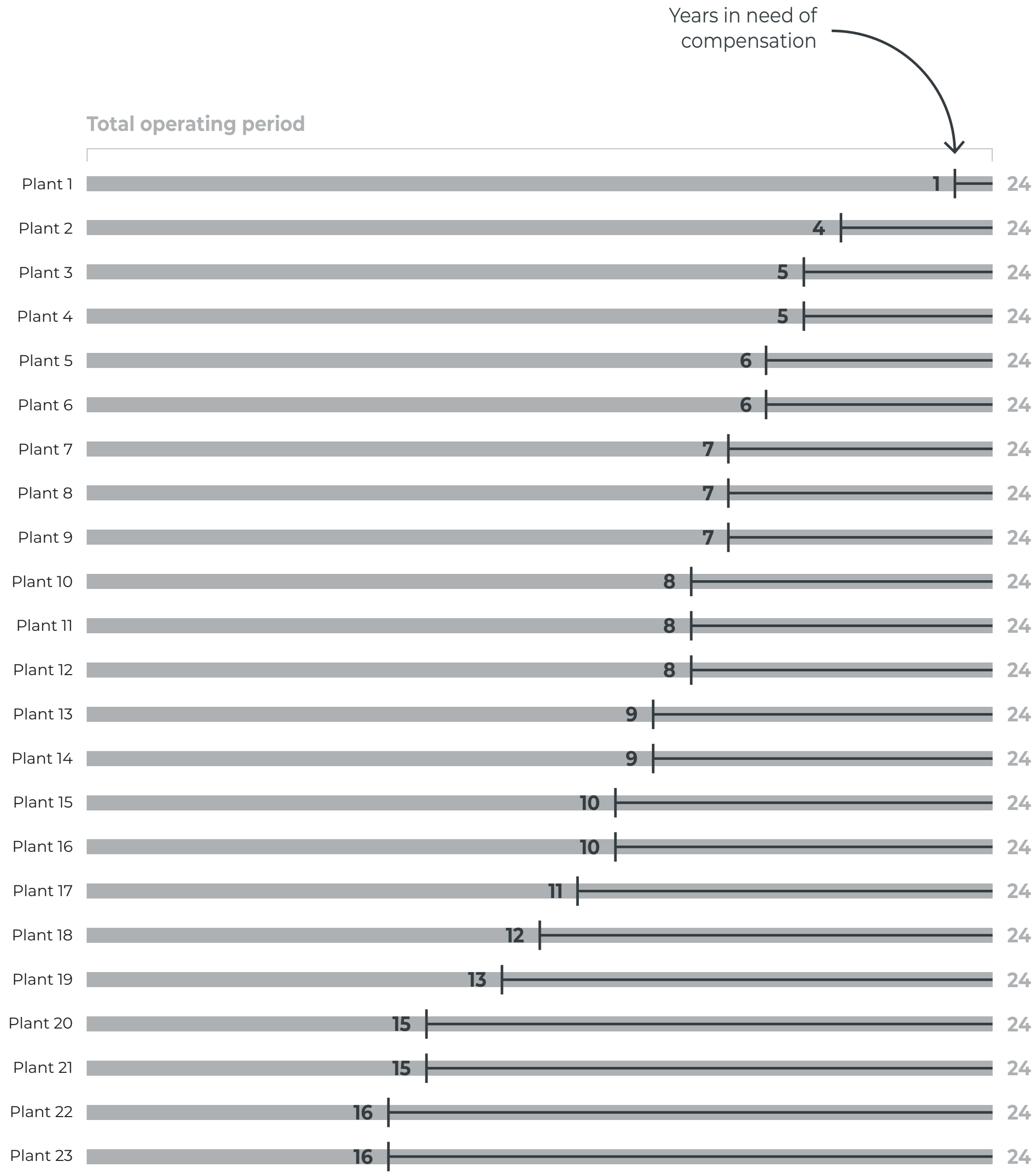
Overview of results from compensation calculations under Method 2

Results

According to Method 2, all 82 plants that would need to shut down before the end of their technical lifetime in line with the "international" scenarios would require compensation payments **(see → Fig. 9)**, following the assumption that the recuperation of the capital costs is evenly spread over the lifetime of the plant. Similar to Method 1, the calculated compensation amounts significantly differ from plant to plant, ranging from 0.2 million USD to 914 million USD. The years in need for compensation vary significantly from 1 to 17 years, with the highest values exceeding the average years it usually takes for a gas-fired plant to break even (Carvalho, Rexon; Hittinger, Eric; Williams, 2021). This also leads to higher average compensation amounts, as the plants need to be compensation for more years of missed operation.

Fig. 9

Method 2 - Operating period before fossil gas fired power plants in Mexico break-even and years in need of compensation for plants over 50 MW



Note: Plants have been made anonymous as the results from the calculations here cannot be used for individual plants due to a lack of data.
Source: Author's own calculations.

Method 3 - Compensation estimation based on generation costs

Applying one of the two methods above ignores that increasingly across the globe installing new renewable power plants is cheaper than operating existing fossil power plants (Gray et al., 2020; The Carbon Tracker Initiative, 2021). If that is the case, the early retirement of existing fossil gas capacity and replacement with new renewable capacity would make economic sense for a utility or power plant owner, pending the availability of appropriate financing to invest into renewables. In this case, there would be no additional financing needed for the compensation of the shutdown of existing power plants, as the switch to renewables enables power plant owners to generate electricity at a lower cost than with the existing power plant park. This is especially relevant for utilities with a large number of fossil gas-fired power plants as these have lower upfront costs and higher running costs. As described above **(→ Section 3.1.1)**, the example of securitisation bonds in the US shows that such instruments can allow utilities to take advantage of the affordability of renewable energy technologies to replace existing fossil fuel fired power plants.

Methodologically, the relationship between new renewables and existing fossil fuel plants is represented by comparing the long-range marginal cost (LRMC) of existing fossil fuel power plants with the levelized cost of electricity (LCOE) of new renewables. The LRMC describes the electricity generation costs only considering running but not upfront capital cost whereas the LCOE describes the electricity costs also considering capital upfront costs. From an economic perspective it makes sense (e.g. for a utility) to replace existing fossil fuel plants with new renewables if the LCOE (new renewables) is lower than the LRMC (existing fossil plants). Whether this is the case depends on several factors, including the capital and financing cost of renewables, but also the fossil fuel and other operating costs of existing plants.

It is important to note that if increasing system costs, caused by an increasing need for flexibility in the power system, would be attributed to renewables, then the method taken here will underestimate the LCOE of renewables, especially as time progresses. While grid connection costs were considered as part of the calculation of the LCOE, based on figures derived from literature (Gorman, Mills and Wiser, 2019), additional storage costs that arise as the share of variable renewable energy sources increase, were not considered. In the early phases of the transition, existing power plants can provide flexibility, but as time progresses, additional investments need to be undertaken to provide non fossil sources of flexibility (De Vivero-Serrano et al., 2019). However, how and whether these system wide costs should be attributed to individual power plants or should be part of a more system wide consideration remains disputed.

Tab. 8

Overview of assumptions made for the calculations of the compensation estimation based on generation costs method (Method 3)

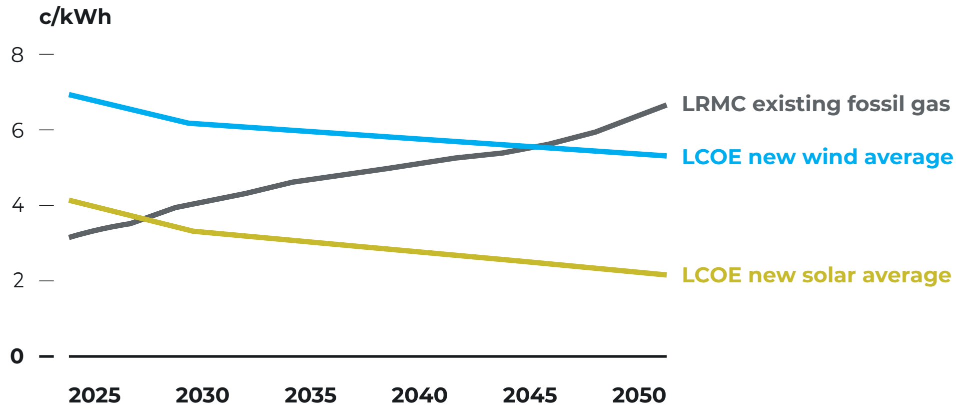
Item	Input data / assumption
Capacity factors, year of operation start and investment costs (CAPEX), Operation and Maintenance costs (OPEX) (future)	Plant specific values as reported in the "Domestic" scenario (Iniciativa Climática de México (ICM), 2023).
	For capacity factor - if not available use of average future value from the "International" scenario (Teske et al., 2023).
	OPEX calculated as 1% of total value.
Capacity factor (future)	Average historical values (Teske et al., 2023) except for Solar utility (IRENA and SENER, 2015).
Fuel costs / gas price development	EIA historic figures for export to Mexico and forecasts for wholesale gas price until 2050 (US EIA, 2023b, 2023a) and (Sarmiento et al., 2019) for coal.
Technical lifetime powerplants	Fossil Gas: 25 years, Solar: 35 years, wind: 30 years (Danish Energy Agency and Ministry of Energy and Mineral Resources of Indonesia, 2021).
Technology learning rates	National decarbonisation study (Sarmiento et al., 2019).
Share of Wind and Solar	"International" scenario (Teske et al., 2023).
Weighted Average Cost of Capital (WACC)	9,4% (average values for Mexico from IEA, 2022).
	4,4% (average values for Mexico from IEA, 2022).
Year of early shutdown	Own calculation based on the "International" scenario (Teske et al., 2023a).
CAPEX, OPEX renewable energy	National decarbonisation study (Sarmiento et al., 2019).
Additional costs considered	Cost of interconnection of renewables to the grid (Gorman, Mills and Wiser, 2019).

