JACA 2019

German-Japanese Scientific Knowledge Exchange in the Field of Energy and Climate: Analysis and Debates of the German-Japanese Energy Transition Council (GJETC)

Prof. Dr. Peter Hennicke, Dr. Stefan Thomas / Wuppertal Institut
Johanna Schilling / ECOS

1. Introduction

There are many reasons for intensifying the German-Japanese co-operation in the field of energy and climate policy. Three of those reasons have also emerged as fundamental for the now nine-year joint work of the German-Japanese Energy Council (GJETC) (*About – GJETC*, n.d.): First, the development in Germany and Japan, as the third and fourth largest economies in the world,[1] undoubtedly has an important impact in geostrategic and climate policy terms (Barnes & AP, 2024). The successes and shortcomings concerning energy and climate policies of both countries are perceived with particular attention in Europe and Asia respectively. Secondly, as relatively resource-poor but highly developed and export-oriented industrialized economies, both countries face particular challenges in achieving a socio-ecological transformation to climate neutrality by 2050 at the latest and a well-being society.[2] Thirdly, despite comparable CO_2 reduction targets for 2045 and 2050 respectively, the fundamental framework conditions—Japan as an island country and Germany as part of the European internal market—make them interesting reference countries for basic energy and climate policy strategies for other countries because of their similarities, but also in terms of differences in energy policy priorities.

This paper is divided into two major parts. In part one, we summarize what we perceive as a success story of scientific knowl-

1 Japan's total nominal GDP was $4.2 trillion and Germany's was $4.4 trillion, behind the United States and China.

2 We refer for the vision of a Well-Being Society as in the latest global publication by Dixson-Decleve et al., 2022; see for an adaptation to Germany Wuppertal Institut & Club of Rome, 2024.

edge exchange between Japan and German concerning the format and the output of the GJETC. As a result of this fruitful bilateral exchange of knowledge, the question of the *geopolitical context* in which the respective two national energy transitions are embedded has become increasingly important for the work of the Council. This is particularly true with regard to electrification. In the second part, we therefore put the results of our bilateral knowledge exchange in a broader geopolitical context and refer to the *global megatrend of electrification* as an exemplary socio-technical key strategy on the way to net zero in both countries. With this specific background, we suggest selected topics for an intensified German-Japanese energy and climate dialogue.

2. The structure, the goals and the vision of the GJETC[3]

The German-Japanese Energy Transition Cooperation Council (GJETC) is an international role model project to strengthen the exchange of knowledge, mutual learning and policy advice on technologies, policies and the impacts of the energy transition. Today, eight renowned experts from Germany and seven from Japan are members of the GJETC. In its form, continuity and size, the GJETC is the first German-Japanese energy transition cooperation project of its kind.

The Council works as an independent scientific body but close to both governments. It meets twice a year to discuss the topics studied and to develop its policy recommendations. Founded in spring 2016, the Council started with an extensive basic study program and conducted four joint German-Japanese comprehensive studies in cooperation with scientific institutes on key topics of the energy transition. With this background the Council was involved in many publications, activities and outreach events.

The project, which was jointly initiated by the Wuppertal Institute, ECOS, hennicke.consult and the Institute of Energy Economics Japan (IEEJ, Tokyo), is supported on the Japanese side by the Ministry of Economy, Trade and Industry (METI). On the German side, the Council was funded by the German Federal Environmental Foundation (DBU) and the Mercator Foundation in the 1st and

3 The links to all publications of the GJETC can be found at https://gjetc.org/

2nd working phases. In the 3rd phase of the Cooperation Council, the former Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) took over support for the GJETC from the DBU. In the current 4th working phase, the Federal Ministry of Economics and Climate Protection (BMWK) is supporting the activities.

3. Dissemination, outreach and collaboration

Ever since its foundation, the GJETC has strived to share its working results with a broad public, to engage into discussion with relevant stakeholders, and to create synergies with other formats and cooperation platforms. Information about the current and past Council Members, the working program and all events is published via the website (www.gjetc.org). The complete studies and topical papers as well as agendas and outlines and some video recordings of past events are also available there. Since June 2016, the GJETC has published several publications and organized manifold events:

Publications	Events
• GJETC reports (2) • Bilateral studies (16) • Topical papers and analyzes (9) • Input papers and presentations • Press releases (27)	• Council Meetings, alternating between Berlin and Tokyo, or online (17) • Outreach events (12) • Webinars in the series "Zoom in! German-Japanese Energy Transition Talks" • Stakeholder dialogues with the industry / young scientists / parliamentarians / administration (12) • Innovation roundtables (2)

Table 1: Overview of publications and events

Outreach events

The results of the GJETC's work are made available to the general public as part of public outreach events. Since 2016, the GJETC has held twelve outreach events, including five onsite, six online and one in a hybrid format ("Meet-the-Co-Chairs"). The latest outreach event took place in Berlin (and online) on 15th February 2024 and was titled "Tripling Renewables and Doubling Energy-Efficiency: Germany and Japan as Forerunners for the Implementation of Ambitious COP Goals". After the members of the GJETC study teams provided insights into the Council's work, the two Co-Chairs discussed the latest studies on an optimized electricity market design, on accelerating the implementation of energy saving measures, and on the comparison of the European Green Deal and Japan's Green Transformation (GX) with an interested audience.

Stakeholder dialogues

The GJETC regularly seeks to discuss its results in both countries with diverse stakeholders, including the industry, young scientists, parliamentarians, NGOs, and administration.

The first GJETC Stakeholder dialogue with the industry (September 2016 in Tokyo) addressed fundamental questions regarding the expectations of the energy policy of both countries, the challenges of the Paris Climate Agreement, the assessment of the decarbonization goals, the energy mix of the future, etc. Among the participating companies were Toyota, NTT Data, Hitachi GE Nuclear Energies, DAIKIN Ind., Sumitomo Corp., EWE, Enercon, BayWa RE Japan.

The second Stakeholder dialogue with the industry (January 2017 in Berlin) addressed German and Japanese representatives of companies engaged in decentral energy generation and supply. While Germany has already gained experience here, this development is still to come in Japan due to the liberalization of the energy markets. The Council Members discussed with representatives of the central and decentralized energy industry such as Energiewerke Schoenau, Solarcomplex, GLS Bank, Stadtwerke Speyer about the opportunities and challenges of this structural change.

The third Stakeholder dialogue with the industry (September 2017 in Tokyo) discussed "How much energy can be conserved – The role of suppliers of advanced energy efficiency technologies and of Energy Service Companies". Strategic statements from key representatives of German and Japanese companies related to energy efficiency were collected. Based on this it was discussed how the gap between targets and true achievements of energy efficiency can be overcome. Participating companies were (among others): KNAUF Insultation, EVONIK, Bosch, BASF Japan, Siemens AG, Schneider Electric.

The fourth Stakeholder dialogue with the industry (March 2023 in Tokyo and online) was an "Exchange on Policy Frameworks that support the Transition to a Carbon Neutral Building Sector in Japan and Germany". Based on the results of GJETC studies on decarbonization of the building sector, the general question of the dialogue was how the gap can be closed and what policies and measures can speed up decarbonization processes. Participants included DAIKIN, Tokyu Land, Vonovia, dena, HOLCIM, DGNB German Association for Sustainable Building, INPEX Solutions, Recosys.

Another format of the GJETC is *the Young Scientists Dialogue*, through which the GJETC seeks to widen its perspective by inviting young scientists (age under 40 years) with a particular focus on the Energy Transition in Germany and/or Japan. Young scientists from various disciplines are encouraged to present their scientific findings to the Council Members or to introduce a question/topic for comparative German-Japanese analysis that could be discussed by the Council in the future. The GJETC has so far held two online Young Scientist Dialogues in September 2021 and in March 2024. For each dialogue, a call was published, and five to six suitable young scientists from Germany and Japan were selected from the applications. The pitches included socio-economic perspectives on energy-related policies as well as specific technology-related analyzes on the potential of hydrogen and other clean fuels as alternative energy sources.

The GJETC shared study results and exchanged opinions with other stakeholders at several further events, including *a Roundtable* with Representatives of the Ministry of the Environment, Japan (MoEJ) in Tokyo and with the German-Japanese Parliamentarians' Group (both held in Tokyo in October 2016), a public dialogue with Secretary of State Steinlein (Foreign Affairs Office) in Tokyo in November 2016, a Stakeholder Dialogue with the Committee on Environment, Nature Conservation and Nuclear Safety of the German Bundestag in March 2018 in Berlin and a Roundtable with policy makers titled "Intensifying the cooperation on the energy transition" in Tokyo in June 2019.

Innovation roundtables

An "innovation alliance" between science and leading companies from the technological pioneers Germany and Japan can accelerate the implementation of climate mitigation goals through demonstration projects. That is why the GJETC has systematically analyzed energy efficiency and renewable energy related technologies according to decarbonization effects, market potential and complementarity of the technologies and implementation strategies in both countries. Based on this analysis, the GJETC selected very specific technological topics and held two intensively prepared and followed-up Innovation Roundtables. They brought together representatives from industry and science related to the specific topic with the aim of initiating German-Japanese demonstration projects.

The *first GJETC Innovation Roundtable* held online in November 2021 targeted "Thermoelectric generators (TEG) for Waste Heat Usage in the Industry". Suppliers and users as well as research institutes and supporting bodies from Japan and Germany were brought together to exchange information on the current state and new developments of technology, current and new applications and future challenges to be addressed. The event successfully provided ideas and research impulses to define content for joint R&D projects and will serve as a basis for further discussions with relevant ministries. Among the participants were Hakusan, NEDO, AIST, IFW (Leibnitz Institute for Solid State and Material Research, KIT Karlsruhe Institute of Technology, E-ThermoGentek Co., Ltd.

