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An overview of the socio-economic impacts of the energy transition

Quantitative findings from international experiences

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

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Table of Contents

Abbreviations 5

Executive Summary 6

Harnessing the socio-economic opportunities of the energy transition..6

Preparing for the transition in fossil fuel dominated regions and industries 6

Chapter 1: The socio-economic dimension of the energy transition 9

1.1. Beyond climate protection: The socio-economic effects of the energy transition 9

1.2. Developing a comprehensive green growth strategy 10

Chapter 2: An Overview of socio-economic effects of the energy transition 12

2.1. Industrial development and economic growth 12

2.2. Increased energy security and reduced costs for energy imports... 15

2.3. Employment opportunities 16

2.4. Reduced air pollution and lower costs for the public health system 20

2.5. Economic opportunities related to the green hydrogen economy.. 22

List of references 24

List of Figures

Figure 1: Socio-economic opportunities related to the Vietnamese energy transition 7

Figure 2: Overview of socio-economic benefits related to the energy transition 10

Figure 3: Imports of energy related technologies in Vietnam 13

Figure 4: Natural gas price on the German market platform EGIX 15

Figure 5: Number of additional employees on a net-zero carbon pathway in Germany 17

Figure 6: Employment factors of various power generation technologies in Viet Nam 18

Figure 7: Employment factors of various power generation technologies in India 19

Figure 8: Measures to prepare and manage the transition of fossil fuel workers 19

Figure 9: Measures to prepare and manage the transition in energy transition regions 20

Figure 10: Research methodology for air quality and health costs studies 21

Figure 11: Countries implementing (green) hydrogen strategies 22

Figure 12: Hydrogen import requirements in Germany until 2030 (Source: Kearney/Uniper 2021)...................... 23

Figure 13: Projection of Chilean market for green hydrogen and its derivatives 23

Abbreviations

CGE	Computable General Equilibrium
CO	Carbon monoxide
CO2	Carbon Dioxide
DALY	Disability-adjusted life years
EU	European Union
EVN	Electricity of Vietnam
EUR	Euro
GDP	Gross Domestic Product
GH2	Green hydrogen
GHG	Green House Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LCOE	Levelized Costs of Electricity (equivalent LEC)
LCR	Levelized Electricity Cost (equivalent to LCOE)
LNG	Liquefied Natural Gas
MoF	Ministry of Finance
MoIT	Ministry of Industry and Trade, Vietnam
MW	Megawatt
NOx	Nitrogen oxides
OECD	Organization for Economic Co-operation and Development
PDP	Power Development Plan
PM	Particulate matter
RE	Renewable energy
SO2	Sulphur dioxide
USD	US dollar
WETO	World Energy Transition Outlook (IRENA scenario)
WHO	World Health Organization
YLLs	Years of life lost

Executive Summary

In the previous decades, climate protection measures have frequently been discussed in terms of “burden sharing”. In the last 10 years, the narrative and perspective has shifted. The opportunities and benefits related to the energy transition are now in the focus.

The energy transition toward clean and renewable energy sources entails much more than just the reduction of greenhouse gas emissions.

When policies are structured well, the energy transition can trigger a large amount of additional socio-economic benefits for Vietnam, including increased energy security, improved trade balance due to reduced energy imports, job creation, reduced air pollution and related health costs, increased investment and GDP, and others.

Harnessing the socio-economic opportunities of the energy transition

This short report summarizes socio-economic effects of the energy transition as they have been quantified in many countries around the world, including Germany, India, Canada, South Africa, Turkey, Chile, and others. These benefits can also be harnessed in Vietnam.

Opportunities have been identified in the context of:

- Industrial development and economic growth
- Increased energy security and reduced cost for fossil fuel imports
- Employment opportunities
- Reduced air pollution and lower (public) health costs
- Economic opportunities related to the green hydrogen economy

This paper also sheds a light on the different scientific methods used for quantifying these socio-economic effects.

Preparing for the transition in fossil fuel dominated regions and industries

Even though the opportunities largely outweigh the (transitional) costs of the energy transition, policymakers can anticipate and prepare for the transformation in regions of the country that are more heavily dependent on fossil fuels and related industries.

With regards to the transformation of regions with fossil fuel industries, various industrial policies can be implemented, including among others:

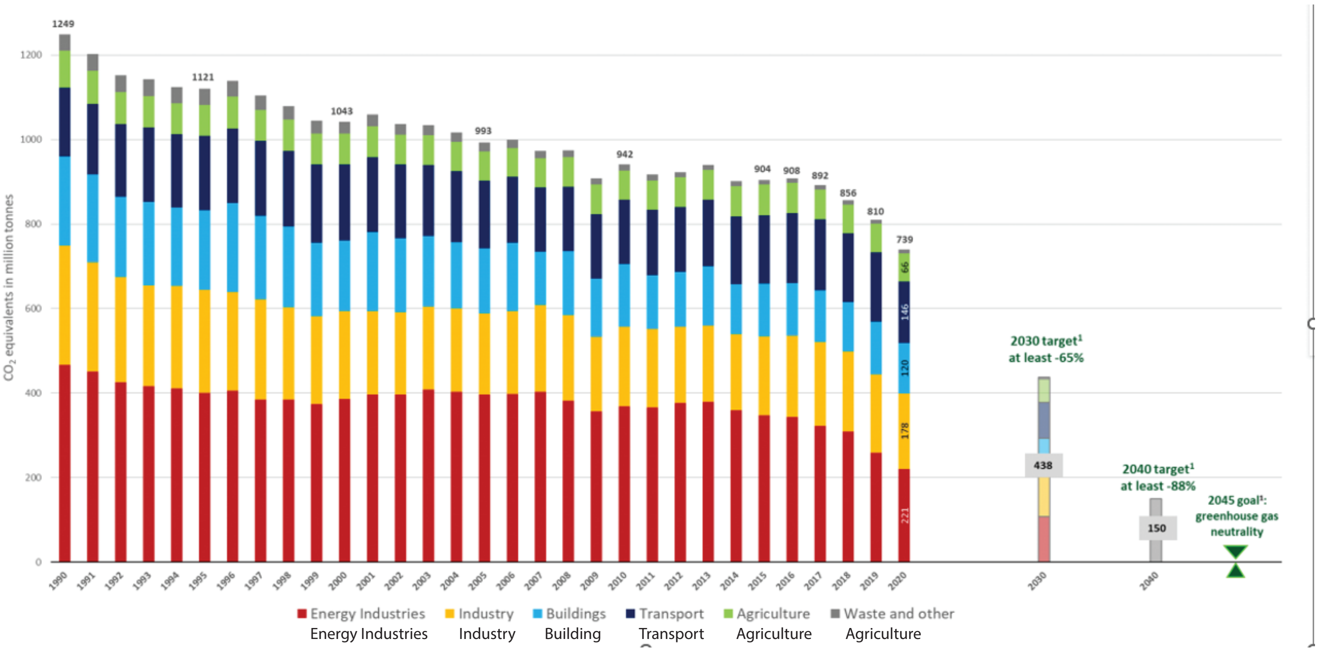
- Establishing special economic zones for clean energy technologies
- Dedicated procurement programs for renewables in these transition regions

Regarding the transition of employees currently working in the fossil fuel industry, it is important to prepare the transformation by:

- Assessing the skills of existing workers and providing a variety of re-skilling and re-training opportunities
- Assessing the age structure of workers and potentially introducing plans enabling older workers to qualify for early retirement

Figure 1: Socio-economic opportunities related to the Vietnamese energy transition

(Source: IET)



Chapter 1

The socio-economic dimension of the energy transition

Key findings for Vietnam policymakers:

The energy transition toward clean and renewable energy sources entails much more than just the reduction of greenhouse gas emissions.