Results

At an interest rate of 9.4%, based on historic values for the weighted average cost of capital (WACC) for solar PV in 2021 in Mexico (IEA, 2022), building new wind and solar is still more expensive than operating already existing fossil fuel power today. The LCOE of renewables becomes lower than that of fossil gas in seven (solar) respectively 24 (wind) years from now **(see → Fig. 10)**, according to our calculations. Technological learning and economies of scale bring down the costs of renewable energy technology over time. The LRMC of fossil gas is significantly increasing over time and is closely linked to the development of the fossil gas prices. Our calculations use data from the US EIA (US EIA, 2023b) as Mexico is heavily dependent on gas imports from the US and will likely not reduce this dependency due to long term contracts between US and Mexico (see → Section 2 and → **Box 2)**.

Fig. 10

Comparison of the LCOE of new wind and solar with the LRMC of existing fossil gas capacity assuming a WACC of 9.4% for wind and solar investments

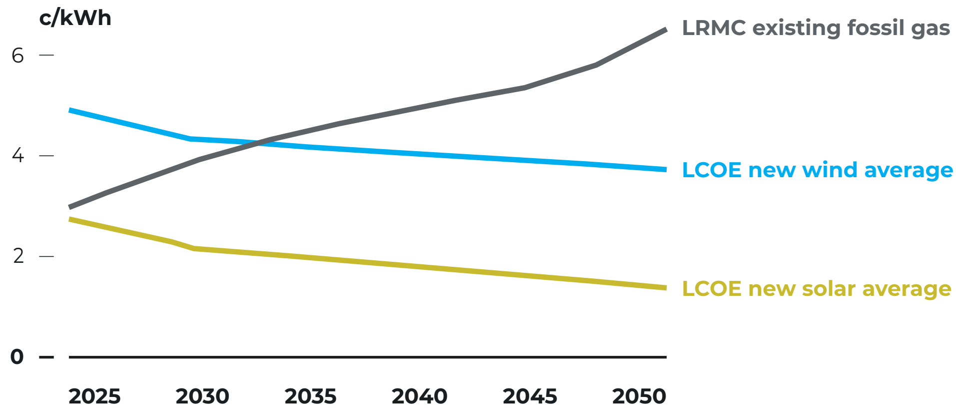


Source: Author's own calculations.

With lower cost financing available, represented here by a WACC of 4.4%, the average LCOE for solar is already lower than the LRMC of fossil gas today, and for wind would reach a breakeven point within a decade, our analysis suggests **(see → Fig. 11)**. Solar electricity is already the cheapest electricity generation source, and due to expected economies of scale and learning effects, will become even cheaper over time. Wind, which, despite its higher costs, plays a significant role in the "International" scenario, potentially due its role in the mix solar to provide energy security in the long run, will surpass the average LRMC of fossil gas by around 2034, as wind costs continue to decrease over time and fossil gas prices are projected to increase (US EIA, 2023b, 2023a).

Fig. 11

Comparison of the LCOE of new wind and solar with the average LRMC of existing fossil gas capacity assuming a WACC of 4.4% for wind and solar investments

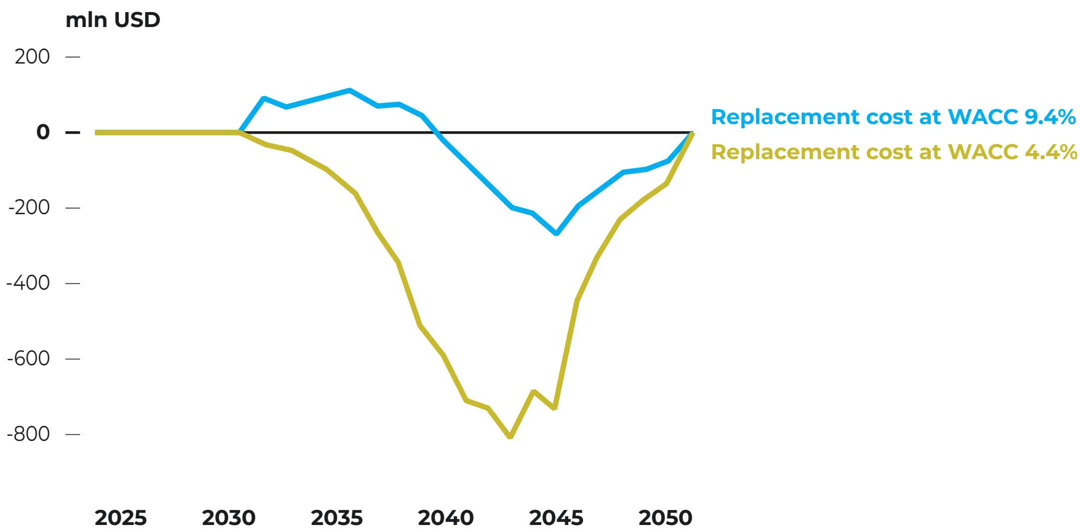


Source: Author's own calculations.

While, in early years, replacing new renewables with existing fossil gas fired power plants might still lead to additional costs, depending on the financing available, this turns to a benefit over time as renewables continue to fall in price and the fossil gas price increases. As already highlighted above, the buildout of renewables to replace the retired plants still costs more due to both technologies initially being more expensive than existing fossil gas plants **(see → Fig. 12)**. As time progresses the cost advantage of solar over fossil gas and the reducing costs of wind lead to a shift, and around 2037 the replacement with renewables becomes cheaper than the operation of existing fossil gas fired power plants. As discussed above, lowering the WACC can change this and can turn investments in renewables into a very attractive option to finance the phase out of fossil gas fired power plants.

Fig. 12

Additional costs due to the replacement of existing fossil gas fired power plants with new solar and wind plants (Method 3)



Source: Author's own calculations.

3.1.2 COMPARISON AND DISCUSSION OF RESULTS ACROSS METHODS

The previous sections have highlighted different angles on how compensation for the early retirement of fossil gas plants could be analysed. The overview of aspects relevant to the compensation discussion in → **Section 3.1.1** highlights that there is no simple answer to determining the (potential) compensation needs. Effectively, the three methods provide separate angles of how the problem could be approached, depending on data availability, focus of the analysis and other factors. This section draws out some of the high-level findings that can be drawn from a comparison of the methods.

According to our analysis, estimates for plant-level financial compensation needs for early retirement of fossil gas plants in Mexico are up to 4 times higher using the simplified capital recovery method (Method 2), compared to a more

sophisticated method based on a calculation of financial break-even (Method 1) (see → Fig. 13). While the figures presented are only first-order estimates, Method 1 suggests that compensation for early retirement might not be justified for a significant number of fossil gas plants in Mexico as they will likely have recovered their upfront costs and returned a profit before the shut-down occurs. Under a simplified method (Method 2) which assumes break-even, or full recovery of capital costs, at the end of the technical lifetime, these plants would still receive compensation. Such type of analysis, as applied for instance to Indonesia in the past (Cui et al., 2022), should thus be regarded with extreme caution and needs to be complemented with further analysis on the break-even of power plants. If regarded only in isolation it could lead to a significant overestimation of the costs.

Our calculation for the sophisticated analysis does not return a break-even year for a relatively large number of power plants, suggesting that these plants do not break even. While this is likely due to the lack of plant specific data described above, recent financial losses experienced by CFE also suggest that this might not be too far off reality. In cases that no break-even year could be calculated, the simplified capital recovery method was used.