The *second Innovation Roundtable* held online in December 2023 focused on "Scan to BIM Technology and Prefabrication of Innovative Insulation in Retrofitting of Residential Buildings". Based on the results from the GJETC study on "Decarbonization of the Building Stock", the GJETC believes that a key contributing factor is to economize this process by making use of new technologies which enable prefabrication and serial renovation. The objective of the Innovation Roundtable was to identify competences in each country to advance retrofit initiatives and to develop ideas and concepts for joint projects, e.g., the development and demonstration of industrial construction/pre-fabrication of sustainable and space-saving insulation elements and concepts, conductive to scaling up cost-effective refurbishment. Participants were (among others): BRI Building Research Institute, dena, DGNB German Association for Sustainable Building, Ecoworks, Sistems, Vonovia, Mitsui Fudosan.

Cooperation with the Japanese-German Energy Partnership

In order to strengthen the synergy effects of the GJETC with the Japanese-German Energy Partnership (EP) (see also below) the German GJETC secretariat exchanges information and ideas with the EP secretariat regularly. The exchange enables the alignment of topics and mutual participation in workshops and meetings and helps to avoid duplications. The fruitful mutual exchange is manifested in the webinar series “Zoom in! – Japanese-German Energy Transition Talks” which is jointly organized by the Japanese-German Energy Partnership Team and the GJETC. Each session zooms in on a specific topic and offers decision-makers from policy, industry and research a platform for in-depth information and discussion on the current status, development and potential for different energy transition policies and technologies in Germany and Japan.

The Zoom in! sessions in which the GJETC or Council Members were involved in addressed the “Nexus of Circular Economy, Resource Efficiency and Climate Protection” (September 2023), “Geopolitical Developments, COP 28 and their relevance for Energy Policy in Japan and Germany” (November 2023), and “Energy Security in Decarbonized Power Systems” (October 2024).

GJETC members also contributed to the annual German-Japanese Environment and Energy Dialogue Forum (EEDF) and to the online lecture series “Energizing Insights: The Japanese-German Lecture Series on Renewable Energy” (“Paths to Net-Zero: Climate Policy in Germany and Japan”, October 2024).

4. Common and differentiated policies and targets

4.1 Selected basic data – similarities and differences

Before looking into the content and recommendations of the GJETC-studies some basic data will be presented to understand the frame conditions of energy and climate policies in both countries better. The following comparison of selected basic data[4] shows e.g. that Germany and Japan have comparable GDPs, surface areas or CO_2 emissions / cap, but stronger differences in population, in total energy and especially electricity consumption, and in government debt ratios.

	Germany	**Japan**
Population	83,445 mio	124,482 mio
Surface area	357,590 qkm	377,974 qkm
Annual GDP	€ 4,185,550 million	€ 3,901,540 Million
CO_2 / cap	8.16 t	8.61 t
Electricity consumption	484,2 TWh	939.3 TWh
Primary energy consumption	10.8 EJ	17.4 EJ
GDP per capita	€ 49,520	€ 31,342
Debt per capita	€ 31,539	€ 83,071
Average income	$ 54,800	$ 39,350
General government debt	63.6% of GDP	261.3% of GDP
Exports	$ 1.65 trillion (3rd largest exporter)	Totaling $ 728 billion (4th largest exporter)
Energy import dependency	ca. 68%	ca. 90%

Table 2: Comparison of selected basic data (2022 or 2023)

Note: Adapted from (*Japan (JPN) and Germany (DEU) Trade*, n.d.; *Country Comparison*, n.d.; *Country Comparison Germany vs Japan*, n.d.; Cahill et al., 2024).

Regarding only these few different framework conditions it is understandable, that the transformation to net zero in both countries will have some common, but also very differentiated characteristics. Thus, it would not have been a good idea, to start the GJETC in 2016 with the concept "Just transfer Germany's targets and experiences with the 'Energiewende' to Japan". On the opposite: Supporting mutual learning processes and creating a trust building dialogue needs to listen carefully to the reason why even

4 For a detailed comparison of these and other basic data see especially (*Country Comparison Germany vs Japan*, n.d.) or (*Country Comparison*, n.d.)

fundamental different views could occur. This is especially true concerning the island status of Japan and the potentials and infrastructure of renewable energies.

4.2 Energy rich or energy poor countries?

Thus, we started the dialogue with a basic question which is related to natural frame conditions, the potentials for renewables and the technical feasibility of a 100% renewable energy system in 2045 and 2050 respectively: Are Germany and Japan "energy poor" of "energy rich" countries? For Germany, the question has been answered meanwhile by research and politics: A 100% renewable energy system by 2045 is undoubtedly technically feasible and today (12/2024) an official goal of the government.

In Japan the debate is still ongoing (see 4.3.) about what is the best energy and technology mix to reconcile the 3E+S objectives.[5] Japan struggles with the decision, at which level to best set long-term energy efficiency and energy mix targets, and how to revise the 2030 energy mix targets.

The former Japanese Co-Chair of the GJETC, Masakazu Toyoda (2017), has provided an excellent and comprehensive rationale for Japan being an "energy poor country" in an article. Assuming that Japan must be classified forever as "energy poor", due to its insularity and precarious national resources, a long-term, complete decarbonization seems only be possible, if nuclear energy risks are permanently accepted as a necessary evil, even if CCS and CCU as well as international carbon offsets are considered as further decarbonization options. Based on this assessment, a target-setting for a rising, but ultimately limited share of renewable energy up to 2050 as part of the official Japanese energy mix would be understandable. But the key question remains whether this is due to natural frame conditions (e.g. missing technical and economically feasible potentials) or dependent of political priorities?

For example, in Germany in the 1990s, both the energy industry as well as a large part of politics held true as an 'axiom' of energy policy that renewable energies could only play an "additive role" together with coal and nuclear (SZ, 1993).The reality has now refut-

5 3E+S means Energy security, Economic efficiency, Environment plus Safety

ed this historical perception. Germany as a member of the EU and due to its geographical position has the favorable possibility of international power exchange, which Japan does not have. However, up to now and even by much higher renewable shares than today (about 60% share) security of electricity supply in Germany is not conditioned, but apparently easier backed up by this international exchange.

If Japan would exploit its extensive technical potential for PV, wind (onshore and offshore), geothermal energy and biomass, could it be eventually evaluated as an "energy rich country" (Prof. Thomas Kåberger)? "Energy rich" in the sense that by simultaneously exhausting existing considerable energy savings (e.g. in the building sector), the supply security and economic competitiveness could be guaranteed, and furthermore, a final abandonment of nuclear energy and similar ambitious long-term CO_2 reduction targets like in Germany could still be achieved?

Undoubtedly, a complete system change from fossil-nuclear to renewable power generation in the long term (2045/2050) represents a huge energy and socio-political challenge especially for Japan, which would have to be started and guided now. But in many aspects, this also applies to the German energy transition, as the outstanding controversial issues and challenges for the German Energiewende show.

It can be taken for granted that due to the world-wide dramatic cost reduction of power generation (PV/wind) and storage technologies as well as by greater adherence to the "Efficiency First" (IEA) principle, drawing on a new diversity of experiences from other countries will increasingly become possible.

Thus, before entering into detailed results of the GJETC, we leave it to the following question: Might it be possible in the future that Japan and Germany will be role models for not only heading for net zero, but also for zero nuclear and thus risk-minimizing economies under very different conditions and challenges respectively?

4.3 In short: the post-Fukushima energy policy changes[6]

The 2011 Fukushima Daiichi nuclear disaster significantly changed the energy policies of Japan and in Germany, leading each country to adopt distinct strategies in response to the challenges posed by nuclear energy and the pursuit of sustainable power sources.

Japan's energy policy post-Fukushima

The incident led to the shutdown of all nuclear reactors, which had previously supplied about 30% of the nation's electricity. This sudden loss necessitated a substantial increase in fossil fuel imports, particularly liquefied natural gas and coal, to bridge the energy gap, resulting in higher greenhouse gas emissions and increased energy costs.

By 2014, Japan introduced a Strategic Energy Plan emphasizing a diversified energy mix, aiming to balance energy security, economic efficiency, and environmental sustainability. This plan sought to reduce dependence on nuclear power while promoting renewable energy sources and improving energy efficiency. Relatively late, in October 2020, the Japanese government decided on a net zero emissions target by 2050 (Farand, 2020).

In recent years, Japan has reaffirmed its commitment to carbon neutrality by 2050, necessitating a reevaluation of its energy policy. The government has indicated plans to make renewable energies a major source of energy, but also to maximize the use of existing nuclear reactors and invest in next-generation nuclear technologies to ensure a stable and sustainable energy supply. This approach is meant to reflect a pragmatic recognition of the challenges in rapidly expanding renewable energy infrastructure and the need for a balanced energy mix to achieve environmental goals.

6 This chapter, using the support of ChatGPT, focusses on selected policy impacts of the Fukushima incident on the power sector, to build the bridge to the scenario comparisons in chapter 5. Chapter 4 presents some additional analysis of the GJETC. For a more comprehensive analysis we refer to the publications on BMWK and METI and the wealth of comprehensive studies of Institutes in both countries.

Germany's energy policy post-Fukushima

In 2011, the German government announced an accelerated phase-out of nuclear energy, committing to shutting down all nuclear reactors by 2022. To compensate for the reduction in nuclear power, Germany significantly invested in renewable energy, particularly wind and solar. This transition was supported by different policies such as e.g. amendments of the Renewable Energy Sources Act. In the 1st half year of 2024, the share of renewable electricity increased to more than 60% (DeStatis, 2024).