When policies are structured well, the energy transition can trigger a wide range of additional socio-economic benefits for Vietnam, including increased energy security, improved trade balance due to reduced energy imports, job creation, reduced air pollution and related health costs, increased investment and GDP, and others.

However, to harness these benefits, different policies and enabling frameworks need to be coordinated (e.g., energy policy, industry policy, labor policy, etc.) as part of an overarching green growth strategy.

At the same time, policymakers need to anticipate potential negative socio-economic impacts on certain industries or in specific regions where the dependence on fossil fuels and fossil fuel-related jobs is greatest.

1.1. Beyond climate protection: The socio-economic effects of the energy transition

To stay on a climate-safe pathway, the global economy will need to drastically reduce carbon emissions in the coming decades and invest in renewable energies, energy efficiency and other energy transition technologies. In previous decades, climate protection measures have frequently been discussed in terms of “burden sharing”. Climate protection measures were considered to be costly and only feasible for more developed or more industrialized countries.

In the last ten years, this narrative and perspective has shifted: the opportunities and benefits related to the energy transition are now in focus. Since the decarbonization of the global economy and the energy systems in all nations is vital to maintaining a stable and livable climate for all of humanity, the question is now how countries can maximize the benefits of this transformation.

In the past years, researchers and government around the world have analyzed and quantified the socio-economic effects of the transformation of the energy sector. Many so-called “co-benefits” of the energy transition have been listed, including aspects related to security of supply, employment, industrial and economic development, the environment, health aspects, the political and social dimension and energy access (see Figure 2 below).

Some analysts and researchers argue that those effects should not be termed “co-benefits” because for several countries around the world opportunities for industrial development, energy security, improved energy access, and others are politically more important than the reduction of greenhouse gas emissions.

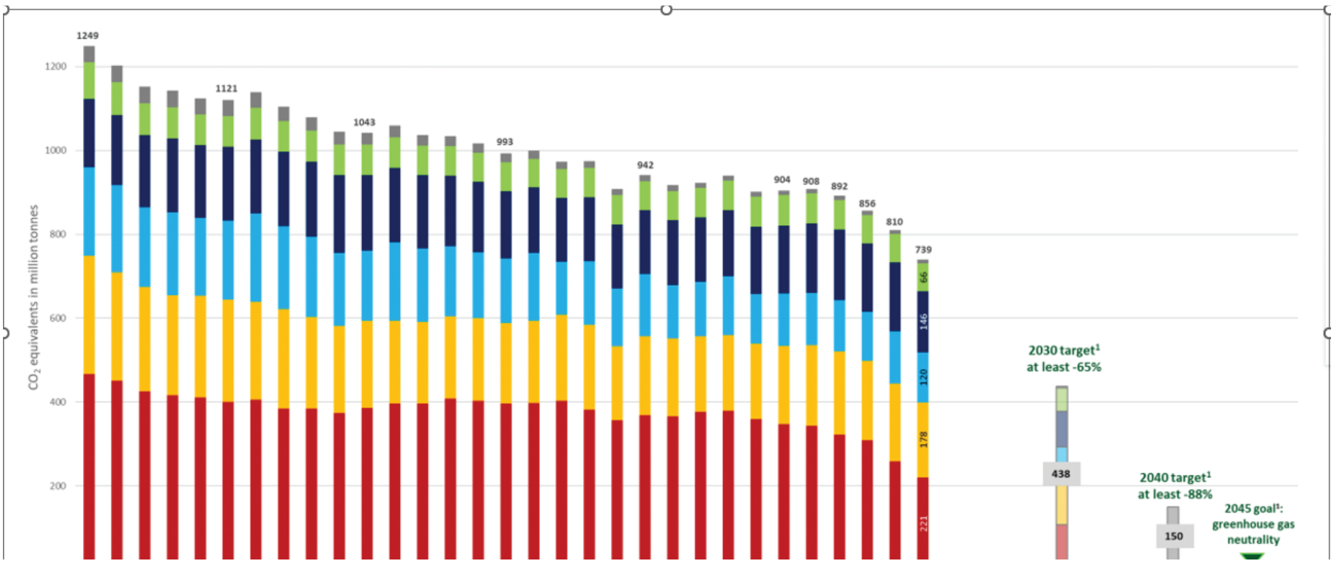


Figure 2: Overview of socio-economic benefits related to the energy transition

(Source: IET)

1.2. Developing a comprehensive green growth strategy

To harness these diverse socio-economic opportunities, an integrated green growth strategy needs to be developed. Different policies and enabling frameworks need to be coordinated (e.g., energy policy, industry policy, labor policy, etc.) to build the future of the Vietnamese economy on green technologies. In an economy based on green growth, economic growth and development are fostered while ensuring that natural assets continue to provide the resources and environmental services on which human being rely (OECD 2011). Green growth strategies are also discussed under different names, for instance green economies, green deal, just transition and others.

In the year 2020, the worldwide market volume of green technologies in all sectors has surpassed the € 4 trillion threshold for the first time. In 2030, this segment of the global economy will raise to almost € 10 trillion, matching annual growth rates of 7.3% (BMU 2020).

Case study: Green growth in Germany

Germany has been successful in moving toward a green economy. The total market volume of German green technologies amounted to € 392 billion. This value is expected to increase to € 856 billion until 2030, equaling annual growth rates of 8.1%. Interestingly, energy efficiency is the single largest contributor to the German green economy, with an annual volume of € 117 billion. Sustainable transport comes second place, with a total volume of € 91 billion. Globally, the energy transition is a major driver for the greening of the economy. In the field of clean energy, annual market growth of 8.5% can be expected (BMU 2021).

Green technology accounts for 15 percent of German economic output creating 1.5 million jobs. Until 2025, the share is projected to increase to almost 20% (BMU 2018). While Germany contributes with only 3 percent to global economic output, its environmental technology and resource efficiency companies hold 14 percent of the global market share (BMU 2021).