The need for financial compensation can potentially be further reduced or even eliminated, if a utility perspective is taken and the possibility of replacing existing fossil gas fired power plants with new renewable plants is considered (Method 3). Our comparison of the LRMC of existing fossil fuel plants and the LCOE of renewables shows that installing new renewables today, while this changes over time, in many cases is still more expensive than operating existing fossil fuel power plants in Mexico. Lowering the WACC from a common power sector level of about 9.4% (Berkenwald and Bermudez, 2020) to 4.4%, a level that solar PV has

Fig. 13

Compensation needs under different methods for calculating fossil gas phase out compensation needs over the time period 2023 to 2050

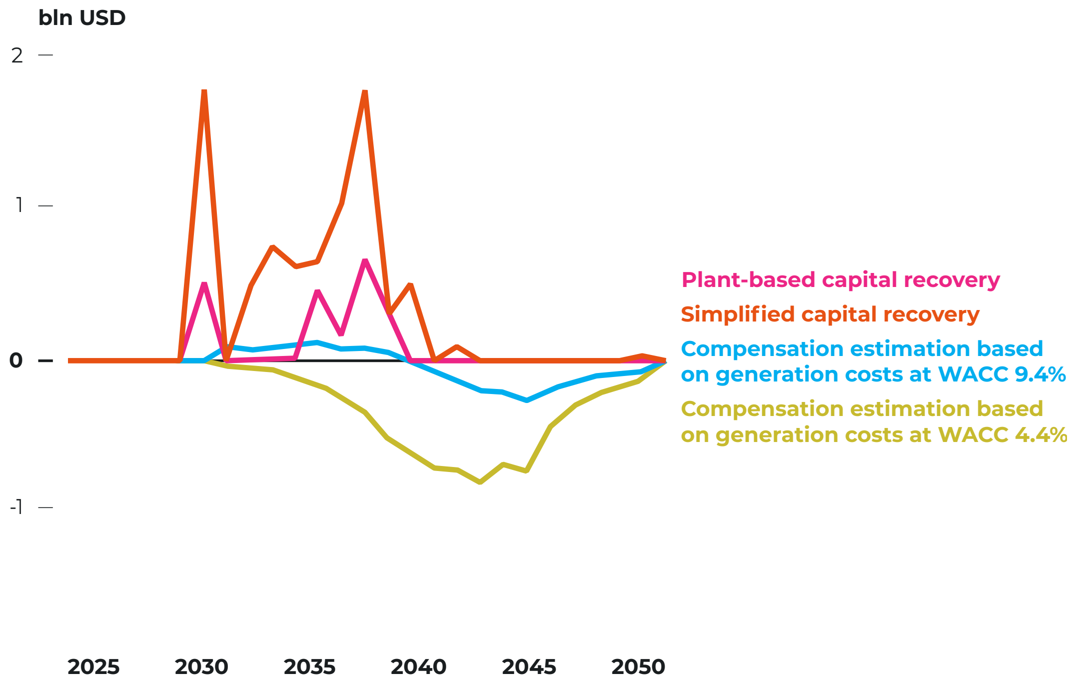
Note: Discount rate of 8.4% used for the graph on the right-hand side.
Source: Author's own calculations.

reached in the past in Mexico (Steffen, 2020), however would reduce the LCOE of new renewables significantly, reducing or even eliminating this gap. Our analysis suggests that, under favourable investment conditions, the LCOE of solar could already today be below the LRMC of existing fossil fuel power plants and wind could reach this break-even point within the next decade (around 2033). It would also impact the electricity generation cost difference before the break-even year significantly, from maximum addition costs of 0.1c/kwh with an 9.4% WACC to reducing the maximum costs to around 0 with a 4.4% WACC.

While compensation costs decrease over time under Method 3, they are mainly dependent on phase-out dates under Method 1 and Method 2. A comparison of the methods over time **(→ Fig. 14)** highlights the difference in temporal compensation. If compensation payments are to be linked to the phase-out schedule of fossil gas fired power plants, then the compensation payments vary greatly, with some years seeing extremely high compensation amounts when larger plants or a significant number of plants need to be shut down. This can have significant budgetary implications in countries in these years, in particular considering limited fiscal leeway in many countries. In contrast, the replacement of existing plants with renewables leads to yearly costs (or benefits) that spread more evenly across time thus reducing the fiscal burden in any given year.

Fig. 14

Development of compensation needs over time under the three different methods for calculating fossil gas phase out compensation needs in the timeframe 2023 to 2050



Source: Author's own calculations.

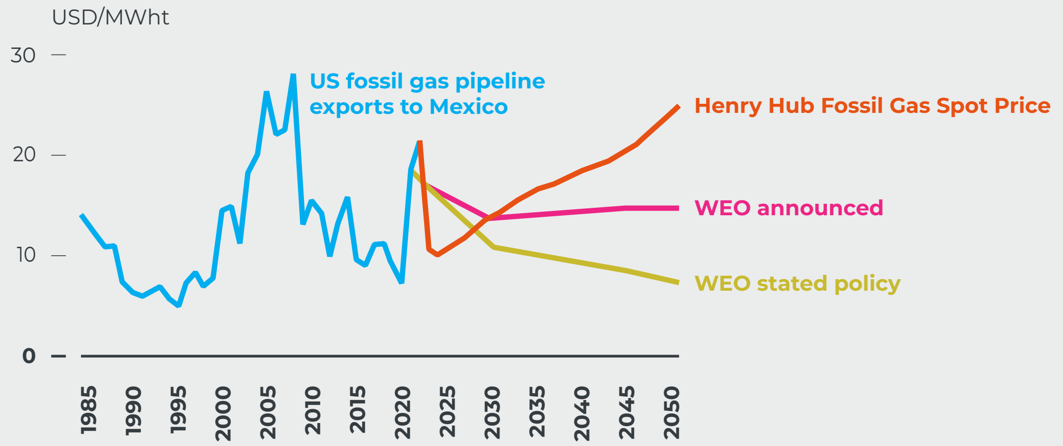
Box 2

The influence of fossil gas price scenarios on compensation results

Historically the price of fossil gas has fluctuated significantly **(see → Fig. 15)**. It is dependent on global circumstances including events such as the Russian invasion of Ukraine or the exploitation of new gas sources such as shale gas. Consequently, any forward-looking projection is associated with great uncertainties. Major factors influencing the development of the gas prices are the availability of resources, the demand for fossil gas but also unexpected events causing price shocks. This report uses the official projections from the EIA (US EIA 2023a), as most of Mexico's gas for power generation is imported from the US. These projections suggest that the cost of gas will continue to increase. However, projections by the IEA (IEA 2023d) suggest that the fossil gas price might also develop differently, especially as the demand decreases under a global decarbonisation scenario **(see → Fig. 15)**. It is important to note that a carbon price would also have an impact here as it would increase the fossil gas price.

Fig. 15

Historical and projected fossil gas price development in Mexico

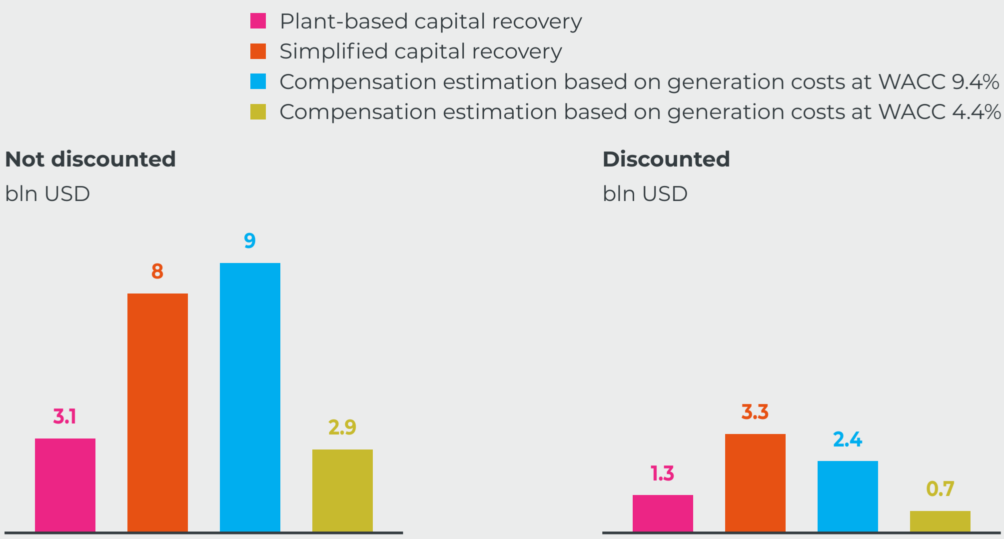


Source: (US EIA, 2023a); (IEA, 2023d).

The compensation amounts calculated under Method 1 and 3 shift upwards under a declining gas price scenario, especially for Method 3. Amounts calculated under Method 2 remain unaffected as it only regards the recovery of up-front costs over time without considering operational income and costs. Method 1 "capital recovery" shifts slightly upwards, mainly due to the temporary price increase of the IEA WEO scenario. This highlights the importance of the price development in the next couple years for the feasibility of fossil gas fired power plants, and their corresponding need for compensation. Compensation amounts under Method 3 is most affected as the competitive advantage shifts to existing fossil gas power plants in a world with decreasing gas prices. While solar energy remains cheaper in all cases, the price differential decreases. Wind on the other hand does not reach a break-even point and also has an increased price differential, thus causing the increase in costs in our scenarios. Notably, the compensation needs of the 3rd method with a low cost interest rate roughly equal those of the complex method **(see → Fig. 16)**.

Fig. 16

Compensation needs under different methods for calculating fossil gas phase out compensation needs over the time period 2023 to 2050 under a low fossil gas price scenario



Note: 1. Discount rate of 8.4% used for the graph on the right-hand side. 2. IEA WEO stated policy scenario used for the gas price (IEA, 2023d).
Source: Author's own calculations.