The rapid expansion of renewables presented challenges, including grid integration issues, fluctuating energy prices, and concerns about supply reliability. Additionally, the diminishing but extended reliance on coal—up to the phase-out agreed for 2038 (at the latest)—and natural gas to ensure energy security during the transition led to criticisms regarding carbon emissions and environmental impacts. The reliance on Russian gas and the import stops after the aggression against the Ukraine complicated the energy transition.

Despite these challenges, Germany remains committed to its energy transition goals, aiming for renewables to constitute 80% of electricity consumption by 2030 and achieving climate neutrality by 2045. The government continues to address the complexities of balancing environmental objectives with economic and energy security considerations, acknowledging the need for a diversified and resilient energy system.

Both countries focused on the transformation of the electricity sector so far. However, particularly in Germany, the net-zero transformation of the buildings, industry, and transport sectors, largely based on electrification, is gaining attention and creating challenges in recent years.

With this background in both countries the GJETC intensively discussed topics of mutual interest for joint research work and for developing recommendations. Some selected study results are summarized in the next chapter.

5. Selected study results

5.1 Objectives of the study program and overview of topics

The GJETC has prepared two to three studies or topical papers per year. Their objective is to analyze selected topics in the energy transition and climate mitigation, to enable science-based mutual learning on what has worked well or not in the other country, joint learning on policy reforms or business models that may advance the energy transition in both Germany or Japan, and developing recommendations for joint international initiatives, if applicable.

Usually, the studies include a parallel analysis of the topic for each of the two countries, a comparison section, and scientific conclusions and policy recommendations. The topical papers are shorter than studies and focus on specific aspects. There are also four output papers from working groups of GJETC members on specific aspects in 2018-20.

The initial study program had four volumes. They laid the foundation for mutual understanding of the energy demand and supply situation in both counties, the potential roadmaps for the energy transition, and the challenges Germany and Japan are facing for the energy transition. They also formed the major basis for the (2018) GJETC report.

- Energy transition as a central building block of a future industrial policy—comparison and analysis of long-term energy transition scenarios
- Strategic framework and socio-cultural aspects of the energy transition
- New allocation of roles and business segments of established and new participants in the energy sector currently and within a future electricity market design
- Energy end-use efficiency potentials and policies and the development of energy service markets (Matschoss et al., 2017)

Building on this foundation, the studies and topical papers have addressed several important fields of the energy transition, often in streams of two or three consecutive studies. These include:

- **Energy efficiency potentials and how policies could be made more effective** in harnessing these potentials; this work stream laid a special focus on *energy efficiency and decarbonization of the building stock*, with a study in 2023 and a working group's output paper in 2020, as well as a study on *the more effective governance of energy efficiency policies*
- **Grid and market integration of electricity from variable renewable energy sources**; from 2019 to 2021, three studies focused on how digitalization could contribute to this objective, from *Virtual Power Plants and Blockchain* to *Peer-to-Peer energy trading and Power Purchasing Agreements* to *optimizing grid operation using AI and Big Data collected from DERs*; in 2023, a study researched *The role of batteries in balancing supply and demand in power markets and grids*, and in 2024, we studied *Electricity Market Design—Instruments to support the investment in flexibilities*, because these will be needed as shares of renewable energies increase to higher levels or even approach 100%
- **Clean hydrogen and the necessary policy framework**; here, the work started with a joint study with the Japanese-German energy partnership released in 2019 on *The role of clean hydrogen in the future energy systems of Japan and Germany*, followed by a GJETC study on *Important Aspects of Production, International Cooperation, and Certification* in 2020; in 2021, the first study on industry also included a focus on hydrogen
- **Net-zero transformation of industry** and the corresponding industrial policies; this research stream started in 2021 with a study on *CCUS and Hydrogen Contributing to Decarbonization of Energy intensive Industries*, followed by two sectoral deep dives on the *steel* and *petrochemical sectors* in 2022/23, and a topical paper on *Green Industrial Policy and Trade* in 2024
- A second comparison study on **long-term net-zero-carbon scenarios** in 2022, after Germany had pledged to be carbon-neutral by 2045, and Japan by 2050 (see chapter 6)
- Imminent subjects of the day, such as how both countries could cope with the **impacts of the Covid-19 pandemic** or the energy price crisis of 2022/23.

5.2 Selected results and policy recommendations

What have we learnt in the nine years of joint research and scientific dialogue, what have Japan and Germany learnt from each other, and which policy recommendations did we develop? This section aims to present some concrete examples.

Energy efficiency in buildings

Buildings are much more different between countries than industrial processes or appliances, due to factors such as climate and culture. Except for Hokkaido and other northern or mountainous parts of Japan, the country has much warmer and more humid climate zones than Germany. These require less space heating but more space cooling. In addition, while Germans have become accustomed to heating most rooms of their dwellings all the time, the Japanese still tend to only heat or cool the rooms they are using and when they are using them.

As a consequence of these divergent factors, Germany has introduced minimum thermal insulation standards for all new buildings since the 1970ies and strengthened them several times since then, and also on energy efficiency renovation of the existing building stock, while Japan has been more focusing on heating and cooling equipment. Still, Japan's homes and buildings could benefit from better insulation to enable warmer indoor temperature during winter at reasonable heating costs. Research by a Japanese GJETC member has shown that many Japanese suffer from health problems due to low indoor temperatures. Because Germany introduced some types of policies on energy efficiency in buildings earlier on, Japan has been able to gain inspiration for its own energy and environmental policies, inter alia, from Germany's set of policies in the past.

Connecting German knowledge of and technology for building shell energy efficiency and Japanese knowledge of and technology for BEMS/HEMS and Smart Cities could provide even better energy performance in both countries, and opportunities for implementation in other countries too. The GJETC has already contributed to this exchange through a working group paper published in 2020 (Rauschen, M. et al. 2020).

Another potential topic regarding building sector decarbonization for an innovation roundtable has been "Cost-efficient Refurbishment in Building Stock with Serial Components". It could combine German building design and envelope technologies with Japanese experiences in serial and prefabricated housing.

Energy market design

In this GJETC-study, investments in flexibility were identified as relevant in both countries to 1) reduce the pressure and costs of further grid expansion, 2) support the expansion of renewables by 3) improving their integration into the markets, and 4) minimizing the overall system cost. The central difference in the market design between both countries is that Japan has implemented a capacity market while Germany, as an EU Member State, works with an 'energy only market' (EOM) until now. Following the identification of similarities and differences in the existing market design, six reform options to directly or indirectly stimulate investments in flexibility resources were analyzed in more detail (Figure 1).

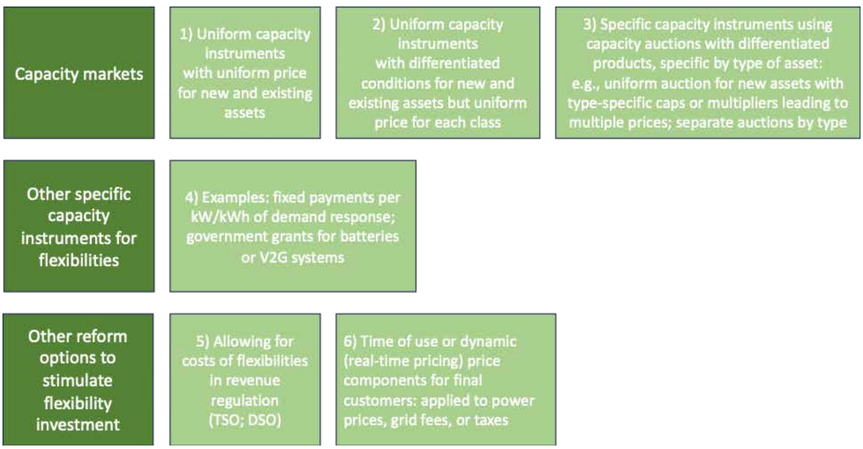

Figure 1: Types of reform options selected for detailed analysis

Germany now wants to develop a capacity market mostly for new assets by 2028. The country may take a closer look at the Long-term Decarbonized Power Source Auctions in Japan to see if something can be learned for the design of the new German capacity market, e.g., regarding the cap on revenues from other power markets. Japan may learn from Germany's experiences in the implementation of dynamic pricing and/or other instruments to stimulate the use of distributed storage like battery electric vehicles and heat pumps, in case there will be a need and a potential for their deployment in the long term, as the share of renewable energy sources in power generation is increasing.

Certification of clean hydrogen

Both Japan and Germany are aiming to become major importers of clean hydrogen, to replace fossil fuels they have relied on. A challenge to the international trade of hydrogen is the lack of an agreed definition for 'clean hydrogen'. It would be useful for the two countries to work together for an international standard. In its studies on clean hydrogen and the 2020 GJETC report, the GJETC has analyzed the technical feasibility of a standard that may enable the use of both 'green' hydrogen from electrolysis using 'green' electricity, and of 'blue' hydrogen from fossil fuels using CCUS, which is expected to be less expensive during a transition period. The GJETC recommended exploring technical, safety, and environmental/sustainability standards and certification for green and blue hydrogen as soon as possible to define 'clean' hydrogen in a transparent and comparable way.

The GJETC suggested that credible contribution by clean hydrogen to climate change mitigation would be desirable to enhance its acceptance by the public, if it could achieve at least a 50% GHG emissions reduction compared to natural gas—the fossil fuel with the lowest GHG emissions—in a 'well-to-tank' analysis. The analysis in the GJETC's study on hydrogen suggests that such a 50% reduction, which would require specific well-to-tank emissions of below approx. 33 gCO_{2eq} / MJ_{H2}, could be achievable using blue hydrogen in the cases analyzed. This may allow a maximum universal threshold level of specific GHG emissions for internationally traded hydrogen until the border gate of e.g. 30 gCO_{2eq} / MJ_{H2}, allowing approx. 3 gCO_{2eq} / MJ_{H2} for national hydrogen distribution from border gate to tank. The EU threshold value of 28.2 gCO_{2eq}/ MJ_{H2} for hydrogen to be considered 'renewable' is quite close to the value suggested by the GJETC, which demonstrates the quality and relevance of the GJETC's analysis.