Chapter 2

An Overview of socio-economic effects of the energy transition

The transition towards clean and renewable energies offers a large variety of socio-economic benefits (see Figure 2). In this chapter, the most important socio-economic effects are highlighted. This includes:

- Industrial development and economic growth
- Increased energy security and reduced cost for fossil fuel imports
- Employment opportunities
- Reduced air pollution and lower (public) health costs
- Economic opportunities related to the green hydrogen economy

This paper also sheds a light on the different scientific methods used for quantifying these socio-economic effects. In addition to the analysis of socio-economic effects in Germany, experience from other countries around the world are presented (e.g., South Africa, Turkey, India, Chile, and others). Moreover, global experiences and trends are depicted.

2.1. Industrial development and economic growth

Key findings for Vietnam policymakers:

World-wide, annual clean energy investment will need to more than triple to around $4 trillion.

To maximize regional value creation, energy policy needs to be coordinated with a consistent green industrial policy.

The energy transition will have a positive effect on the global GDP, especially when taking the costs of climate inaction into account.

Modelling the effects of the energy transition on GDP requires complex models (Computable General Equilibrium models) and the results are very sensitive to a large number of input parameters.

The effect of the Vietnamese energy transition on the national GDP have not yet been modelled. In order to do so, a sophisticated Computable General Equilibrium (CGE) model would need to be developed to reflect the interactions within the Vietnamese economy.

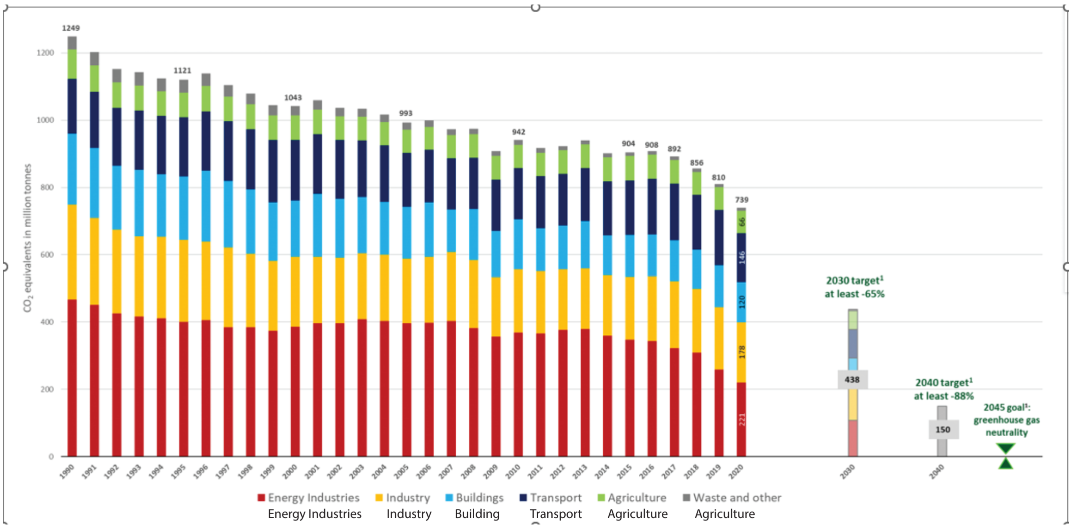
2.1.1. Increasing investment and regional value creation

The transformation towards clean energy technologies will require unprecedented investment in the energy sector. According to the International Energy Agency (IEA), annual clean energy investment will need to more than triple by 2030 to around $4 trillion (IEA 2021). This represents about 5% of global gross domestic product (IRENA 2022). In countries like Vietnam, this transformation of the energy sector and the necessary investment is also an opportunity to increase the amount of foreign direct investment.

To maximize local value creation related to these investments, it is important to link energy policy making with a consistent clean energy industry policy. Well-designed industrial policies will be important to attract green industries in emerging economies like Viet Nam. In many developing countries with a lack of targeted industry policy, primarily consumption jobs have been created, but not the more sustainable employment in the manufacturing sector (GIZ 2021).

Vietnam currently imports relatively high volumes of energy related technologies, primarily driven by imports of renewable energy technologies (see Figure 3).

Figure 3: Imports of energy related technologies in Vietnam
(Source: GWS 2020)



Strategies for creating national supply chains for clean energy technologies can be aligned and incorporated into Decision No. 879/QD-TTg to approve the Industrial Development Strategy through 2025, vision toward 2035.

Case study: Renewable energy investments, local value creation and export opportunities (Germany)

The German energy transition will require unprecedent levels of investment into the national energy system. To reach the climate targets, about €320 billion need to be invested until 2030 (BDEW 2020). Total investments in the renewable energy sector amounted to € 11 billion in 2020. Investments in energy efficiency amounted to about €43 billion in 2018 (UBA 2021). But these levels will need to triple in the coming decade. For instance, Germany will need to increase annual deployment levels for solar PV from 2 GW in the past years to 16 GW or more every year.

In the past decades, Germany was able to increase its exports of energy related products. While the share of this products was little more than 6% of overall exports in the year 2000, the share was increase to almost 9% in 2018. In this year alone, energy related products with a value of € 141 billion were exported (GWS 2020).

Interestingly, large fraction of the required investment will generate regional value creation. Depending on the project, between one-third and two-thirds of the national value creation will remain within the region where the energy project is located (BDEW 2020).

2.1.2. Increasing GDP

Renewable energy investment and other energy transition technologies can create stronger economic growth. Many analyses focus on the effects that the energy transition can have on the gross domestic product (GDP). From a global perspective, the effects of the energy transition have frequently been modelled by the International Renewable Energy Agency (IRENA). The latest World Energy Transition Outlook (WETO) shows that a faster transition could increase global GDP by 2.4% within the next decade. This comparison is based on the two major scenarios analyzed, the Planned Energy Scenario and the 1.5°C Scenario (IRENA 2021a). Also in Germany, a recent study has shown that a more rapid energy transition will lead to higher GDP growth. A report from GWS highlight that an additional GDP of € 74 billion can be achieved until 2030 (GWS 2021).

Other studies indicate that most of the economic benefits will be realized in the period post-2050 whereas in the medium-term, decarbonizing the energy system might actually slightly reduce global GDP. A recent study by Wood Mackenzie states that global GDP might be 2% lower by 2050. These losses are partially triggered by stranded investments in fossil fuels and because of front loaded investment needs into clean energy alternatives. According to this analysis, however, lost economic output will be recouped before the end of the century, i.e., until 2100 (Wood Mackenzie 2022).

As illustrated by the two studies mentioned above, modelling the long-term development of GDP is challenging since many input variables need to be taken into consideration.

- When will a certain investment take place?
- What are the cost differences between fossil fuel options and clean energy options?
- How will prices develop in the future?

Most studies conclude that decarbonizing the energy system will certainly be economically more favorable than the excessive costs of climate inaction. However, the studies differ regarding the timeframe when economic output will increase – in the short-term, mid-term, or long-term.