The early phase out of fossil fuel plants could lead to compensation claims. Policy decision for the coming years play a crucial role for Mexico to ensure the transition will be managed in a way that minimises these potential costs and maximises the opportunities that arise through the uptake of low-cost renewables. Mexico has several important policy decisions to make that influence the needs for such compensation payments.

→ **Further development of its electricity market design** – Electricity market regimes are transitioning around the globe and an increasing number of electricity markets are reconsidering how flexibility services (from short to long term) are included as the share of variable renewables increases (e.g., European Commission, 2023). Examples from other countries show that such redesigned market regimes allow fossil gas fired power plants to operate with similar pay back periods as they are operating under a base load system (Carvalho, Rexon; Hittinger, Eric; Williams, 2021). If designed well, these adjusted rules could reduce or even eliminate the need for compensating operators for the reduced operation of fossil gas fired power plants. However, a note of caution needs to be added that these designs should ensure that they do not lead to windfall profits and that over time these schemes should transition to non-fossil fuel-based flexibility options such as energy storage or dispatchable renewable energy sources.

→ **Build out of new (planned) fossil gas fired power plants** – Currently a series of fossil gas fired power plants are under planning in Mexico. Our analysis includes plants that are currently under commission (Iniciativa Climática de México (ICM), 2023). The calculated potential compensations for these plants will be especially large given their need to generate a return on investment entirely in the future. In addition, the development of these plants makes little economic sense as new renewables are already cheaper to build than new gas fired power plants and are not required to provide flexibility, given the current dominance of gas fired power plants in the Mexican power system. Instead, these same investments should be redirected towards renewable energy installation **(see → Section 3.2.2.)**.

In addition, as highlighted by Method 3 above **(see → Section 3.1.1),** the build-out of renewables is directly linked to the phase out of fossil gas. A well-designed approach towards the build-out of renewables can further help to reduce the need for compensation **(see → Section 3.2.2)**.

Even if Mexico takes the policy decisions that are conducive to the transition, a need to financially support the early phase-out of fossil gas fired power plants might remain. How this is done however can significantly shape the amount and type of finance needed **(see → Section 3.1.2)**. Our analysis suggests that changing the business models of existing power plant operators is likely to reduce the compensation needs over simply compensating the shut- down of individual plants. However, the diverse ownership structure of power plants in Mexico, including both independent power producers (IPPs) that often only operate a limited number of power plants and state-owned utilities that operate a large portfolio of power plants, will likely require different approaches:

→ **Utility level transition of Mexico's state-owned utilities** – Mexico's state-owned utilities CFE and PEMEX would lend themselves well to a utility level transition approach, especially since the financial health of these utilities is central to their objectives (CFE, 2024b). Given the questionable economic health of these utilities, CFE for instance operated at a loss during 2021 and 2022 (CFE, 2024a), they could use investments into new low cost renewables, especially solar energy, to reduce their overall operating costs (see results from Method 3 in **→ Section 3.1.1**). However, they cannot achieve this without further financial support as they lack access to affordable financing, a common dilemma faced by public utilities across the globe. A solution in this context could be the provision of low-cost financing for renewables to these utilities, potentially combined with initial grants to cover remaining differential costs to existing fossil gas fired power plants, and a timeline for shut down of existing fossil gas fired power plants. Alternatively, financing for renewable energy could also be freed up though the refinancing of existing fossil gas fired power plants, such as done under securitisation bonds in the US (Fong, Christian; Mardell, 2021). Given the steep cost declines of renewables, international finance might in this scenario even be phased out eventually as financial markets mature around renewables.

→ **Independent power producers: Replacing or restructuring PPAs** – Replacing fossil gas PPAs of IPPs with renewable ones can offer investors a return on early retirement. Independent power producers (IPPs) have often signed long-term PPAs with a guaranteed offtake price with the utilities to secure the recovery of upfront investments and to protect themselves from volatile commodity prices. In these cases, it can become contractually difficult to replace fossil fuel based power generation with renewables before the end of the contract. Several approaches can be applied to get out of such long-term PPAs (Kansal, Khannan and Vial, 2023); Through contract termination, replacement, or restructuring. The most desirable approach to get out of a PPA would be either through replacement or restructuring. Terminating a PPA contract risks leading to high and potentially inflated compensation payments. Replacing fossil fuel PPAs with renewable PPAs by selling the fossil fuel asset for retirement and providing finance for the replacement with renewables offers the investor an opportunity to generate a profit from the early retirement of fossil fuel plants.

The level of compensation requirements is particularly relevant in the context of scarce (public) climate finance resources, including at the international level. Despite commitments and calls to successively increase the level of climate finance, as enshrined in the Paris Agreement, developed countries have so far failed to do so at the required scale. In addition, climate finance made available internationally mainly takes the form of (concessional) loans. This is also the case for the current JETPs which are dominated by loans with limited amounts of grant finance in the package (Hagemann, Outlaw and Röser, 2023).

3.2 INFRASTRUCTURE - CLEAN BUILD UP

The buildout of clean infrastructure requires a concerted effort and investments into a number of areas, including the expansion of renewable energy capacity **(see → Section 3.2.1)**, the build out of the electricity grids **(see → Section 3.2.2)** as well as the development of electricity storage (not covered in the report). In recent years these investments have started to outpace fossil fuel investments at a global level, but this effort has been very unevenly distributed across countries (IEA, 2023d). For instance, in 2023 the share of clean energy investments in total energy investments amounted to around 76%, while this share was only 50% in Central and South America and overall in emerging and developing economies only 36% (IEA, 2023d). This points to an imminent need to support the increase in these investments to buildout the infrastructure in particular in these global regions.

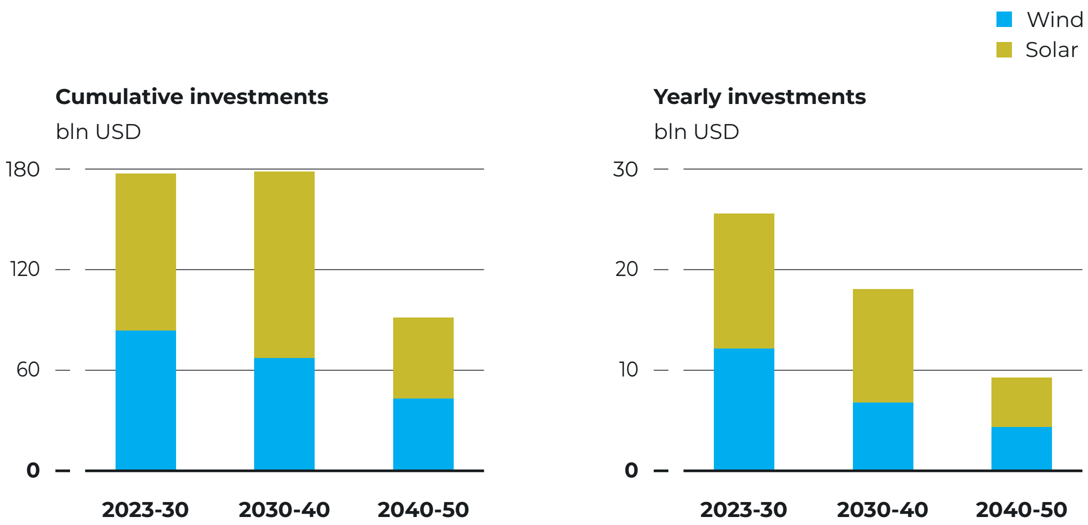
3.2.1 INVESTMENT INTO RENEWABLE ENERGY CAPACITY EXPANSION

The phase out of fossil gas needs to be coupled with the build out of renewable sources, as highlighted in the previous section. The estimation of investment needs for a clean energy build-up is significantly more straightforward than for the fossil gas phase out. Investment requirements for the expansion of renewable energy sources are mainly linked to the projected renewable energy and capacity build-out based on the scenario used, as well as the capital costs and assumed learning curves of the technologies. Nevertheless, these assumptions are associated with significant uncertainties, including the dependency on certain pathways, the availability of reliable data for cost estimates and the high degree of uncertainty around the future development of renewable energy costs (Cronin et al., 2015). For instance, recent developments of renewable costs in 2022 show a mixed picture, with increasing and decreasing costs depending on the technology and country (IRENA, 2022). The quantification of investments needs for renewables can therefore only provide first orders of magnitude and is subject to change depending on developments in the sector.

For the Mexican context, our calculations based on the "International" scenario suggest investment needs to build out the necessary wind and solar capacities of around 180 bln USD between now and 2030 and a similar amount between 2030 and 2040. For the time period between 2040 and 2050 this amount decreases to around half of that. The average yearly investment needs decrease over time, and while initially wind and solar need a similar scale of investments, solar overtakes wind at some point as the capacity additions outpace those of wind **(see → Fig. 17)**. These figures are highly scenario dependent but give an indicative order of magnitude overall. Especially on the technology split other studies might suggest different roles for wind and solar.

Fig. 17

New wind and solar capacity in the "International" scenario



Source: Author's calculations based on (Teske et al., 2023).