6. Scenario comparison of net zero strategies up to 2025/2050[7]

In 2021, the GJETC conducted a study to identify and compare representative climate neutrality scenarios for Germany (by 2045) and Japan (2050). Up to now a lot of new scenarios were published. Nevertheless, the basic results and methodology of the following scenario comparison (base year 2021 / 2022) are still valid. Thus, the strategic policy implications and the strengths and weaknesses of scenario methodology as a foundation for policy making did not change fundamentally. Here are some results of the GJETC's study.

6.1 Japan

In 2020, the primary energy supply from fossil fuels accounted for 85%. All scenarios show the primary energy supply from fossil fuels in 2050 can be significantly reduced because of cost optimization and the partly strong use of CCS when carbon neutrality is assumed in back-casting models. Instead of fossil fuels, renewable energy, hydrogen, ammonia, and nuclear are assumed to fill the gap for securing the primary energy supply.

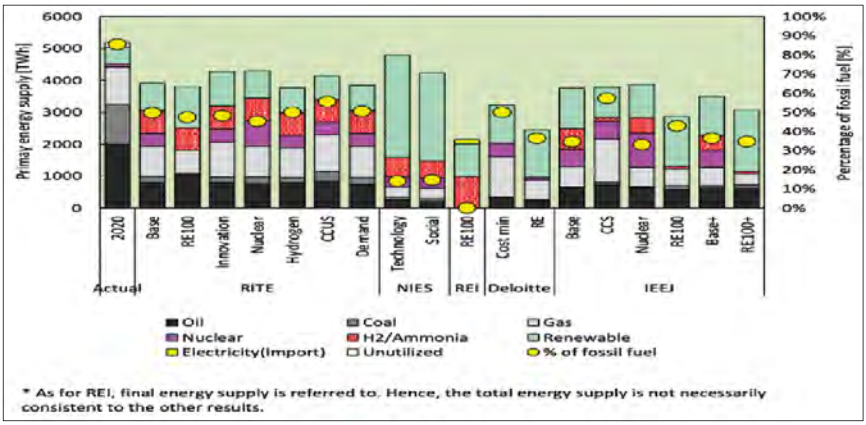

Figure 2: Primary energy projected by 2050 representing a bandwidth of Scenarios for Japan

7 For details, the selections criteria and specific assumptions of the scenarios please see Obane et al. (2022)

The scenarios that assume a strong utilization of CSS would make it possible to tolerate a higher remaining percentage of fossil fuels in 2050. The most ambitious scenario of the Renewable Institute (REI) in contrast shows (here in terms of final energy) a net zero and nuclear phase out path, using efficiency, renewables and hydrogen as key strategies.

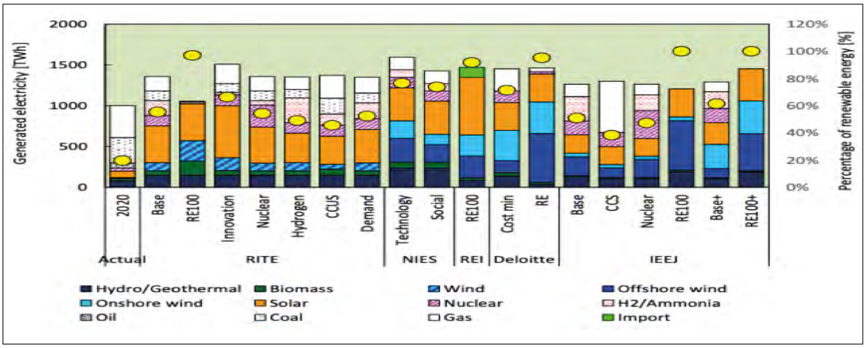

Figure 3: Representative projections of generated electricity in Japan in 2050 (TWh)

The low bandwidth of different projections of generated electricity and the relatively moderate increase up to 2050, are remarkable in comparison to Germany or USA. Interesting also: Five scenarios end up by nearly 100% renewable electricity in 2050.

6.2 Germany

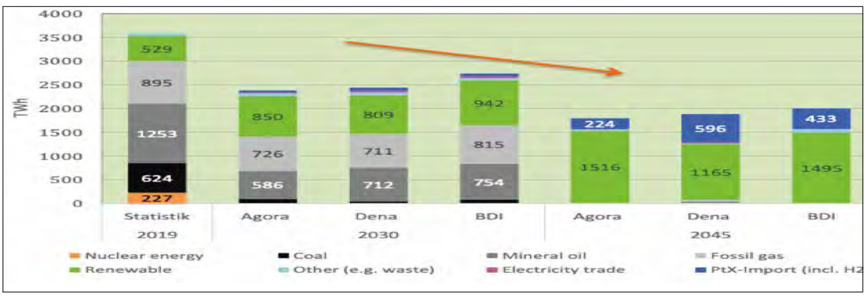

Figure 4: Primary energy consumption

As shown by the following Figure 5, an ambitious reduction of the energy demand through efficiency measures and renewables in all sectors are considered to be the priority pillar to reduce the GHG emissions and to secure the energy supply through the extensive use of renewable energy in all German scenarios; especially in the building and the transport sectors, efficiency increases by renovation, use of heat pumps and all-electric vehicles are assumed.

In comparison to Japan especially the broad range of estimates and the strong increase of electricity by 2045 are interesting in the following Figure.

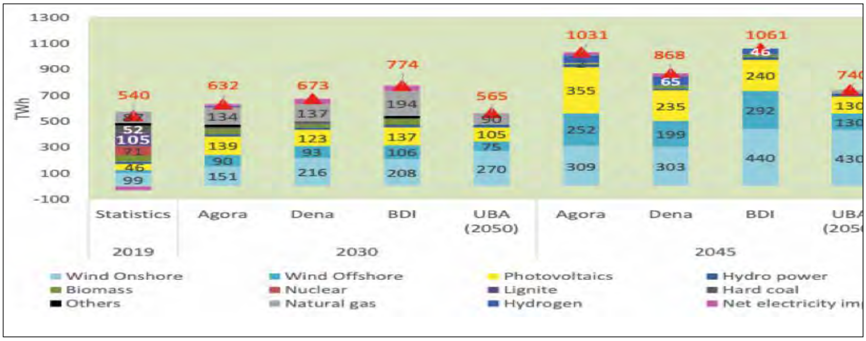

Figure 5: Net Power generation by fuel plus power imports (by pumped hydro and batteries) in Germany (in TWh)

The decarbonization of the industry, the energy and the transport sector in Germany depend on an increasing use of hydrogen and PtX. Hydrogen will be used for 5 to 10 per cent of power generation (e.g., during 'dark doldrums'). PtX will be especially used in international shipping and air traffic, thus reaching a significant importance in 2045. Only the UBA GreenSupreme scenario considers hydrogen to be fully produced domestically by 2045.

6.3 Japanese-German comparison

The selected scenarios in both countries follow a back-casting approach,[8] seek to reach economic solutions with a focus on cost efficiency and are assuming country-specific framework conditions. Identified common strategies to reach climate neutrality are the reduction of energy demand through improved energy efficiency, the shift in the energy mix towards climate neutral energy carriers,

8 As the national targets for net zero are decided by 2045 (Germany) and 2050 (Japan) the scenario methodology takes these years as a starting point and calculates "back", what has to be done up from today to reach the target.

the electrification of energy end uses, and the compensation of residual GHG emissions through technical sinks. However, supply technologies, strategic characteristics and targeted shares differ enormously.

In contrast to Japan, in Germany, improving energy efficiency is—theoretically—a key point to reduce CO_2. The final energy demand in most scenarios decreases from 2,484 TWh to a range of 1,604 to 1,572 TWh, whereas for the UBA scenario that has a special focus on *energy efficiency and sufficiency*, it even reaches a decrease of 57% (down to 1,056 TWh in 2050). All German scenarios project 100 % renewables in 2045.

Concerning the primary energy mix, the Japanese scenarios differ strongly. The share of fossil energy decreases from 85% (2020) to 0-10% (REI, NIES) or 40-50% (RITE, IEEJ scenarios with CCS) in 2050. The share of renewable energies in the generated electricity mix rises from 20% in 2020 to 100% (REI) or 40-70% for the other scenarios. But following the perspective of IEEJ the installation of renewable energies is limited because of land use restrictions (e.g. on areas as forests or farmland). In contrast to Germany, nuclear energy is also considered as a supporting electricity generation source towards climate neutrality by most scenarios.

6.4 Shortcomings and critical dialogue

The basic availability of less risky climate protection technologies to achieve climate neutrality by 2045 is no longer in question in any scenario in Germany. Instead, the scientific discussion[9] focuses on fundamental questions about the socio-economic implications and the costs of the strategies as well as on the tension between scenarios, levels of ambition and the gaps of policy implementation. In contrast in Japan, it seems to be, that the cost effective, feasible and most suitable technology mix for net zero (2050) is still under discussion; unfortunately, the pros and cons according to the more ambitious targets and analysis done by REI 2024 does not show up in a public debate (Renewable Energy Institute, 2024).

9 Nevertheless, the apparent consensus building between research institutes has not reached the political arena. See for example (Grisard, 2024).

But a more integrated, systemic and socio-economic approach of the Energiewende is *missing in both countries*.