Required modelling: Computable General Equilibrium (CGE) model to compute GDP development

To model GDP effects related to investment in renewables and other energy transition technologies, usually a sophisticated Computable General Equilibrium (CGE) model is required. These CGE models are large numerical models which link real economic data with economic theory to analyze the impacts of policies, new technology or other external factors. These models attempt to reflect the interactions in the economy as a whole, going beyond just the effects within the energy sector.

CGE models are complex. The modelling results are very sensitive to a large number of input parameters (e.g., when a certain investment will need to take place, the share of national value creation in certain industries, future projects of fuel prices, electricity prices and prices of other commodities, etc.).

Case study: Analyzing the economic costs of climate inaction (Germany)

Next to modelling the impact of the energy transition on economic growth, a growing number of studies are also quantifying climate inaction. What are the financial consequences of policymakers not acting quick enough to mitigate the worst effects of the climate crisis?

When assessing the impact of the energy transition on economic growth, it is also necessary to calculate the potential negative effects of not decarbonizing the economy. The economic costs of climate inaction can be very high. In Germany, for instance, the economy could lose up to €730 billion by 2070 if the transition towards a green economy is not realized (Deloitte 2021). Climate change would lead to an annual GDP loss of 0.6 percent relative to a world without climate change. A lower growth rate due to climate change would also result job losses amounting to 470,000 jobs.

The study analyses various aspects that can reduce economic output due to climate changes, including:

- Heat stress (lost labor productivity from extreme heat)
- Sea level rise (lost productive land)
- Damaged capital (stalling productivity and investment)
- Human health (increased incidence of disease and mortality)
- Tourism loss (disrupted flow of global currency)
- Agriculture loss (reduced agricultural yields from changing climate patterns)

2.2. Increased energy security and reduced costs for energy imports

Key findings for Vietnam policymakers:

By deploying nationally available renewable energies, Vietnam can improve energy security.

Due to the concentration of fossil fuel exports in the hands of a few countries, the geopolitical risk of being dependent on fossil fuel imports is high.

Price increases of fossil fuels can drive up inflation rates, thus undermining many of Vietnam's critical long-term policy objectives, such as industrial development, decarbonization, and social and economic development.

Vietnam can save money on fossil fuel energy imports and thus improve the national trade balance.

Renewable energy deployment and energy efficiency measures are emerging as central ways in which governments around the world can improve energy security. In countries which are highly dependent on energy imports, the risks related both to the availability as well as the price volatility of fossil fuels is especially pronounced. Energy import dependency is very high in many countries around the world, including Vietnam and Germany.

When assessing energy security, a number of different parameters need to be taken into consideration. These include:

- The overall geopolitical risk related to fossil fuel imports
- The macro-economic risk related to increasing inflation
- Savings on energy imports and improved trade balance

2.2.1. Geopolitical risks related to fossil fuel dependency

The export of fossil fuels is dominated by a few countries around the world. In the case of LNG and natural gas, the three largest exporting countries account for more than 50% of global export volumes (Russia, Qatar, Norway). In the case of coal, the three largest exporters (Indonesia, Australia, Russia) account for more than 75% of global export volumes. In the case of crude oil, the exporting markets are less concentrated but still the six largest exporting countries account for more than 50% of total export volumes (IEA 2020). Due to this dependency on very few suppliers, fossil fuel-based energy policy always has to be seen in the light of geopolitics. The supply risk is inherently high in the case of fossil fuels.

A global economy based on renewables and clean energy technologies will significantly shift global power structures and also increase energy security as energy generation will become more decentralized and diffused (IRENA 2019). In the case of (green) hydrogen, a greater regionalization of energy relations could occur in the coming decades due to high transporting costs of hydrogen (IRENA 2022). An analysis in Portugal showed that the deployment of renewables has decreased energy import dependence by 20% in the period 2004 to 2011 (Gouveia et al. 2014).

Case study: Germany's dependence on imports of Russian gas and the associated geopolitical risks

Germany is heavily reliant on fossil fuel imports. 93% of hard coal, 94% of natural gas and 98% of crude oil are imported (GWS 2018b). Only in the case of lignite, Germany has a considerable degree of national production. The implications of relying heavily on energy imports from one country can recently be observed in Germany. Germany imports 50% of its natural gas from Russia. Due to a lack of LNG terminals, the supply from Russia cannot easily substituted by imports from other countries.

The invasion of the Ukraine by the Russian army and the resulting geopolitical tensions also highlighted the geopolitical risk of being overly dependent on fossil fuel imports. In the past months, gas prices on the German market skyrocketed by more than 500% (see Figure 4). This sharp price increase does not only have implications for German citizens (natural gas is mostly used for heating) but also for German manufacturing industries.

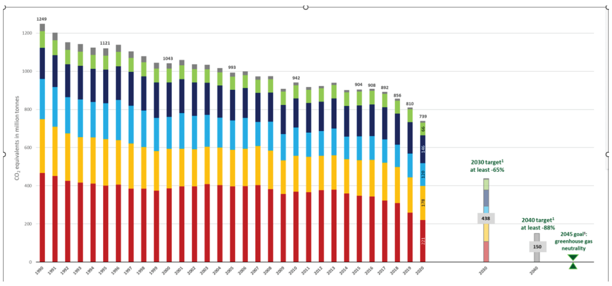


Figure 4: Natural gas price on the German market platform EGIX

(Source: Frontier Economics/EGIX)

2.2.2. Macro-economic risk related to fossil fuel imports and increasing inflation

Another element related to energy security is the economic and macro-economic risks of continued fossil fuel reliance. Increasing fossil fuel prices, especially oil prices, lead to higher inflation. This usually forces central banks to raise interest rates, which dampens investment and makes it harder to invest in new projects and ventures across the economy. All companies active in other sectors of the economy also suffer, along with households who have to deal with higher bank interest rates. This affects the entire economy and can pose an important risk to critical long-term policy objectives, such as industrial development, decarbonization, and social and economic development.

Case study: Fossil fuel imports and the risk of inflation (Turkey)

In Turkey, the impact of fossil fuel imports, namely oil, gas and coal, on inflation and GDP has been analyzed by various studies over several decades (Kargi 2014, IPC 2020, IPC/IET 2022). There is a clear correlation between increasing costs for importing fossil fuels and increasing inflation. The severe impact of increasing energy prices on inflation have been especially pronounced in 2021 and early 2022.

For the year 2022, electricity prices were raised by up to 125% for commercial users and by around 50% for households for 2022. Natural gas prices increase by 25% for the residential sector and 50% for the industrial sector (Reuters 2022a). In 2021, the inflation rate jumped to 36.1% (Reuters 2022b).