Despite the rapidly decreasing cost of renewables in recent years, their wide deployment is impeded by the lack of political will but also by relatively high perceived investment risks in Mexico. The WACC in Mexico was around 9.5% - 10% in 2021 for a solar PV plant (IEA, 2022), whereas it ranged from 2.3 % to 4.3% in

France in 2019 for instance (Brückmann et al., 2021) and had reached similar levels of around 4.8% under the auction scheme in Mexico in 2016 (Steffen, 2020). As highlighted by the IEA (2022), several risk factors contribute to a higher WACC. In particular regulatory risks, such as inconsistent energy policies as is currently the case in Mexico, have increased the WACC significantly. In order to address these risks and hence reduce the WACC for renewable energy in Mexico to previous levels or below, the enabling policy environment plays an important role, as outlined in the following.

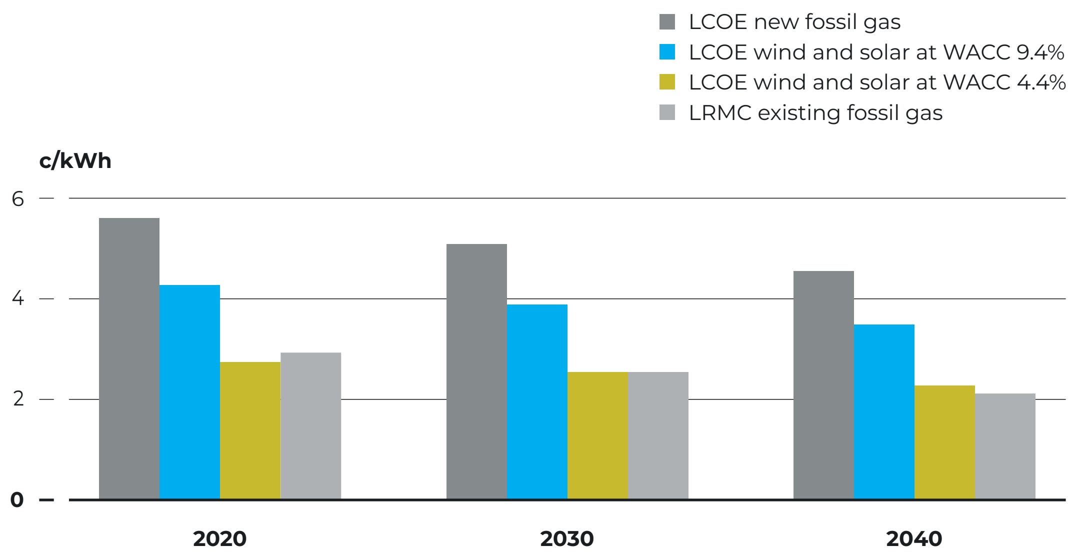
- → **Reliable, long-term renewables remuneration regimes** - The past auctioning schemes have attracted significant interest in renewable energy in Mexico, and have achieved extremely low bid prices, as low as 1.7 cent/ kWh for wind energy (USAID, 2020). While these prices are likely also the result of strategic decisions to enter the important Mexican market and cannot necessarily be replicated, they give an indication of what a well-designed renewable remuneration scheme could achieve. The relatively lower WACC achieved in Mexico under the auction scheme is a good example of that (Steffen, 2020).
- → **Long-term renewables targets** – Targets for renewable energy do not exist as such in Mexico instead renewable energy sources are indirectly covered by Mexico's clean energy target. A major problem with the clean energy target is however that it also includes efficient gas fired power plants. As such it becomes an accounting exercise, as the current government has proven, and does not provide any guidance to renewable energy developers in the country. Clear renewable energy targets, ideally with separate indicative sub-targets for wind and solar, would provide much more certainty to investors and thus reduce investor risks (Climate Action Tracker, 2023).

Additional levers were identified in other countries that can further help reduce the risk and thus reduce the WACC of renewables. These include streamlined permitting processes, improved grid development, improved power market conditions to ensure market access for renewables, long term PPAs for consumers and the implementation of a guarantee fund (Lütkehermöller et al., 2019).

Building new renewable energy generation to cover the ever-growing electricity demand and to replace retiring plants makes sense, irrespective of the financing available. Our analysis, in line with other studies (The Carbon Tracker Initiative, 2021), suggests that the average LCOE of new wind and solar capacity projected under the "International" scenario is significantly lower than that of new fossil gas fired power plants, even if favourable low-cost financing is not available. Favourable financing, i.e., bringing down the WACC to a level of 4.4%, can in turn bring down the costs of wind and solar to a level that is in line with the LRMC of existing fossil gas-fired power plants **(see → Section 3.1)**. This would be the case even in a scenario where the fossil gas price is reduced **(see → Fig. 18)**. As already suggested in the previous section, low-cost financing would allow the economic replacement of generation from fossil gas fired power plants with that of renewables. If Mexico puts measures in place to reduce investment risks coupled with an international effort to provide low-cost financing, low WACC rates become realistic.

Fig. 18

Comparison of the LCOE for the average wind and solar mix in the "International" scenario compared with the LCOE and LRMC of existing fossil gas fired power plants

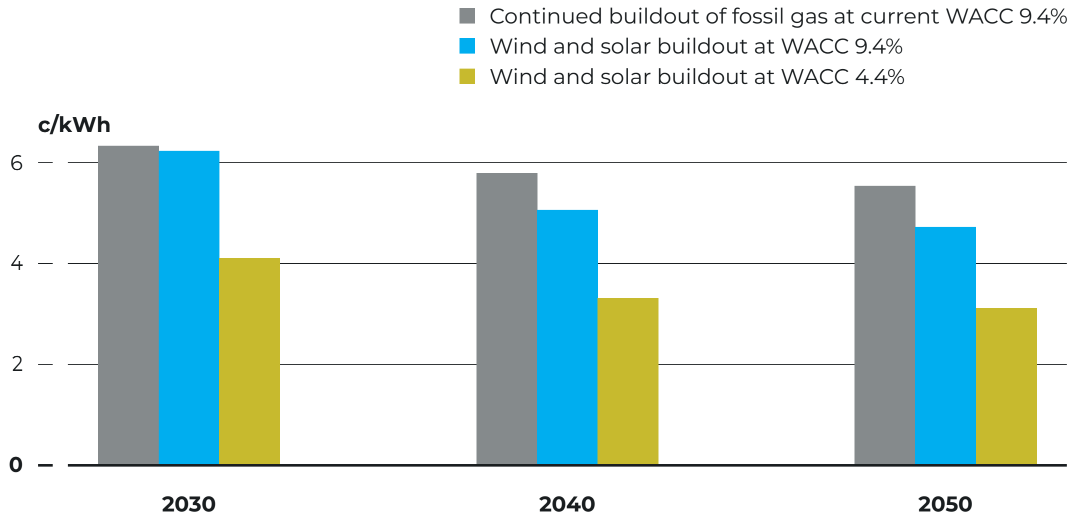


Note: Assuming a decreasing fossil gas price over time in line with (IEA, 2023e).
Source: Author's own calculations.

The buildout of renewable energy could also help Mexico reduce its electricity generation costs and in turn lower current energy subsidies. Our modelling suggests that, even if low-cost financing would not become available in Mexico, building out new wind and solar capacity can lower the electricity generation cost of new generation compared to a scenario where fossil gas is further expanded, in line with the findings on the LCOE above **(see → Fig. 19)**. The cost difference becomes even more significant as time progresses. Achieving a WACC similar to the level reached under the auction scheme would further shift the cost advantage to wind and solar. This presents an opportunity to reduce the existing end consumer subsidies in Mexico. In 2019, while subsidies varied depending on a multitude of factors, studies estimated the subsidies to end consumer to amount to around 9.9 c/kWh (Hernandez and Patiño-Echeverri, 2022). In our calculations we find that the difference between a continued expansion of generation based on fossil gas fired power plants and a wind and solar capacity buildout in line with the "International" scenario range between 0.4 c/kWh for the current WACC ranges, and 2.3 c/kWh if low cost financing becomes available. The total cost savings amount to 33.8 million USD per year and 129.3 million USD per year.

Fig. 19

Electricity generation costs for new buildout of capacity between 2030 and 2050, comparing fossil gas and a combination of solar and wind at different WACC levels



Note: Assuming a decreasing fossil gas price over time in line with IEA WEO Stated policy scenario (IEA, 2023e).
Source: Author's own calculations.

3.2.2 NEW AND UPDATED GRID CONNECTIONS

The increase in the share of renewable energy on the grid must be accompanied by a restructuring of the electricity grid. There are several areas that require investments to enable this:

- At the **transmission grid level**, new lines need to be installed or existing lines upgraded to a) reach new areas with good wind or solar resource potential, and b) account for the differences in load flow pattern caused by newly established generation location. At the same time, existing lines might become redundant and need to be decommissioned if existing fossil fuel sites are not suitable for renewable energy generation.
- At the **distribution grid level** investments must be undertaken to enable greater visibility and participation of distributed renewable generation as well as flexible loads and changes in load flow patterns. Investments into the distribution grid are mainly focused on upgrading existing lines and are also affected by the decarbonisation and electrification of energy demand sectors such as buildings, transport, or industry.
- Grid investments should be paralleled by investments into the **digitalisation of the grid**. The digitalisation of the grid can enable the integration of flexible demand sources, which become important in the mid to long term of the transition. Investments here could focus on the installation of smart meters or other more advanced smart devices that enable the development of a smart grid. Many of these areas are still under development and commercially available technology is available only to a limited degree.