The selected German and Japanese scenarios are strongly focused on energy-related strategies and the associated *technical* feasibility of decarbonization. A special focus is on the electricity market and on the differentiated analysis of a renewable electricity supply. This is undoubtedly a crucial pillar of ambitious climate protection policy, but the essential socio-economic and behavioral aspects (e.g. rebound and growth effects or the opposite, sufficiency and more sustainable consumption patterns) of an energy transition are not touched upon at all or only marginally in all scenarios, except for the UBA study.

Energy efficiency plays an important theoretical role in all scenarios to reduce the overall demand. But nevertheless, in most scenarios, the existing cost-effective potentials, particularly in the transportation and building sectors, but also in the industry sector, are not fully exploited. Hence, the principle of 'energy efficiency first' (IEA) is not fully considered (see below). Only the GreenSupreme scenario of the UBA takes a larger potential and options of sufficiency policy into consideration.

While technical feasibility is a crucial prerequisite of transformative paths to decarbonization, economic optimization and societal acceptance of possible pathways are at least also important. However, in the selected studies, the simulation of macroeconomic effects like changes in energy costs and impacts on competitiveness are missing. Regarding social acceptance, distributional effects for households, companies and regions, these questions deserve closer attention.

While the importance of including significant amounts of hydrogen and hydrogen-based synthetic fuels is common ground among the studies, only little is said about the challenges that come along with it: Neither do the scenarios present detailed concepts of the necessary infrastructure (e.g. in combination with the reduction of natural gas), nor do they thoroughly discuss possible target conflicts concerning domestic and imported hydrogen (e.g. perspectives of exporting countries/global competition/international standards for certifying green hydrogen/synfuels).

All scenarios fail to explicitly discuss whether the ambition level and the strategies they provide suffice to achieve the internationally agreed 1.5 °C target.

As a preliminary study of Wuppertal Institute showed, Germany would have to reach climate-neutrality as early as 2035, because the remaining CO_2 budget of 4,200 tons would have been consumed by then.[10]

Finally, a general shortcoming of the current long-term perspectives—the deficits in acknowledging the geopolitical embeddedness of the energy transition in both countries—will be taken up in the next chapters.

The export-to-GDP ratios of Germany are 47.0 and Japan 18.5 respectively (USA: 10.1, China 19.5).[11] The corresponding import-to-GDP ratios are 41.3% for Germany and 17.5% for Japan (USA: 14.6%; China: 18.0%). Additionally, the reliance on imported energy is very high in Japan (97% in 2022) and high in Germany (66.5%). Thus, there is a growing interest to put the many bilateral study results and recommendations of the GJETC into an explicit geopolitical context.

7. Geopolitical perspectives and implications for Japan and Germany

As leading industrial nations, Germany's and Japan's national energy strategies are on the one hand directly embedded in the geopolitics of the global energy transition, but on the other hand they can jointly intervene with international initiatives, for example within the framework of the G7.[12]

An interesting example is the joint support for the G7 Climate Club. The concept of a Climate Club was prominently featured during Germany's G7 presidency in 2022 (Federal Ministry for Economic Affairs and Climate Action, 2022). The initiative aimed to create an open, cooperative international forum dedicated to accelerating climate action and achieving climate neutrality. The G7 leaders agreed to establish this Climate Club to enhance ambitious and transparent climate change mitigation policies. Japan holding the G7 presidency in 2023, continued to support and promote the

10 Wuppertal Institut, 2020

11 Compare (Imports of Goods and Services (% of GDP) | Data, n.d.)

12 The Group of Seven (G7) is an informal forum of leading industrialized nations and democracies. Its members are Germany, Canada, France, Italy, Japan, the UK and the United States of America. The European Union is also represented at all G7 meetings.

Climate Club's objectives. The G7 Climate Club currently (Nov. 2024) has 43 members.

Geopolitically, the German energy transition is embedded into the framework of European energy and climate policy. There is a wealth of literature on this subject, which can only be referred to here.[13] Additionally to the close integration into the European context a perceived transatlantic energy and climate policy consensus with the Joe Biden administration[14] existed—before Donald Trump took office a second time in 2025. The times they are changing now.

Nevertheless, due to the island status, the geopolitical embeddedness of Japan's energy transition in the Asian region seems to be even more complicated. Up to now, the GTETC did not analyze this topic in detail, but Wuppertal Institute and ECOS started a cooperation with the Japanese Economic Foundation (JEF) on this issue.[15]

As a recent publication of the German Institute for International Politics and Security (SWP) has pointed out this geostrategic topic should be taken up more intensively: "Greater Asia is developing into a center of the global energy transition. This is characterized by a growing independence from external actors such as the EU and the USA, while dynamics and networking are increasingly taking place within the region. What is emerging here are, for example, tendencies towards the monopolization of critical raw materials, new alliances based on growing interdependencies along value chains and a trend towards innovative technologies such as small modular nuclear reactors. … To remain relevant and capable of action in Asia, Germany and the EU should align their engagement there more constructively." (Gehrung et al., n.d., without page).

13 See for example, (European Commission, n.d.)

14 In reality there always existed different interests e.g. on shale gas, on nuclear, on drilling, on the role of free competition and financing of industrial policies (IRA).

15 See (Japan Economic Foundation, n.d.-a); Masakazu Toyoda, the current CEO of the JEF, has been the Japanese Co-Chair of the GJETC until 2021; on September, 16th the Japan-Europe Forum on "The development of geopolitical developments on energy security, environment, supply chains and green transformation" was organized at the Wuppertal Institut with the support of ECOS together with a Japanese Delegation of the JEF under the leadership of Masakazu Toyoda (Japan Economic Foundation, n.d.-b).

The activities of China, as a mayor global player for fostering competitive PV, wind power and e-mobility etc. and with a tendency to monopolize critical raw materials should be an important signal for intensified joint German-Japanese initiatives to protect common interest. Also, a future intensified collaboration between Japan and Russia is not out of reach, as the SWP article argues. For example, LNG-imports from Russia or—in the long run—even power exchange via high voltage submarine cables (see for example Renewable Energy Institute 2018) could be of mutual interest of Japan and Russia and might have an influence on geopolitical alliances. The developments in China (in Asia) and USA (concerning the transatlantic axis) are important external forces for driving or breaking the Energiewende in Japan and Germany and competitive economics, energy security and just transition will be decisive success factors.

Thus the following SWP argument for more economically focused collaboration between Japan and Germany underlines the future basics of the scientific work of the GJETC as well: "Instead of simply pushing forward transformative narratives, it is particularly important in terms of climate foreign policy to focus on the opportunities offered by the energy transition, i.e. the prospects for security of supply, cost advantages and the creation of local jobs. Raising awareness is needed here, but also improved access to finance. Otherwise, approaches that declare renewable energies to be a stability factor will quickly fail due to high capital costs in politically fragile contexts. Stability and economic growth are not just results of the energy transition, but at least as much prerequisites for its success." (Ibid., p. 8).

7.1 The global megatrend of electrification

With that global context, interesting topics concerning the future work of the GJETC are involved. Especially the global megatrend to decarbonized electrification has deep strategic-scale implications, not only for the USA and China, but especially for Japan and Germany. Referring to a recent publication of CSIS (see McGeady, 2024) for the USA, the following statement holds true for Germany and Japan as well: "There is strong evidence that a confluence of three trends—the reshoring of industry, AI-driven database expansion, and broad-based electrification-will drive a sustained era of electricity demand growth…" (Ibid., no page). There are strong arguments why the (global) *political economics of electrification* is of special interest for the scientific knowledge exchange between Japan and Germany.

The following Figure of an estimated *strong electricity demand growth* in the USA for the coming decade might be driven by country specific factors. But the strong upward trend of electricity demand and the driving technology fields and markets behind it which are shown in Figure 6 are important for Germany's and Japan's climate mitigation strategies in the future as well; especially, when green hydrogen (based on electrolysis powered by renewable electricity) is included as an additional driver of electricity demand growth.

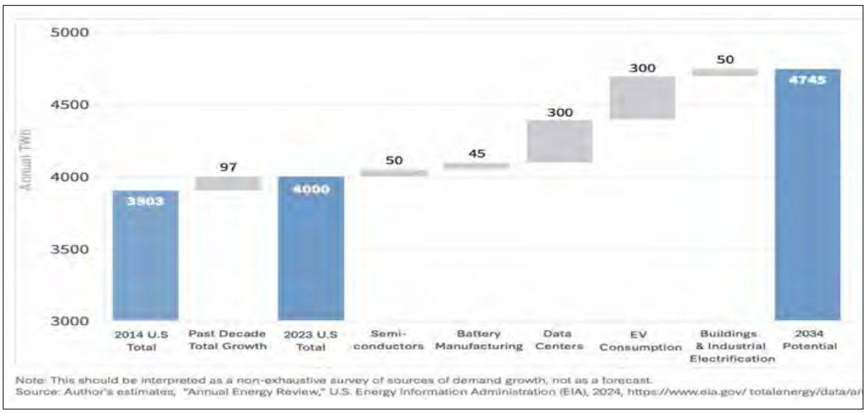

Figure 6: Key Sources of Electricity Demand Growth in the USA

Note: Adapted from McGeady (2024)

The perspective of a strong Hydrogen Economy, powered by domestic and imported hydrogen is a priority strategy of Japan since 2023. But the share how much hydrogen will be produced a) by electrolysis powered by green electricity like in the Fukushima Hydrogen Energy Research Field (FH2R) or by nuclear energy/ pink hydrogen (*Toward an Eco-Friendly Future*, 2024) or b) imported blue hydrogen from fossil fuels (in combination with CCS) is unclear.

7.2 Differences of electric power projections in Japan and Germany

But this alone does not explain the striking differences between electricity demand projections for Germany and Japan respectively. As for the USA also in Germany a broad range of estimates for electricity demand in the future are projected. This demonstrates that there is still much uncertainty how far electrification will go. But the strong average upward trend in Germany as well as in the USA is not debated.