2.2.3. Savings on fossil energy imports and improved trade balance

In many countries, the cost for fossil fuels makes up a large portion of the country's (negative) trade balance. In other words, deploying renewable energies and thus reducing the import of fossil fuels can help to improve a country's trade balance and thus improve the overall macro-economic situation. Saving related to fossil fuel imports can be especially high in countries with high import dependency.

The past 12 months have shown that fossil fuel prices can be extremely volatile. In Europe, coal prices increased 70% in 2021 and natural gas prices increase by almost 500%. Therefore, deploying renewables can also be seen as a strategy to hedge against potential fossil fuel price increases. The analysis in various countries has quantified the benefits in terms of reduced energy imports and the positive effects on national trade balances.

Case study: Savings on energy imports (Germany)

As highlighted above, Germany is extremely dependent on fossil fuel energy imports. Therefore, a shift towards renewable energy sources also reduces the costs for energy imports. The aggregated savings related to the avoided imports of fossil fuels increase from € 13 billion in 2016, to €17 billion in 2017 and €24 billion in 2018. The sharp increase of savings was primarily related to energy efficiency measures and to increasing prices of fossil fuels (GWS 2020).

Case study: Improving the trade balance (Turkey)

Turkey is very dependent on the imports of fossil fuels. More than 98 % of the natural gas and 42 % of the coal burned for electricity generation were from imported sources (EPDK 2019). Recent fluctuations in the prices of imported fossil fuels represent a threat for energy security in Turkey. The high cost of energy imports also has a negative effect on the current account balance. Between 2013 and 2017, Turkey's total current account deficit was 220 billion USD, with more than 85 % (188 billion USD) deriving from the energy sector (IPC 2020).

Several scenarios were calculated to estimate the potential savings related to reduced fossil fuel imports based on an increasing share of renewable energies in the electricity system. When comparing the business-as-usual case with a scenario of high shares of renewables (55% of total power demand) total savings can amount to USD 2.1 billion (IPC 2020).

2.3. Employment opportunities

Key findings for Vietnam policymakers:

Future energy systems based on renewable energies and energy efficiency are more labor intensive than fossil-fuel based energy systems. Therefore, a net increase of employment can be assumed for the coming decades.

Renewable energy deployment and energy efficiency measures are both considered job motors of the future.

In Vietnam, an analysis of gross renewable energy employment effects has been executed based on an employment coefficient methodology. More sophisticated methodologies (input-output analyses and Computable General Equilibrium models) would also allow for modelling net employment effects across the entire Vietnamese economy.

The negative impacts on the fossil fuel industry and fossil fuel-dependent regions can be mitigated by political foresight.

The global energy transition will increase the number of people working in the energy sector, even when taking the negative effect on fossil fuel industries into account. According to the IEA's Net-Zero Emissions by 2050 (NZE) Scenario, around 14 million new jobs can be created by 2030. Over the same period, job losses in the fossil fuel industry could amount to 5 million, resulting in a net gain of 9 million jobs (IEA 2021). However, this number only takes direct jobs into account. When also considering indirect and induced employment effect, around 100 million jobs could be created by 2030 (IRENA 2020b).

Definition of employment categories: Direct, indirect, and induced jobs

Employment can be broadly classified into three categories: Direct, indirect and induced jobs.

Direct jobs include employment that is directly linked to a specific renewable energy or energy efficiency projects. For example, in the case of a renewable energy project, this includes plant design, site development, financial closure, project management, fuel supply (in the case of biomass), construction/ installation and the operation and maintenance of power plants.

Indirect jobs include employment opportunities in the secondary industries that supply equipment for specific renewable energy or energy efficiency project. This relates to the manufacturing of equipment and materials used for the direct functioning of a power plant, which includes manufacturing of turbines, generators, boilers, solar PV panels and wind systems for power plants.

Induced jobs are created when the salaries earned in the primary and secondary industries (see above) are spent and thus enter the wider economy. For instance, earnings spent by the power plant's workers on purchasing food at grocery stores and restaurants, house rents, etc., induce additional employment in these respective industries (CEEW et al., 2019).

Case study: Employment effects of a net zero carbon pathway (Germany)

Following a net zero economy pathway, Germany can create a considerable amount of additional employment. Until 2030, 359,000 new jobs can be created (see Figure 5), resulting primarily from additional investments into renewable energy sources and grid infrastructure (GWS 2021).

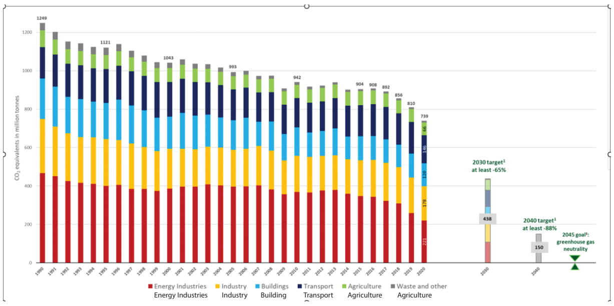


Figure 5: Number of additional employees on a net-zero carbon pathway in Germany

(Source: GWS 2021)

In Germany, negative employment effects are primarily expected in the transport sector. My moving from the internal combustion engine – where Germany was traditionally strong with its many car companies – toward electric vehicles will reduce the number of jobs available, especially in the supply industry producing components for internal combustion engines. The late adjustment of the German car companies to the new "e-mobility" reality will likely be the major reason for job losses in the transport sector (GRW 2021). It should be noted that this late adjustment was partially induced by outdated and backward-facing policies which tried to "protect" the German car industry the inevitable transition towards decarbonization of the transport sector but at the same time hindered the necessary structural adjustments within the German car industry.

Skill development will be crucial to prepare for a future where thousands of new clean energy experts will be required. Developing adequate education and training programs can help avoid or minimise skills gaps which are likely to occur in countries with rapidly evolving energy markets, like Viet Nam (GIZ 2021).

Case study: Skill development and training requirements in Vietnam

A report analyzing the future renewable energy skill requirements in Viet Nam has shown that due to the present low installed capacity of solar PV and wind turbines, there is still limited demand for and availability of local technical expertise. Since there are only limited specialized training options currently available in Viet Nam, project developers often retrain workers on-the-job with the support of foreign experts.

This can significantly reduce the potential for local value creation and job creation. Highly skilled labor for the solar PV and wind power deployment is still frequently “imported” into Viet Nam. Vietnamese RE companies have stressed that they are willing to recruit skilled local workers locally, if the training provided by universities and technical schools in Viet Nam is aligned with the technical skills demanded by the RE sector.

Currently, there is a lack of formal training in universities, colleges, and technical schools to meet the technical skill requirements of the RE sector. Even though a large number of electrical engineers have graduated from Vietnamese universities, they frequently still lack the specific knowledge for RE technologies and systems. In addition, vocational training schools are not yet equipped to provide the specialized RE training (IASS et al, 2019).