The large-scale restructuring of the grid needs to happen at a system level and is set in a dynamically evolving field. Today's technology might be outdated tomorrow (especially with regard to digitalisation) and technology costs are likely to change over time, either due to technological learning or resource availability. In addition, the power grid is highly complex. Comprehensive planning, which is regularly reviewed and revised, is needed to always ensure continuous security of supply. At an institutional level this means that planning for the power system/ transmission grid must be coordinated between different institutions at the various governance levels and geographies.

Investment and associated finance needs should ideally be determined in line with a comprehensive power system planning that aims towards achieving a decarbonised grid by mid-century. In Mexico, short to medium term power system planning is undertaken under the umbrella of PRODESEN (Programa de Desarrollo del Sistema Eléctrico Nacional). The power grid is operated by the CFE company Centro Nacional de Control de la Energía (CENACE), Mexico's transmission system operator (TSO). Grid expansion projects are procured by CFE in line with PRODESEN, which lays out a plan for investment into the grid between 2020 and 2034 (CFE, 2024c). However, as the current plan is not aligned with a decarbonisation scenario it does not form a good basis to determine investment needs for the power sector transition unless revised.

Approaches to estimating investment needs

Finance needs for grid extension and enhancement are best derived from national exercises with substantive stakeholder involvement. They are ideally the result of a comprehensive planning process that takes account of future extension needs of the grid in line with the goals of the Paris Agreement. These plans could be compared to existing power sector planning exercises (such as the one presented by PRODESEN) to determine the level of additional investment needs that arise from a Paris Agreement aligned sector transformation. The additional investment needs can in turn provide a useful marker to determine the level of domestic resources to finance the sector transition.

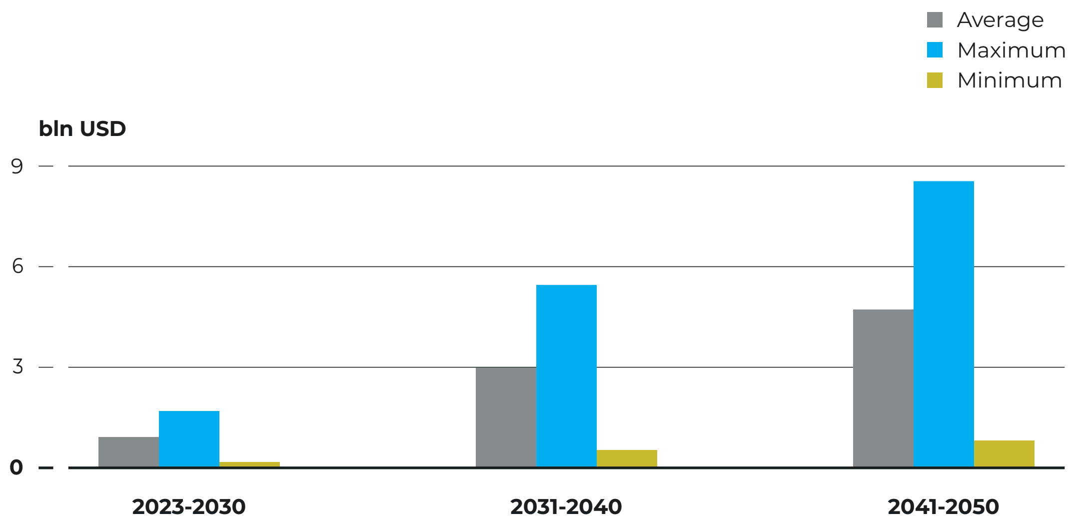
Since detailed grid extension studies are not available in the Mexican context, the costs need to be estimated using simplified approaches. One way of approaching this is to estimate the cost by directly linking grid extension costs to the build-out of renewable energy capacity which need to be connected to the grid which are often in remoter locations and thus requiring significant grid expansion. This simplified approach can provide first order estimates, however, neglects important aspects such as digitalisation and further enhancement needs of the transmission grid. In this study we use interconnection costs (in USD per installed renewable energy based capacity) from a US based meta study that provides figures based on a literature review of different types of studies (Gorman, Mills and Wiser, 2019).

The study presents four different interconnection cost estimates on a per MWh basis which are all based on different methods; The four different interconnection estimates are applied to the renewable energy capacity expansion required under the "International" scenario.

Finance needs for new and updated grid connections associated with the renewable energy capacity expansion projected in the "International" scenario in Mexico are presented in → **Fig. 20**. The range of investment needs between now and 2050 is significant, from 20 bln USD to almost 160 bln USD, depending on the approach used (Gorman, Mills and Wiser, 2019). On average, investments of about 80 bln USD are needed. While this provides a first order of magnitude, it also highlights the importance of developing country specific grid extension plans rather than relying on international scenarios and benchmarks.

Fig. 20

Finance needs for grid extension in Mexico based on simplified assumptions



Source: Author's calculations based on (Gorman, Mills and Wiser, 2019).

The financing of the grid connection needs that are included in this analysis can often also be directly integrated with renewable energy finance. For instance, certain renewable energy support schemes have provisions that also include the coverage of, at least part of the cost for connection to the grid. However, as the share of renewable energy grows and grid re-enforcement, upgrading, and extension in line with the changing power system become more relevant, separate financing channels will need to be established.

3.3 JUST SOCIAL TRANSITION

Transitions require technical solutions but first and foremost are about people. Bringing people along a process of deep structural change is challenging and ultimately needs to be at the heart of any transition strategy. The energy transition, like any transition in the past, will produce winners and losers. While studies suggest that, in the long run, the positive impacts of the energy transition will likely outweigh the negative ones, it is important to address and manage any adverse impacts, such as people losing their jobs or incomes. This requires additional financial support that goes beyond the investment into new infrastructure and the compensation of existing power plant assets described in the previous sections.

Social impacts of the transition are not always separable from wider factors that impact the economic wellbeing of households or sub-national regions. Parallel events such as the global COVID-19 pandemic, the energy crisis or generally fluctuating fossil fuel prices can be as much a cause of job losses or increased electricity prices as structural changes in the energy sector. Independent of the difficulty of attribution of any negative impacts, it is important to ensure that principles of social justice are considered in the energy transition to the extent possible, so that the transition itself contributes to an improved situation over the status quo. This is important from a perspective of justice as well as to ensure that the transition efforts enjoy a broad base of support which is necessary for its success. While an energy transition offers an opportunity to improve many social and justice aspects, it is also important to highlight that it cannot resolve all underlying injustices nationally or at the global level.

3.3.1 INTERVENTION AREAS

Just energy transition frameworks typically consider several, often interlinked, aspects: the transition of workers affected by the fossil fuel phase out and reskilling needs for the clean energy system; the economic development and transition of affected sub-national regions including the rehabilitation of fossil fuel sites; and the protection of vulnerable groups and communities. These are grouped into three areas outlined in the following.

→ **Job creation and losses (turn-over)** experienced, for instance by workers in fossil fuel industries, require counter measures that enable them to find new sources of income. Workers need to be able to transition from their current jobs into new ones and/or to retire earlier than they had originally planned. In order to transition into new jobs, workers might require direct financial support to pay for educational programmes or transitional income in the interim period until they have found new employment. At the same time, the clean energy build-out requires new skills and will provide new job opportunities. However, even if employment losses may on balance level with new jobs being created, job levels, skills, quality, and location may not always match and hence limit the direct transfer potential. The creation of new employment opportunities is also closely linked to regional development and economic diversification efforts.

→ **Regional diversification** is needed to help fossil fuel dependent sub-national regions develop a new economic basis. Those regions that rely heavily on the incomes from fossil fuel extraction are likely to experience economic losses and reduced tax revenues, but also sub-national regions that depend on the income associated with the operation of power plants may require new sources of income. Especially those regions with coal fired power plants will require economic re-development as coal fired power plants in many cases rely on on-site mining and/or an extensive transportation network to provide coal to the plants. In addition, coal fired power plants tend to be larger in size than fossil gas plants, and hence generate more income for the region. Regional diversification can for instance be achieved through supporting existing business in the region, providing incentives for companies to relocate to the region or fostering the creation of new business in these regions. Experience in other countries has shown that investments in infrastructure and educational facilities are effective ways to attract new opportunities in particular to remoter regions. The loss in tax revenues could be addressed through economic diversification but also through revenue transfers from the federal level. Some regions may also require support in the clean-up and rehabilitation of brownfield sites.

→ **Vulnerable groups** should not be negatively affected by the energy transition. Already today, electricity generation is subsidised in many countries to alleviate energy cost burdens on households or to protect domestic industries. The power sector transformation should be structured in a way to not contribute to an increase in electricity prices and ultimately lead to a phasing out of demand side subsidies. However, should the initial energy transition related investments lead to temporarily increased electricity prices, interim measures may be needed to not disproportionately affect vulnerable and low-income groups.