In contrast Japan's latest Strategic Energy Plan anticipates only an 12-22% increase in electricity by 2040 compared to 2023 attributed (like in the USA) to e.g. the expansion of semiconductor manufacturing and data centers driven by digitalization (Obayashi et al., 2024). In contrast to this electricity demand projections the latest study of Agora-Energiewende "Climate-neutral Germany" states for Germany: "Electricity demand increases from 553 terawatt hours (TWh) in 2023 to 1.280 TWh by 2045." (Agora Think Tanks, 2024, p. 4).

Thus, we summarize: While in Germany there might be an overestimation of the future growth of electricity, driven by overoptimistic projections due to the impressive decrease of the generation costs[16] of PV and wind power; whereas in Japan, an underestimation[17] might be possible because the megatrend of electrification and the driving forces behind it are not fully included in the analysis of industrial structural change. From the perspective of the GJETC, it is advisable to dig deeper into the reasons for the strong differences of the electricity growth projections in USA, Japan and Germany.

This topic is highly correlated with demand reduction policies (efficiency and sufficiency) as well as with the priorities of industrial and innovation policies. One simple explanation might be also the different perspectives of population growth due to different patterns of migration and aging society. But different priorities of industrial policies and structural industrial change or path dependencies (e.g. on nuclear and CCS in Japan; see below) might be also relevant.

16 See the remark to the system integration internal and external costs below

17 Some sources underline this thesis, e.g. (Shiraishi et al., n.d.).

7.3 Diverging electricity mixes of Japan and Germany

Up to now the apparent differences of the future electricity mix in Japan and Germany has been debated with priority and in detail within the GJETC. The latest projection in the study "Climate-neutral Germany" calculates by 2030 almost 80% generation from renewables, coal phase-out and decarbonization of district heating and by 2045 "…100% electricity generation from renewables, replacement of natural gas with hydrogen and synfuels, flexibility, CO_2-free district heating"… (Ibid., p. 6). Consequently, within the scenario-based perspectives for Germany a very strong growth of green electrification is the main driver to net zero in 2045. Thus after the complete phase out of nuclear 2022/2023 and coal (if possible 2030) Germany would be on the way toward a risk-minimizing, fully decarbonized power sector.

According to a draft of its revised Basic Energy Plan Japan the Japanese Government wants to increase the share of renewable electricity up to 50% by 2040 and nuclear energy up to 20% (compared to 8.5% in 2023) (Obayashi & Golubkova, 2024). This renewables increase would mean a roughly doubling of the 22.9% share in 2023 exceeding the current 2030 target (36-38%). The share of power from inefficient coal-fired power plants would be decreased to between 30-40% compared to 68.6% in 2023. Nevertheless, no road map for the complete phase out of coal power was announced and also the small target share, between 4 to 8%, for wind power in comparison to 20% for nuclear, was criticized e.g. by the Renewable Institute. Instead it was observed: "The new energy plan removes the previous target of "reducing reliance on nuclear power as much as possible" and includes plans to build innovative next-generation reactors at nuclear power sites owned by operators who have decided to decommission existing reactors." (Reuters 2024, ibid., no page). As a recent paper (Hennicke et al., 2024) has shown, a forced parallel expansion of (fluctuating) green, often decentralized electricity and huge, centralized base load nuclear power-plants, connected with a highly complex and cost intensive nuclear infrastructure system, implies many contradictions and challenges concerning cost-effectiveness, flexible security of supply, public acceptance and incompatibilities with a Circular Well-Being Society.

7.4 Upcoming energy and climate topics

Apparently, the future role of nuclear is a main point of current differences by comparing the energy and climate policies in Japan and Germany. By analyzing strengths and weaknesses in both countries and focusing on joint solutions the GJETC has excluded conflicting views on nuclear after a phase of intensive discussion in the 1st phase of our cooperation. This might change in the future.[18] But today it looks more promising to intensify the dialogue on the many questions how the major percentage, 80%[19] of the future electricity mix, can be generated securely, cost-effectively and fully decarbonized in Japan and how advanced German experience of managing a share of about 60% fluctuating renewable based electricity can contribute to find joint answers e.g. on electricity market design, flexibility options and actor constellations.

With that background and looking forward to hopefully further intensified cooperation phases and the urgency in both countries of more ambitious implementation decisions to net zero, the following research topics might be helpful from our perspective.[20]

Implement the "Energy First" principle

Whatever the reasons might be behind the striking difference of the strong growth projection of electricity consumption in Germany (and in USA) and the moderate projections in Japan, one point is of common interest: the more additional electricity growth in the future can be avoided the better for reducing electricity bills, for international competitiveness, for risk-minimization and for public

18 Today it is an open question how the perception of the role of nuclear will develop In the future in Japan. If a decision on building a new nuclear power plant comes on the agenda, it might be helpful to conduct under the leadership of GJETC an international cost and risk assessment of existing and future generations of nuclear power plants including SMR.

19 Referring to the latest draft of the new strategic energy plan it seems to be an ambitious target to raise at the same time the share of nuclear from today 8% to 20% and the share of renewable electricity from today 22.3% (2023) 50% in 2040, leaving open the question what concrete options are planned to close the apparent gap of 30%.

20 Note that this is the perspective of the German partners (WI and ECOS) of the GJETC with suggestions which have been partly proposed to the Japanese partners but not decided yet.

acceptance. 130 countries, including Germany and Japan, made a prominent and solemn commitment at the "Conference of the Parties" (COP28 in Dubai 2023): "With the endorsement of 130 national governments (as of 11 December, including the European Union (EU)), the pledge stipulates that signatories commit to work together to triple the world's installed renewable energy generation capacity to at least 11,000 GW by 2030 and to collectively double the global average annual rate of energy efficiency improvements from around two per cent to over four per cent every year until 2030." (UNFCC, n.d.).

Thus the worldwide message was quite clear: The less energy is wasted, the faster, more cost-effective, more environmentally friendly and more socially acceptable a 100% supply with renewables can be achieved.

However, studies for Germany show that there has been a notorious implementation gap compared to the official energy saving targets for years: "If all measures planned by the government coalition are implemented, a decline in final energy consumption (EEC) of around 16% compared to 2008 is to be expected in 2030… . This would mean that the target of the (German) Energy Efficiency Act of a 26.5% decline in EEC by 2030 would be clearly missed."(Federal Environment Agency, 2024). We are not aware whether a comparable monitoring process in Japan exist. But the scenarios demonstrate that huge efficiency potentials up to 2050 exist in Japan as well. In terms of energy intensity, the current value for Germany is approximately 0.09toe/1000$ of GDP and for Japan 0.11toe/1000$of GDP (Enerdata, n.d.).

As we have shown, care must be taken especially concerning the megatrend electrification and to ensure that the inevitable increases in electricity consumption due to additional applications is kept as low as possible by saving electricity, adopting sufficient lifestyles and using electricity efficiently. If this is not followed, the use of space and materials, the impact on the landscape, the expansion of the grid, the storage requirements and the acceptance issues may grow into a severe or even prohibitive obstacle to transformation.

The EU (see Articles 3 and 27 of the EED) and the global COP28 commitment mentioned above therefore attach particular importance to actually placing the principle of "Energy Efficiency First" or "Energy Efficiency First Fuel" "… at the center of policy-making, planning and important investment decisions". (see above).

Behind this list of "policy-making, planning, important investment decisions" lies a fundamental paradigm shift concerning the economic decision-making logic: As long as avoiding energy and resource consumption through efficiency or sufficiency strategies is more cost-effective than investing in new energy and resource supplies, the decision should be made in favor of "Energy Efficiency First". When planning power plants and grid expansion in the energy sector, consistent application of this planning and decision-making criterion would not only theoretically create a fairer "level playing field" for providers on the supply and demand side of energy markets. In practical terms as well, the construction of new energy infrastructure would be limited and numerous new Megawatts of power plant, grid and storage capacities could be avoided.

We foresee a huge field of cooperation for the GJETC to work together on the concretization of the "Energy Efficiency"-Principle in Japan and German. By making it operational a basic recommendation of the GJETC Annual Report 2018 could be taken up: "The GJETC recommends that both countries enhance the process and control responsibilities for the realization of their energy saving targets/goals through energy efficiency and energy sufficiency policies. Corresponding institutional innovations at the national and decentralized level should be identified. For example, if applicable, a country might consider establishing a strong National Energy Efficiency Agency and Energy Savings Fund that is integrated into the institutional setting and policy-making process, with a clear mandate for such policy and process responsibility to achieve energy saving targets"(Wuppertal Institut & Institute of Energy Economics, Japan, 2018).

Renewable energies: Balance the degression of production cost and increasing system integration costs

The amazing global cost reduction of PV and wind power induced by the German "Renewable Energy Sources Act" ("Energieeinspeisegesetz")[21] is probably the success story with the largest glob-

21 LCOE for PV down to 4.1-14.4 € cts/kWh, see (Bellini, 2024) and for onshore windpower down to 4.3-6.9 € cts/kWh in 2024 (Kost, 2024)

al impact due to introducing "feed-in laws" in nearly 100 countries, also in Japan. The GJETC discussed why the LCOE for PV and wind power in Japan are still higher than in Germany or other comparable industrialized countries. A high-level Japanese expert of the GJETC stated in an internal meeting: If Japan can reach comparable cost levels for PV and wind power this might make nuclear energy avoidable in Japan as well. Thus, joint work on the topic how this rapprochement can be achieved remains an important issue. While further learning effects for production cost reductions are important, the cost increase of system integration of a rising share of fluctuating PV and wind power should also be anticipated carefully and cushioned as much as possible.[22]

The most effective strategy against rising energy *prices* for end users is reducing the increase of electricity consumption by energy conservation and sufficiency policies, which will reduce energy *costs and thus the energy bills for the customers*. Thus, the electricity price developments for consumers and industry on the path to net zero remains a key issue of analysis for German-Japanese energy cooperation. For example, even today only the network charges (including transmission, distribution, and metering services) for German households averaged 9.35 € cts/kWh in 2023,[23] with rising tendency. But looking to the total system integration costs per kWh of a 100% share of renewable electricity (including e.g. guaranteed security of supply in all conditions of dark doldrums) will be probably much higher. Accordingly, further research is needed also within the GJETC.