2.3.1. Renewable energy employment opportunities

Renewable energy deployment has been able to create millions of new jobs world-wide in the past decades. Globally, the renewable energy sector employed about 12 million people in 2020. This number could increase to more than 38 million by 2030 and 43 million by 2050 (IRENA 2021b).

Required modelling: Employment coefficients, input-output models, CGE models

There are different research methodologies to quantify employment effects. The simplest approach is to work with so-call employment coefficients. These employment factors are typically developed based on employment generation along the value chain of a given technology (expressed as full-time-equivalent jobs/MW/year). Employment coefficients typically need to be developed for individual countries, since the value creation along the value chain (e.g., in the manufacturing sector) can vary largely from one country to the next. Employment coefficients have already been developed for Vietnam (IASS et al., 2019) (see Figure 6).

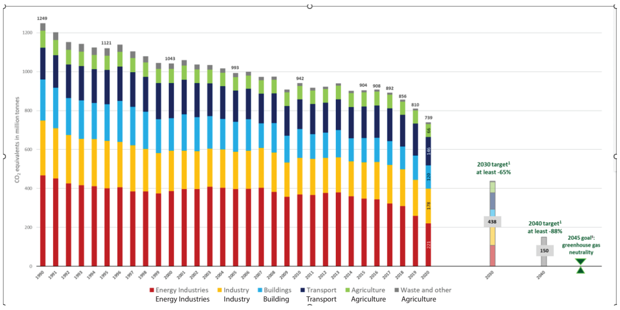


Figure 6: Employment factors of various power generation technologies in Viet Nam

(Source: IASS et al. 2019)

More sophisticated approaches for modelling employment effects include input-output (I-O) analyses and Computable General Equilibrium (CGE) models. Input-output analyses allow for the quantification of gross employment, while also computing macro-economic impacts (e.g. gross value added as a contribution to GDP). Even more complex CGE models allow for the estimation of net employment impacts across the entire economy (IEA-RETD 2011).

Employment effects of renewable energy technologies have been modelled in many countries around the world, including India, Vietnam, the United States, South Africa, Mexico, Turkey, Hungary, Tunisia and many more (COBENEFITS 2022).

Case study: Renewable energy employment effects (India)

Based on employment coefficients that have been developed for various power generation technologies, employment effects in the India power sector have been calculated according to various scenarios until 2050. According to the analysis, renewable energy technologies are more labor intensive than conventional energy technologies. When comparing small-scale and large-scale renewable energy systems, distributed renewables such as small-scale hydro, rooftop solar and biomass create maximum employment for every MW of installed capacity. Rooftop solar employs 24 persons, small hydro employs 13 persons and biomass employs 16 persons for constructing and running a one-megawatt plant (see Figure 7).

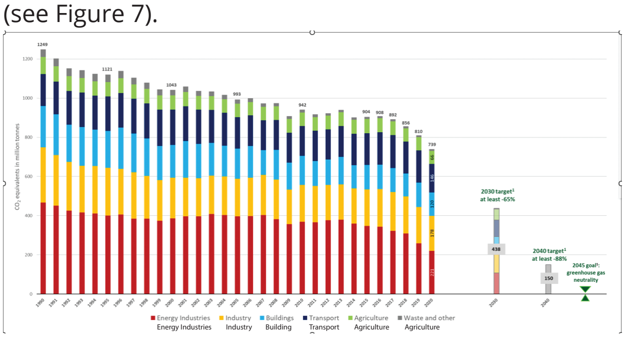


Figure 7: Employment factors of various power generation technologies in India

(Source: CEEW et al. 2019)

According to this study, India could almost double the number of employees in the power sector by 2030 when following a pathway with very high shares of renewables (IRENA REMap scenario). Biomass and solar energy will be the major drivers of employment, with up to 2 million and 1.1 million employees, respectively, by 2050 (CEEW et al. 2019).

2.3.2. Employment effects related to energy efficiency

Energy efficiency measures equally create many employment opportunities, even though the available data is less robust. The IEA has estimated that energy efficiency jobs range from 1-3 million in Europe (depending on the estimation technique), 2.4 million in the United States, more than 700,000 in China and almost 500,000 in Canada.[1] In most countries, the high share of people working in energy efficiency is due to measures and activities in the building sector.

Case study: Employment related to energy efficiency (Germany)

In Germany, most of the employment generated by energy efficiency is related to the building sector, In the last years, more than 500,000 people were employed in conducting energy efficiency refurbishments . Employment in the other energy efficiency segments were much lower. Around 6000 people were employed to advise companies and households on energy efficiency measures. Around 25,000 people were employed in energy contracting (UBA 2021).

2.3.3. Employment effects on fossil fuel industries and policies to mitigate the negative impacts

The energy transition can have negative impact on the employees in the fossil fuel industry. Even though almost all studies show that a decarbonized energy system will yield more net employment than the current energy systems which are dominated by fossil fuels, the negative impacts on the fossil fuel industry need to be mitigated.

Especially in regions with high levels of value creation via fossil fuels, specific policy interventions might be necessary. A number of measures and policies have emerged as “best practice” for countries that are currently planning the phase out of fossil fuels. Especially for the coal phase out, important lessons learned can be drawn from other countries (see also GIZ 2021). Measures to prepare and manage the transition of fossil fuel workers include:

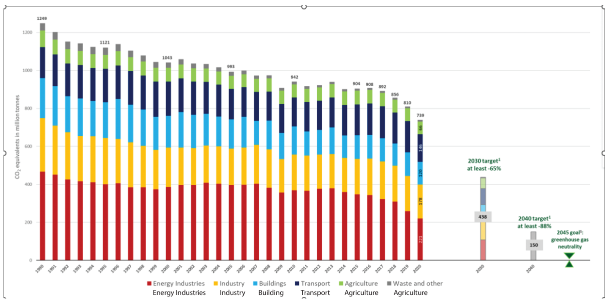


Figure 8: Measures to prepare and manage the transition of fossil fuel workers

(Source: IET)

In addition, specific industry policies and other measures in the energy transition regions might be necessary (see also IASS/IET/CSIR 2022). This includes:

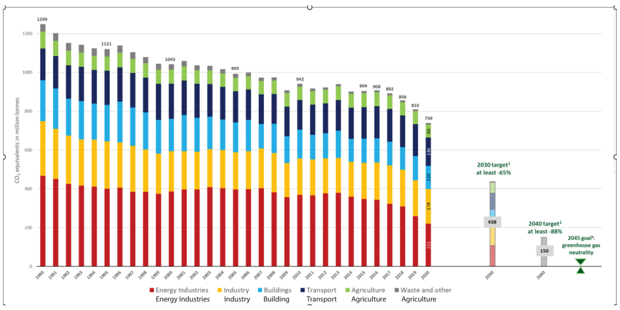


Figure 9: Measures to prepare and manage the transition in energy transition regions

(Source: IET)

Case study: Mitigating the negative socio-economic effects in coal regions (South Africa)

South Africa is still very coal-dependent. About 80% of power generation is provided by coal fired power plants. Moreover, almost all coal-fired power plants are located in one region, the province of Mpumalanga. In some parts of Mpumalanga, more than 60% of economic value creation is directly or indirectly linked to the coal industry.