In some contexts, specific groups might be impacted by the energy transition in a more direct way. This may include impact on land access and land rights, for example for indigenous communities in rural areas. Renewable energy projects, which are often situated in rural areas, may also compete for agricultural land use or be viewed as a nuisance due to their visual impacts. These kinds of negative impacts can often be mitigated through careful policy design and planning, or participatory or communal ownership structures. In some cases, finance may be required to compensate communities for land access.

3.3.2 INSIGHTS FROM PAST AND CURRENT COAL TRANSITIONS

Experience with past and current transitions can provide valuable insights into the effectiveness of just transition measures on the ground. Although just transition measures are always context specific, considering lessons learned from other countries can help to avoid common misconceptions and ineffective measures that ultimately result in a misallocation of already limited resources. Past energy transition experiences, associated with coal phase out, were mainly the result of unplanned, abrupt changes and led to the implementation of often ineffective, ad hoc measures. Current energy transition frameworks are planned transitions and hence present an opportunity to implement carefully designed policies and measures grounded in the specific context. Some important aspects and insights are highlighted in the following.

Stakeholder engagement and visioning – Consulting and involving affected stakeholders is essential in order to develop appropriate measures and get a broad buy-in for the energy transition. Civic dialogues or other forms of active stakeholder engagement are an essential part of defining a just transition framework (ITUC, 2024). Experiences with energy transitions in other sub-national regions have shown that in particular approaches that combine bottom-up participation on definition of appropriate measures and policies with top down coordination and finance are successful (Wong, Röser and Maxwell, 2022). International examples of such processes, such as the just transition fund in the US or the coal commission in Germany, can provide useful insights. In Mexico, it is also important to adhere to the FPIC principle, when indigenous land use rights are affected.

Context specific regional development – The local context plays a decisive role in determining what kind of interventions are most effective and how these should be designed. Hence a deep understanding of the regional context, economic and social DNA as well as legal framework is needed. The involvement of local stakeholders – as mentioned – is critical in this context. To date most examples of just transition mechanisms are from the Global North. The challenges in communities of the Global South might be different and may require deeper engagement and additional measures or funding. For example, in some cases coal mining communities in the Global South have deeper dependencies on fossil enterprise as these often take over responsibilities of public institutions, such as providing access to electricity or water or access to health care and education facilities.

Fairness and equity – Questions of intra country equity may arise when channelling funding to regions affected by the fossil fuel phase out. Any support needs to be considered in the context of other disadvantaged regions which have not benefitted from fossil fuel income in the past. The opportunity costs of allocating funding to coal regions, which could otherwise be used for clean energy build out or the support of other vulnerable communities, may therefore be significant. In addition, already today, economics push out coal in many parts of the world and phase out plans might even prolong the existence of coal in the power matrix (Heffron and McCauley, 2022). Furthermore, a real risk exist that fossil fuel asset owners are overcompensated while local communities don't get the support that they need.

Integrated approaches – Just transition frameworks go beyond compensation packages or retirement schemes for workers and should consider a range of integrated measures specific to the local and regional context. These can span, for example, schemes to support local economies and the development of small and medium enterprises, infrastructure projects that enable better access to services and connectivity including digitalisation and transport, relocating public sector institutions or educational facilities into affected regions, restoration of industrial and fossil fuel sites for other, including tourism, purposes or support for energy efficiency in households to reduce electricity costs. A narrow focus, for example, on worker compensation packages misses opportunities to drive new employment prospects through more strategic, longer term structural development planning. Especially the creation of local jobs that do not require relocation, can only be achieved through the development and diversification of the local economies. In several countries (e.g., in Germany, the United Kingdom, and the US) transition programmes have mainly focussed on providing structural funds to affected regions. Based on specific development plans, regions can draw on these funds on a project basis to support a diverse set of activities in support of business development, infrastructure or remediation activities.

Direct worker compensation – Measures to support workers directly succeeded to some extent in alleviating poverty but widely failed to reorientate worker to secure jobs. Early retirement has been one of the main instruments to manage the labour market shock both in cases of faster, unplanned transitions and slower planned transitions (Wong, Röser and Maxwell, 2022). Subsidising individual workers might lead to new potential conflicts, as it raises new intra-country equity questions as mentioned above. In some cases worker compensation measures can also create perverse incentives (Śniegocki, Aleksader; Wasilewski,Marek; Zygmunt and Look, 2022). Providing subsidies to coal mining regions, and in particular to coal workers, might actually help coal mining operations become more profitable.

Restoration and infrastructure – Investments in education and transport infrastructure prove to be key enablers for economic development and restructuring especially in remoter regions. Such investments not only help to create short term jobs but allows people to commute greater distances increasing employment opportunities. On the other hand, investment in education was the basis for attracting innovative new businesses and hence creating secure and often higher quality employment. In coal mining regions the environmental restoration was critical to improve the quality of life and reduce outward migration by attracting new businesses including in the cultural and tourism sectors. (Wong, Röser and Maxwell, 2022)

Interesting specific examples of just transition support mechanisms include the following:

→ The **EU Just Transition Mechanism** provides targeted support to coal regions in Europe, aiming to mobilise around €55 billion between 2021 and 2027 through three main pillars: the Just Transition Fund, the InvestEU Just Transition scheme, and a new public loan facility (European Commission, 2024b). Complementary to this is the Just Transition Platform, which provides comprehensive technical and advisory support for coal regions, including detailed case studies of coal transitions, analysis of successful projects, and toolkits for specific policy objectives such as environmental rehabilitation (European Commission, 2024a).Under the heading "Leave no one behind" the EU has been supporting vulnerable citizens under the Social climate plan with energy subsidies and energy efficiency subsidies (Velten et al., 2023).

→ The **securitisation scheme in the US** where utilities were enabled to refinance their fossil fuel power plants with securitization bonds to lower their financing costs, which in return freed up resources. Through the issuance of rate payer backed bonds the utility reduced their debt (rate payer backed bonds are priced at 3% to 4% and utility financing at 8% to 9%). As part of the coal phase out negotiations, several utilities have committed to support the transition of their workers as well as provide electricity at a lower costs, reducing the burden especially on vulnerable groups (Fong, Christian; Mardell, 2021).

→ **Skills Development Scotland (SDS)** is an example of a proactive, accessible service that offers a wide range of services to support workers facing redundancy. The broad coverage of service including apprenticeships, application support, career management workshops, numeracy and literacy courses, as well as help understanding unemployment benefits was a critical success factor. Also the SDS conducts regular regional skills assessments to identify mismatches between supply and demand allowing the service to integrate into regional development planning (Wong, Röser and Maxwell, 2022).

Generally, the discussion on just energy transition frameworks centres on coal. There is a lack of discourse on fossil gas phase out and associated implications for just transition measures. While part of the questions will likely be similar for fossil gas plants, some aspects will be different. A major factor driving the just transition impact is whether the fossil gas is locally sourced or imported. The oil and fossil gas extraction industries span an even larger part of the economy than coal and also have much stronger links to other sectors, including transport (e.g., internal combustion engines), buildings (heating and hot water) or industry (multiple uses). Hence, comprehensive just transition planning needs to be wider in scope beyond the power sector. In cases where the fossil gas is imported, as is the case in Mexico in the power sector, just transition questions shift from local employment and social impacts to a broader discourse on energy security, economic dependence and its social implications.

3.3.3 APPROACHES TO ESTIMATING FINANCE NEEDS

The diverse nature of the different just transition intervention areas require specific approaches to estimating the finance needs for each area or type of intervention. While initial estimates of finance needs can be derived for some areas (e.g. employment impacts) other measures need a more iterative approach.

Regional development funding depends on the specific context and situation in the region and does not lend itself to ex-ante estimations of finance needs without deeper stakeholder consultations. Funding could be based on a pledge and review approach where an initial regional or structural fund is capitalised and amounts revised over time as more insights are gained with the implementation of specific projects or measures. Similarly, the ex-ante estimation of finance needs to support vulnerable groups which may be exposed to temporarily higher electricity costs or to put in place appropriate counter measures and support for rural communities affected by land use conflicts is not a useful exercise. Again, this requires deeper consultation as well as an integrated assessment of measures in the context of wider policy and governance reform.

Finance support needs related to **job losses and gains associated with a given net zero scenario** can be derived using the following factors:

- → **The level of investment and domestic share** which determines the direct, indirect as well as induced ripple effects in the economy. These require the input from modelling exercises and the use of more complex (e.g. CGE models) or simple economic models (e.g. based on input output analysis or job factors)

- **Existing salary levels** – Annual salary levels per sector.
- **The demographic structure of the existing work force and retirement age** – This includes the age structure of workers in the different areas affected and is needed to determine whether workers should retire early or receive support for re-orientation of their careers.

In addition, assumptions on early retirement payments, retraining allowances and temporary salary payments need to be made. Data from countries that have developed or are starting to develop financial support packages to transition fossil fuel workers suggest that while there are some similarities in the approaches, amounts differ significantly from country to country **(see → Tab. 9)**. Country characteristics, such as the cost of living or existing unemployment benefits, are key influencing factors. Ultimately compensation packages for workers are the result of political decisions.