Combine the technical pillars of efficiency and consistency (renewables) with the third societal pillar sufficiency (lifestyle changes)

The mutual scientific knowledge exchange of the GJETC is focused on the two main technical pillars, efficiency and consistency (re-

22 For Germany rising investments costs and cost per kilowatt-hour have been calculated by the "Fortschrittsmonitor 2024"; (EY, 2024) but also studies on the development of the total system costs, estimates on integration costs and of the costs of flexibility options like batteries, CHP or demand side management (DSM; see Agora Energiewende, 2015; Agora Energiewende, 2020 and IEA, 2024.

23 As the article mentions introducing real-time electricity tariffs might be an option as well e.g. (Häseler & Wulf, 2024

newables). But combining it with sufficiency policies, the third pillar of a social and economic sustainable transformation to net zero, should be taken more seriously. Because there is growing evidence that ambitious mitigation targets ("leaving 1.5 degrees within reach") are only feasible by including sufficiency policies as an intensifying and socially accepted strategy.[24] To ensure a comprehensive analysis of the pathway towards climate-neutrality, socio-economic aspects need to be considered. This includes values, change-management, innovation and exnovation strategies. Most important societal topics of socio-economic transformation (e.g. behavior shifts, societal tipping points, mobility patterns, floor space, living comfort, eating habits, reducing meat/dairy products, food waste, etc.) sometimes cannot easily be included into existing modeling approaches. The risk that a scenario-based "proof" of the technical feasibility leads to wishful thinking and unrealistic target-setting should be avoided. For example, rebound effects, the inertia of lifestyles, or growth effects are a reality, and they should be anticipated into scenario assumptions and procedures so that policies can be developed how to cushion rebounds as much as possible.

Integration of climate mitigation policies with circular economy (CE) strategies

The synergies and co-benefits between the combination and simultaneous implementation of interlinked turnarounds (e.g. concerning energy, resources, equity, poverty, nutrition) are a very promising field of cooperation between Germany and Japan.

As has been mentioned in 2022 the Club of Rome (CoR) published the book Earth for All[25] and Wuppertal Institute in cooperation with the CoR transferred the concepts to Germany. One interlinkage of this study seems to be especially interesting for advanced scientific cooperation topic between Germany and Japan: There is evidence that combining climate mitigation policies

24 See (Hennicke, 2025) which includes existing international literature on the power of sufficiency policies e.g. referring to IEA, to the IPCC and summarizing the status of relevant work on scenarios.

25 See footnote 2

with strategies of a Circular Economy (e.g. harvesting the economic, social and ecological benefits of a simultaneous resource and energy turnaround) makes it easier to "keep 1.5 degrees within reach" (Pauliuk et al., 2021).

The integration of circular economy strategies into climate protection policies unfolds significant synergies related to material and energy efficiency: Including the use of raw materials into the scenario analysis would also help to avoid problem shifting to critical metals and unsustainable extraction facilities. Every kilowatt hour avoided through energy and material efficiency would facilitate the expansion of renewable energy generation and particularly help to reduce implementation problems (e.g. space requirements, network expansion, resource consumption, import requirements, acceptance).[26]

"Just transition" and citizen participation

The socio-economic transformation and enormous economic structural change on the way to carbon neutrality makes it imperative to anticipate possible detrimental or supporting distribution and welfare effects. For example, carbon pricing will have a regressive impact on households and can induce carbon-leakage of companies under international competitive pressure if not supported by compensation measures. Also, wind power and huge ground-mounted PV might face strong local opposition. But refunding a part of the revenues from carbon pricing, citizens participation, financing and local benefit sharing can increase public acceptance for the transformation. Thus, just transition should be a basic focus of scenario-related analysis, and it should be directly included into scenario assumptions and strategies, especially on sectors and regions

26 A so called global "Societal Transformation Scenario (STS)" has been published in 2020: "The … results for the STS show a large decline in energy demand in the Global North and a reduction of global GHG emissions of roughly 50% from 2020 to 2030 and a further 22% (12.7 Gt CO2eq) by 2050. The cumulative CO2 emissions remain within the carbon budget that gives us a 2/3 chance to staying within the temperature increase of 1.5° C." (p. 10). The assumed redistribution of wealth, power consumption and production might be utopian but it presents food for thought to analyze opportunities and risks of including sufficiency policies into technically focused scenarios (Kuhnhenn et al., n.d.). For Europe a consortium under the lead of the French think tank Negawatt published recently a sufficiency Scenario for Europe; (Clever, 2024).

which are focal points of structural change. Thus, macro-economic analyzes are of utmost importance, but they should be combined with calculating net effects, e.g., for jobs, added value, income and budgets referring to regional hotspots of economic structural change. This is our understanding of the above quoted statement that the real socioeconomic effects of the energy transition should be given more attendance within German and Japanese research cooperation.

8. Outlook: Perspectives for a science-based dialogue

International scientific knowledge exchange which intends to have an impact[27] on both governments depends on trust, mutual respect, acknowledging different framework conditions and a frank openness to work together on solutions. An open-minded, critical, but constructive, evidence-based dialogue between Japanese and German researchers is not self-evident. It must be learned due to different cultural backgrounds and a deep reluctance to being perceived as unpolite or not diplomatic enough in "official" debates. But often, a too diplomatic communication is a barrier for the search of common solutions. In chapter 4 of the mentioned GJETC Report 2018 we did a first exercise, to mutually criticize the shortcomings of the energy and climate policy of our own countries as well as to encourage all members to take a critical view on the partner countries respectively. As this dialogue was not protected by Chatham House Rules but published it was a beginning and only partly a success.

There are different formats and levels for the German-Japanese Energy and Climate Dialogue. The most important one, the official "Japanese-German Energy Partnership" (*The Japanese-German Energy Partnership*, n.d.) works on the level of the governments: "In February 2020, the Japanese Ministry of Economy, Trade and Industry (METI) and the German Federal Ministry of Economy and Climate Action (BMWK) adopted a roadmap for their cooperation under

27 For example: As the Japanese Government decided on the binding 2050 net zero target the GJETC Japanese Co-Chair, Mazakazu Toyoda, was asked whether the analysis and the discussion of the GJETC did have any influence on this decision. His answer: "Certainly yes".

the Energy Partnership."[28] It is self-evident that the GJETC cooperates as close as possible with the Energy Partnership. The same holds true in relation to the "German-Japanese Environment and Energy Dialogue Forum"[29] which is organized by ECOS since 2012. The thematic mutual information and coordination of activities between these three initiatives is well established. The continuity, the synergies between political diplomatic and research focused fora, the broad outreach to different audiences and the different formats of discussions and recommendation reinforce each other.

The dialogue at the level of the official "Japanese-German Energy Partnership" is the basic framework e.g. for preparing and conducting high-level exchange of knowledge, for preparing joint international initiatives (e.g. concerning the G7 or G20), for funding policy, for joint pilot projects or research initiatives and for expanding partnerships with other countries. When it comes to the detailed scientific foundation, expanding the outreach of results to the research community or to the civil society or even to the concrete initiation of business cooperation, the work of the GJETC can contribute to significant synergies and possible acceleration effects. But the format of the GJETC can also contribute to overcoming intercultural barriers through continuity (including the concrete personal partners) and for the systematic built up of a trust basis.

The GJETC has encouraged mutual critical, but constructive, science-based dialogues between the German and Japanese experts and the networks behind the Council Members.[30] For example: Germany is criticized in Japan for the gap between overambitious target setting and reluctant implementation processes especially in the transport and building sector. Japan is criticized in the German expert community by overcautious target setting and missing strategic directional decisions ("Richtungsentscheidungen") e.g. in grid infrastructure and clear priority regulation for the priority grid feed-in of renewable electricity, thus causing lock-in effects through relying too long on nuclear and coal-fired power plants.

28 AHK, ibid.

29 See (ECOS, 2024); as the organization secretariat of the GJETC

30 This has been a successful exercise in chapter 4 of the first GJETC Report; see Wuppertal Institut & Institute of Energy Economics, Japan, 2018

Even such fundamental different perspectives can and should be taken up in a constructive science-based dialogue even when it does not end up in consensus recommendations. We are convinced that critical expert eyes from outside help to challenge shortsighted perspectives from inside.