A recent analysis in South Africa has shown that by directing investment in and deployment of renewables towards these regions where the coal industry was traditionally strong, the negative effects of the coal phase-out can be largely compensated in terms of (net) employment and value creation. More than 70,000 jobs can be created in the region and investment will increase from threefold by following a pathway with high shares of renewables in the electricity sector and for hydrogen production.

In order to achieve this, a number of policy measures have been proposed, including:

- regional procurement of renewables with clearly defined annual capacity targets,
- an expansion of the transmission grid, localization of value creation via local content requirements,
- the establishment of dedicated economic zones
- Renewable energy skill development programs at regional level (IASS/IET/CSIR 2022).

2.4. Reduced air pollution and lower costs for the public health system

Key findings for Vietnam policymakers:

The use of fossil fuels is a major source of air pollution and leads to considerable health costs.

Replacing fossil fuels – especially coal – with renewable energy sources can lead to fewer premature deaths, lower financial costs for national health systems and improved economic output by reduce the number of restricted activity days.

Integrating the health costs of fossil fuels into integrated electricity systems planning will result in higher shares of renewables and other emission free technologies.

The research methodology to quantify the health effects is relatively complex

The use of fossil fuels is an important contributor to air pollution. Emissions from coal- and gas-fired power plants include several toxic components, including sulphur dioxide (SO2), nitrogen oxides (NOx), and carbon monoxide (CO), and particulate matter (PM).[1]

Globally, the World Health Organization (WHO) calculated that indoor and outdoor air pollution is responsible for about 7 million premature deaths every year (WHO, 2020). Of those, about 65% can be attributed to air pollution from fossil-fuel-related emissions (Lelieveld et al, 2019), i.e., about 4.5 million premature deaths annually. In Europe, the use of coal-fired power plant for electricity generation causes almost 34,000 premature death per year (Kushta et al., 2021). In Ontario, Canada, health concerns were absolutely central to the coal phase out, even more than climate concerns. Costs for the health care system were estimated at $4.4 Billion CAD in the early 2000s due to coal fired power plants (IISD 2015).

Reducing the use of fossil fuels and the related toxic emissions can lead to a number of benefits, including:

- Fewer premature deaths
- Lower financial costs for national health systems
- Improved economic output by reduce the number of restricted activity days

1 Particulate matter is typically differentiated into particles with diameters smaller than 10 and 2.5 μm (PM10 and PM2.5 respectively).

Required modelling: A complex approach for health costs quantifications

The research methodology to quantify the health effects (premature death, years of life lost (YLLs), Disability-adjusted life years (DALY), the economic costs for the public health system and the impact on productivity (restricted activities from workforce that has become sick) is relatively complex.

Typically, air pollution and health cost studies need to include the follow five steps (see also WHO 2016):

1. Evaluate air pollution emissions from different sectors (based on various scenarios)
2. Model the dispersion of air pollutants in the atmosphere
3. Calculate the proportion of the population exposed to different levels of air pollution
4. Estimate the change in disease incidence expected in relation to pollution exposure, using exposure-response functions
5. Attribute costs to different diseases, providing total health impacts

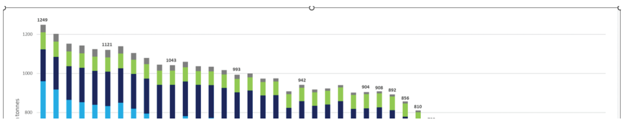


Figure 10: Research methodology for air quality and health costs studies

(Source: Prime Africa/IET/IASS 2019)

2.4.1. Reduced costs for the health system

Even though determining the costs of air pollution is challenging – what is the economic value of avoiding one pre-mature death and of hospitalizing one person? – several international studies have been executed to undertake these analyses. According to one study, the economic costs of air pollution from fossil fuels are estimated at US$2.9 trillion in 2018, or 3.3% of global GDP (CREA 2020).

Case study: The cost of air pollution (India)

In India, similar to many countries in (South-East) Asia, ambient air pollution is a major health problem. In early 2022, Delhi topped the list of the world's most polluted major cities, pollution that is leading to a profound and far-reaching health crisis in the country (Business Standard 2022).

Air pollution is the second leading health risk factor in India, significantly contributing to the country's burden of cardiovascular diseases, chronic respiratory diseases and lower respiratory tract infections. The mean PM2.5 concentration is five times higher than that recommended by the World Health Organization (10 µg/m3). Air pollution is responsible for more than 4 % of total mortality in India (TERI, 2019) and more than 6% of the country's DALY according to the Indian Council of Medical Research (ICMR).

Interestingly, air pollution primarily results from the industry sector and the residential sector and the respective use of coal and biomass. The contributions of the transport and power sector are comparatively low because of increasingly strict emission standards.

Without any changes to the current policies in India, almost 500,000 people will die prematurely due to exposure to particulate matter (PM10). This number would rise even further to 600,000 premature deaths during 2030 and 830,000 during 2050 (TERI 2019).

The negative impact on human health in India would also create considerable economic losses. Without any modifications to the business-as-usual trajectory, economic losses related to health costs could increase from INR 4.6 trillion (USD 64.6 billion) in 2020 to INR 47 trillion (USD 660.3 billion) in 2050. However, by reducing the share of coal in the power mix and increasing the share of renewables, economic losses could be reduced by as much as INR 12 trillion in 2050 (USD 168.6 billion) (TERI 2019).

2.4.2. Including the negative health externalities from coal-fired power plants in power system planning

When planning electricity systems and the optimal power generation mix, frequently least cost power system planning is applied. However, many least cost analyses do not include the environmental, health, and social costs of different options, focusing strictly on the power system costs. In recent years, these models have also been taken other parameters into consideration to compute the ideal power generation mix.

Case study: Health externalities of coal (South Africa)

In South Africa, where about 80% of electricity is produced via coal-fired power plants, the negative health externalities are a relevant cost factor. According to an analysis from 2019, the health-related negative externalities (not including the climate related externalities) amount to almost 1 USD/cent per kWh (5-15 Rand Cent per kW) (Prime Africa/IET/IASS 2019). By including these values into least cost electricity system planning, the share of coal will be reduced and the share of other power generation technologies, with lower emissions of pollutants, will increase

Key findings for Vietnam policymakers:

Since (green) hydrogen and its derivatives will become an integral part of the future energy system world-wide, a front-runner role can lead to important socio-economic benefits for Vietnam in terms of jobs creation and investment opportunities.

Most hydrogen strategies start with a focus on serving the domestic market (e.g. for ammonia) before considering importing and exporting strategies. The trade in hydrogen is currently at its early stages, and electrolyser technologies are likely to come down rapidly in cost in the coming years.