Aspect	Approach(es) taken by countries	Value range associated
Early retirement payments	Amount – As share of previous income	70-75% of previous earnings
	Length – Years until full retirement	
Retraining allowance	Amount – Voucher linked to retraining costs in national context	7,477-9,107 USD
Temporary salary payments	Amount – As share of previous income	30-60% of previous earnings

Source: (Hambrecht, 2023).

Tab. 9

Overview of different worker compensation support approaches

The total number of jobs that need to be retired early is directly linked to the early retirement of plants; with each early shut down a number of workers will lose their jobs earlier than they had originally planned. The age structure of the workers in the industry will thereby play an important role in determining the type of payment that has to be made as well as the total amount needed.

3.3.4 FINANCE NEEDS AND INTERVENTION AREAS IN THE MEXICAN CONTEXT

Determining just transition measures and associated finance needs in the Mexican context can only be done credibly on the basis of a deep consultation process engaging all affected stakeholders of the transition in particular at the regional level. The finance needs will also depend on the policy and regulatory instruments and governance framework to be implemented for the power sector transition. Hence at this stage this work can only provide an overview of just transition aspects that should be considered, based on experience in other sub-national regions.

Estimation of finance need for the area would be too speculative to include here (e.g. regional development) and/or paint an incomplete picture of the finance transition needs **(see → Tab. 10)**.

Aspect	Description	Quantification difficulty	Relevance in the Mexican context
Fossil fuel job transition (e.g. coal)	Enabling transition of existing 6,056 coal jobs (Coahuila) into retirement or new jobs.	Medium (for transitioning out of existing), high (for transitioning into new jobs, as linked to regional development).	Low to medium
Regional development	Diversification of economic activities within the coal regions in the states of Coahuila and Guerrero.	High – requires stakeholder consultation.	High
Vulnerabilities – indirect temporary increased electricity costs	Support for vulnerable groups affected by the temporary increase of electricity generation.	Medium	High
Vulnerabilities – direct (infrastructure) impact on selected groups	Support for vulnerable groups (e.g. indigenous populations) affected by land use for infrastructure projects related to the transition (e.g. renewable power plants, electricity lines).	High – requires stakeholder consultation.	High

Tab. 10

Just power sector transition elements and relevance in the Mexican context

A first area of focus for just transition in Mexico is the phase out of coal (Fonseca and Grados, 2021), but eventually, as our analysis shows, the focus needs to also shift to phasing out gas. As gas phase out discussions are in their infancy globally, experiences with associated just transition frameworks are limited. However, many of the instruments applicable to the socially just coal phase-out may also be applicable to gas. **→ Tab. 10** provides an overview of relevant aspects for a just transition of the power sector as well as an initial assessment of their relevance the Mexican context.

Building on experience in other sub-national regions, below are potential elements of an approach that could be taken in Mexico to support sub-national regions and communities in the transition.

National/ regional just transition plans should be the backbone of any just transition strategy. The development of such plans should be done in a consultative manner to ensure all voices are heard. In particular parts of the community that are directly affected by the power sector transition, such as indigenous groups need to be engaged in the respective region. The regional plans could set out a vision, key objectives, activities and milestones. The identification of concrete measures and projects could also be part of the process.

Regional transition fund(s) could be put in place to support sub-national regions to transition from fossil fuel activities. These funds could finance individual projects in the affected regions Coahila and Guerrero but also other regions affected by reduced income streams from fossil fuel projects. On the basis of the regional development plans a list of eligible projects could be developed also drawing on the experience in other global constituencies. Allocation of funds could be achieved through an application and review process, including, if desired on a competitive basis. The fund should be monitored over time to see if additional funding is needed and to identify whether the projects achieved the desired impacts.

Social transition funds could complement the regional transition funds to alleviate the impacts on vulnerable groups (e.g. below a certain income level). Temporary energy subsidies could be provided to reduce the impact that the transition might have in the first years. This could be a more efficient and targeted instrument than current electricity subsidies as only groups in need would benefit. There is a risk of double subsidies given the in-transparency around current energy subsidies. Ideally the current energy subsidies are phased out, also due to their negative impact on saving energy. Support for energy efficiency such as through rebates for energy efficient devices targeted especially at vulnerable groups could serve as a more long-term measure to ensure these groups are also not affected by energy prices in the long run (independent of how electricity gets produced).

Workers compensation funds could directly address those affected by the phase out of fossil fuels. These funds could set standards for retraining, compensating as well as early retirement of workers. Workers could directly apply for funding and the funds could enable them to transition into new jobs or into retirement. Ideally these funds are however coupled with regional transition funds that ensure the creation of new jobs, otherwise relocation efforts might be necessary. It is to be noted that early retirement schemes or compensation packages for some workers (e.g. PEMEX) may not be possible given existing contractual and legal obligations.

Beyond a regional focus which considers specific communities dependent on gas-based power generation, national implications on energy security and economic dependence are also relevant. This is particularly the case for the Mexican power sector which relies heavily on imported gas from the US, locking the country into costly, long term supply agreements.

/Λ 04 CONCLUSION

The accelerated transition of the power sector in a socially just way requires significant investments across different dimensions of the transition. This includes potential compensation payments for the early phase out of fossil fuel systems and infrastructure, the build out of clean energy systems as well as measures to support people and communities affected by the transition. Underpinning all this, strengthened institutional capacities and policy reforms are needed which may require additional public funding. The investment and finance needs vary significantly across these different dimensions in scale and type.

Alongside domestic resources, international support plays an important role to finance the transition efforts of emerging economies. A robust and credible evidence base is essential to inform domestic strategies as well as international support mechanisms. Bi- and plurilateral partnerships have emerged with the objective to channel scaled international finance to support the transition of mainly coal-based emerging economies. A detailed understanding and analysis of the required scale and type of investment and finance is often missing. On top, the just energy transition discourse has so far been centred on questions of accelerated coal phase out. The just transition implications of phasing out fossil gas, as relevant in the Mexican context, has not received much attention if any at all. More discourse on the implications of the phase out of other fossil resources, including but not limited to fossil gas, is needed internationally as well as in relevant country contexts. This is an important building block to enable the mobilisation of finance at scale.

The exercise to develop approaches to assess and, where possible, quantify investment and financial support needs has proven to be highly complex. It is in parts a political exercise that requires deep engagement with affected stakeholders in the local context. The results of the approaches tested in the context of Mexico demonstrate that any quantification highly depends on the underlying assumptions used, policy and prioritisation decisions as well as the availability of often proprietary data. While infrastructure investments lend themselves more readily to any quantification exercises, investment and finance needs in equally important areas such as just transition of workers and regions or the development of institutional capacities and implementation of policy reforms cannot be quantified easily. The latter two in particular require intensive stakeholder engagement and deep understanding of local contexts. Even where estimating finance needs appears more straightforward, such calculations still rely on significant assumptions that are influenced by political processes. Nevertheless, attempts to assess and quantify investment and financial support needs are important exercises to underpin the discourse on just transition implementation and guide different stakeholders' positions. They provide order-of-magnitude figures, clarify important trade-offs, highlight potential pitfalls (such as windfall profits) and provide a starting point for investors and other financing institutions to engage with a country. Engagement of stakeholders in such analyses presents a value in itself.

In the context of Mexico, financing the build out of renewable energy systems and associated infrastructure should be a priority. According to our analysis, the build out of renewable energy requires the highest investment and finance needs in comparison to the finance needed to phase out fossil fired power plants. From an economic perspective a focus on renewable energy finance is advantageous considering technology costs and the volatility of gas markets as well as the potential to reduce subsidy needs. This can be achieved through policy reform in combination with de-risking instruments to lower financing costs. The early phase out of gas fired power generation can also be effectively linked to the build out of renewables if replacement of fossil plants is considered at the wider company of fleet rather than individual plant level. In this case, if structured intelligently, the need to compensate plant owners for early closure of their plants can be minimised or even avoided. This is also a question of structuring power markets and remuneration systems.

The deep transformation required in the next decades can only be successful if done in an inclusive way to ensure that the perspectives and needs of different stakeholder groups are taken into account and, if possible, addressed in a way to minimise any potential negative impacts. Measures to support vulnerable groups and communities affected by the transition are important from a perspective of fairness but also to support sustainable development goals as well as to ensure that the transition enjoys broad societal support.

Going forward, in the case of Mexico engagement with relevant stakeholders at national and regional level could be envisaged to discuss the implications of the just transition across the different dimensions highlighted in this report. An objective of such processes could be the identification of priority actions and strategies for further analysis in order to concretise the transition roadmap and enable more detailed transition and investment planning both nationally as well as in the most affected sub-national regions. At the national level a broader strategic discourse on the energy transition and in particular the role of fossil gas is important.

Internationally, approaches to assess finance needs for just energy transitions in different country contexts could be streamlined and harmonised. Further fostering exchange and discourse on approaches and lessons learned would be helpful in this regard. Additionally, the just energy transition discourse should be expanded to move beyond coal to consider the implications of phase out of all fossil fuels in this critical decade for global climate action.

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