Planning exporting opportunities for clean hydrogen should be part of a larger hydrogen strategy. First, policies and regulations are needed to support green hydrogen production and use within Vietnam (cover national demand). Second, the momentum created by using green hydrogen nationally can be used to prepare the exporting plans.

Due to the important role of shipping costs, and of the cost of capital in determining the cost of hydrogen production, a key determinant of success in exporting green hydrogen will be the proximity to export markets, as well as the cost of financing. In this regard, Vietnam should consider measures to help further reduce the cost of capital for renewable energy and green hydrogen investments.

2.5. Economic opportunities related to the green hydrogen economy

Next to renewable energies and energy efficiency, several other energy transition technologies have recently moved into the focus. Amongst others, this includes green hydrogen. Even though electricity (from renewable energy sources) will play a pivotal role in the energy transition, not all sectors can be easily electrified. In several "hard-to-abate sectors", (e.g., steel. chemicals, cement, maritime shipping and aviation, green hydrogen (GH2) and GH2 derivatives known as Power-to-X (PtX) products will play a crucial role in establishing net zero carbon economies.

As green hydrogen and other power-to-X derivatives will be traded globally in the future, an increasing number of countries is currently analyzing strategies and industry policies to become global front-runners in this field. This way, the early mover economies intend to harness the socio-economic benefits related to the emerging green hydrogen economy. The IEA predicts that global hydrogen use will expand from 90 Mt in 2020 to up to 530 Mt in 2050 (IEA 2021).

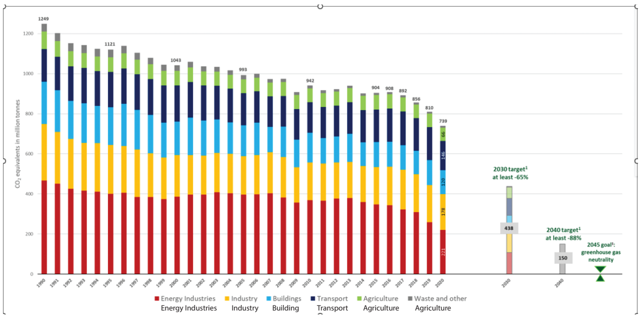


Figure 11: Countries implementing (green) hydrogen strategies

(Source: World Energy Council 2020)

2.5.1. National hydrogen strategies: Importing countries

Many countries around the world will rely on (green) hydrogen imports in order to reach a net zero economy. Due to its high population density and the limitations regarding solar resources, not all required renewable energies can be sourced nationally.

Case study: Strategies of future green hydrogen importing countries (Germany)

In Germany, the country's Hydrogen Strategy estimates that the demand for GH2/PtX products will expand from 1.67 Mt (55 TWh) in 2020 to between 2.7 and 3.3 Mt (90-110 TWh) in 2030 and 11.5 Mt (380 TWh) in 2050 (BMWi 2020).

The German hydrogen strategy follows a dual approach. In a first step, a German "home market" will be developed to also become a frontrunner in manufacturing hydrogen equipment. In order to meet parts of the German hydrogen demand with nationally available renewable energy sources, a capacity target of 5 GW onshore and offshore wind energy by 2030 is part of the national hydrogen strategy. An additional 5 GW of capacity on German ground are planned until 2035 (BMWi 2020).

In a second step, imports of green hydrogen need to be prepared. Imports of (exclusively!) green hydrogen will be necessary to reach the 2030 climate targets and greenhouse gas neutrality by 2045. Already in 2030, only about 14TWh of the necessary 90-110 TWh will be produced based on nationally available renewable energy installations (see Figure XX).

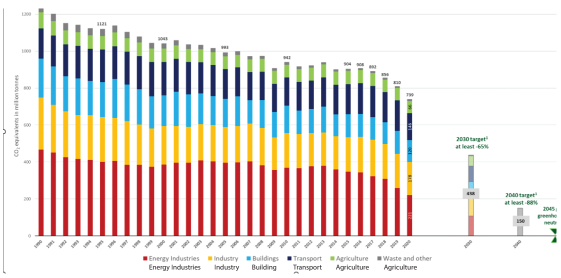


Figure 12: Hydrogen import requirements in Germany until 2030 (Source: Kearney/Uniper 2021)

Germany and the European Union are currently working on strategies for importing green hydrogen. The risk of being overly dependent on a few exporting countries (as in the case of fossil fuels) needs to be mitigated by diversifying exporting cooperation countries world-wide. This is also why Germany is actively supporting countries which have the potential for becoming green hydrogen exporters in the future.

2.5.2. National hydrogen strategies: Exporting countries

Since many countries will rely on imports of green hydrogen, like Germany, other countries are currently developing national hydrogen strategies including a focus on export opportunities. This comprises countries with ample renewable energy potential and large landmasses with low population density (for very high wind and solar power generation capacity that is required). At the same time, access to low-cost capital will be crucial to achieve very low levelized costs of electricity for wind energy and solar PV. Sample countries are Chile, Morocco, and Australia.

Case study: Strategies of future green hydrogen exporting countries (Chile)

Chile published its green hydrogen strategy in 2020 (Gobierno de Chile 2020). The country is ideally suited for becoming a green hydrogen exporter, with the highest solar radiation world-wide in the northern part of the country (reaching capacity factors of 35%) and very good wind energy locations in the southern part of the country (reaching capacity factors of 60%).

In Chile, the export orientation of green hydrogen is part of a larger hydrogen strategy. In fact, in the first phase of the program (2020-2025), Chile will focus on ramping up the national market in order to develop know-how and expertise for the exporting market. In a second phase, a national industry for green ammonia production and exports will be established. In the third phase, Chile wants to become a leader in the export of green hydrogen and its derivatives.

The required installed renewable energy capacity and the associated investments are very high. Chile is planning to install 40 GW of renewable capacity by 2030, 200 GW by 2040 and 300 GW by 2050. The respective investments in renewable energy technologies will amount to USD 45 billion in 2030, USD 220 billion in 2040, and USD 330 billion in 2050 (see Figure XX). About 70% of this market will be related to exports.

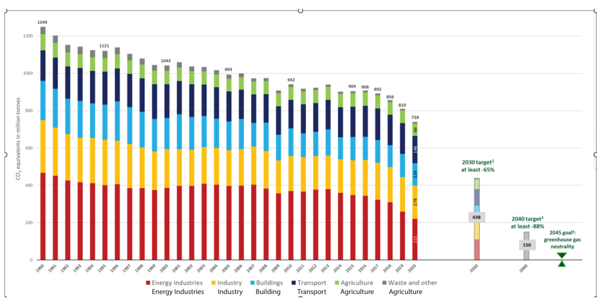


Figure 13: Projection of Chilean market for green hydrogen and its derivatives

(Source: Gobierno de Chile 2020)

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