References

About – GJETC. (n.d.). Retrieved January 27, 2025, from https://gjetc.org/about/

acatech, Circular Economy Intiative Deutschland, & SYSTEMIQ. (2021). Circular Economy Roadmap for Germany. *Acatech - National Academy of Science and Engineering.* https://en.acatech.de/publication/circular-economy-roadmap-for-germany/

Agora Energiewende. (2015). *The integration cost of wind and solar power.* https://www.agora-energiewende.org/publications/the-integration-cost-of-wind-and-solar-power

Agora Energiewende. (2020). *Minimizing the cost of integrating wind and solar power in Japan.* https://www.agora-energiewende.org/publications/minimizing-the-cost-of-integrating-wind-and-solar-power-in-japan

Agora Think Tanks. (2024). *Climate-neutral Germany. From target-setting to implementation.*

Barnes, A., & AP. (2024, February 15). *Germany now world's third largest economy as Japan loses its spot.* Euronews. https://www.euronews.com/business/2024/02/15/germany-now-worlds-third-largest-economy-as-japan-loses-its-spot

Bellini, E. (2024, October 7). *Germany has solar LCOE ranging from €0.041/kWh to €0.144/kWh.* Pv Magazine International. https://www.pv-magazine.com/2024/10/07/germany-has-solar-lcoe-ranging-from-e0-041-kwh-to-0-144-kwh/

Cahill, B., Nakano, J., & Kunro, I. (2024, May). *How Japan Thinks about Energy Security—CSIS Briefs.* CSIS. https://csis-website-prod.s3.amazonaws.com/s3fs-public/2024-05/240522_Cahill_Japan_Energy.pdf?VersionId=Pgy6VHMVGNDe8k4kLEro.HsBRoka.lKv

Clever. (2024). *The CLEVER scenario.* https://clever-energy-scenario.eu/#clever-major-publications

Country comparison: Germany / Japan. (n.d.). Worlddata.Info. Retrieved January 27, 2025, from https://www.worlddata.info/country-comparison.php?country1=DEU&country2=JPN

Country comparison Germany vs Japan. (n.d.). Countryeconomy.Com. Retrieved January 27, 2025, from https://countryeconomy.com/countries/compare/germany/japan?sc=XE34

DeStatis. (2024, September 4). *Stromerzeugung im 1. Halbjahr 2024: Mehr als 60 % aus erneuerbaren Energien.* Statistisches Bundesamt. https://www.destatis.de/DE/Presse/Pressemitteilungen/2024/09/PD24_334_43312.html

Dixson-Decleve, S., Gaffney, O., Ghosh, J., Randers, J., Rockstrom, J., & Stoknes, P. E. (2022). *Earth for All: A Survival Guide for Humanity*. New Society Publishers.

ECOS. (2024, January 25). *13th German-Japanese Environment and Energy Dialogue Forum—ECOS Consult (EN)*. https://www.ecos.eu/en/events/details_en/13th-german-japanese-environment-and-energy-dialogue-forum-2.html

Enerdata. (n.d.). *Energy intensity of GDP | Global Energy Intensity Data* | Enerdata. Energy Intensity. Retrieved January 27, 2025, from https://yearbook.enerdata.net/total-energy/world-energy-intensity-gdp-data.html

European Commission. (n.d.). *Update of the integrated national Energy and climate plan Draft*. https://commission.europa.eu/system/files/2023-11/GERMANY-%20DRAFT%20UPDATED%20NECP%202021-2030%20EN.pdf

EY. (2024). *Fortschrittsmonitor 2024*. https://www.bdew.de/media/original_images/2024/04/24/fortschrittsmonitor_2024_zCu1QX7.pdf

Farand, C. (2020, October 21). *Japan set to announce 2050 net zero emissions target—Report*. Climate Home News. https://www.climatechangenews.com/2020/10/21/japan-set-announce-2050-net-zero-emissions-target-report/

Federal Ministry for Economic Affairs and Climate Action. (2022, December 12). *G7 establishes Climate Club*. https://www.bmwk.de/Redaktion/EN/Pressemitteilungen/2022/12/20221212-g7-establishes-climate-club.html

Gehrung, R. M., Pepe, J. M., & Dawus, A. (2024, December 20). *Die Geopolitik der Energiewende im Großraum Asien*. Stiftung Wissenschaft und Politik (SWP). https://www.swp-berlin.org/publikation/die-geopolitik-der-energiewende-im-grossraum-asien

Grisard, M. (2024, December 18). *Energiepolitik von Union, SPD und Grünen: Zwischen Technologieoffenheit und Fortführung des eingeschlagenen Weges*. https://www.energiezukunft.eu/politik/zwischen-technologieoffenheit-und-fortfuehrung-des-eingeschlagenen-weges

Häseler, S., & Wulf, A. J. (2024). Promoting real-time electricity tariffs for more demand response from German households: A review of four policy options. *Energy, Sustainability and Society, 14*(1), 59. https://doi.org/10.1186/s13705-024-00490-z

Hennicke, P. (2025). *Klimagerecht*.

Hennicke, P., Röttger, A., Präger, F., & von Hirschhausen, C. (2024). *Das Atomstromsystem bremst die sozial-ökologische Transformation zur Dekarbonisierung – ein Impuls*. https://doi.org/10.5281/ZENODO.11406367

IEA. (2024). *Integrating Solar and Wind*.

Imports of goods and services (% of GDP) | Data. (n.d.). Retrieved January 27, 2025, from https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS

Japan Economic Foundation. (n.d.-a). *Japan Economic Foundation*. Retrieved January 29, 2025, from https://www.jef.or.jp/en/

Japan Economic Foundation. (n.d.-b). *Japan-Europe Forum: International Forum | Japan Economic Foundation*. Retrieved January 29, 2025, from https://www.jef.or.jp/en/forum/euforum/

Japan (JPN) and Germany (DEU) Trade. (n.d.). The Observatory of Economic Complexity. Retrieved January 27, 2025, from https://oec.world/en/profile/bilateral-country/jpn/partner/deu

Kost, C. (2024). *Study: Levelized Cost of Electricity - Renewable Energy Technologies - Fraunhofer ISE*. Fraunhofer Institute for Solar Energy Systems ISE. https://www.ise.fraunhofer.de/en/publications/studies/cost-of-electricity.html

Kuhnhenn, K., Costa, L., Mahnke, E., Schneider, L., & Lange, S. (n.d.). *A Societal Transformation Scenario for Staying Below 1.5 °C | Heinrich-Böll-Stiftung*. Retrieved January 27, 2025, from https://www.boell.de/de/2020/12/09/societal-transformation-scenario-staying-below-15degc

Matschoss, D. P., Kochems, J., Grashof, K., Guss, H., & Linuma, Y. (2017). *Study Program of the German-Japanes Energy Transition Council*. https://gjetc.org/wp-content/uploads/2022/07/GJETC_ST3_New-allocation-of-roles-and-business-segments-of-established-and-new-participants-in-the-energy-sector.pdf

McGeady, C. (2024). *Powering the Commanding Heights: The Strategic Context of Emergent U.S. Electricity Demand Growth*. CSIS. https://www.csis.org/analysis/powering-commanding-heights-strategic-context-emergent-us-electricity-demand-growth

Obane, H., Naomi, G., Lotte, N., Bunge, F., & Hennicke, P. (2022, March). *Key strategies towards Decarbonization of Energy Use and Supply in Japan and Germany: Insights from a Comparison Study on Long-term Scenario Analyses up to 2050.*

Obayashi, Y., & Golubkova, K. (2024, December 17). *Japan targets 40-50% power supply from renewables by 2040 | Reuters*. https://www.reuters.com/sustainability/climate-energy/japan-targets-40-50-power-supply-renewable-energy-by-2040-2024-12-17/

Obayashi, Y., Golubkova, K., & Obayashi, Y. (2024, December 17). Japan targets 40-50% power supply from renewables by 2040. *Reuters*. https://www.reuters.com/sustainability/climate-energy/japan-targets-40-50-power-supply-renewable-energy-by-2040-2024-12-17/

Pauliuk, S., Heeren, N., Berrill, P., Fishman, T., Nistad, A., Tu, Q., Wolfram, P., & Hertwich, E. G. (2021). Global scenarios of resource and emission savings from material efficiency in residential buildings and cars. *Nature Communications, 12*(1), 5097. https://doi.org/10.1038/s41467-021-25300-4

Renewable Energy Institute. (2018). *Asia International Grid Connection Study Group Second Report Summary.*

Renewable Energy Institute. (2024, December 20). *Comments from Renewable Energy Institute on the Government's Strategic Energy Plan Draft A Dangerous Path That Could Undermine Japan's Competitiveness Through Failed Decarbonization and Rising Costs A Call to Unlock the Full Potential of Energy Efficiency and Renewable Energy*. https://www.renewable-ei.org/en/activities/reports/20241220.php

Shiraishi, K., Park, W. Y., Abhyankar, N., Paliwal, U., Khanna, N., Morotomi, T., Lin, J., & Phadke, A. (n.d.). *PLUMMETING COSTS OF SOLAR, WIND, AND BATTERIES CAN ACCELERATE JAPAN'S CLEAN AND INDEPENDENT ELECTRICITY FUTURE.*

The Japanese-German Energy Partnership. (n.d.). AHK Japan. Retrieved January 27, 2025, from https://japan.ahk.de/en/topics/the-japanese-german-energy-partnership

Toyoda, M. (2017) https://eservice.nlb.gov.sg/flipviewer/data/booksg_publish/1/15656709-3147-415f-9b7d-f34bf89c1c14/web/html5/index.html?opf=tablet/BOOKSG.xml&launchlogo=tablet/BOOKSG_BrandingLogo_.png&pn=9

Toward an Eco-Friendly Future: The Case for "Pink" Hydrogen. (2024, October 3). Nippon. Com. https://www.nippon.com/en/in-depth/d01026/

UNFCC. (n.d.). *Summary of Global Climate Action at COP 28*. https://unfccc.int/sites/default/files/resource/Summary_GCA_COP28.pdf

Wuppertal Institut. (2020, October 13). *Studie: Wie Deutschland bis 2035 CO2-neutral werden kann*. https://wupperinst.org/a/wi/a/s/ad/5169

Wuppertal Institut, & Club of Rome. (2024). *Earth for All Deutschland: Aufbruch in eine Zukunft für Alle. Wie wir soziale Gerechtigkeit und Klimakrise überzeugend lösen und Wohlstand erhalten*. oekom.

Wuppertal Institut, & Institute of Energy Economics, Japan. (2018). *GJETC Report 2018: Intensified German-Japanese Cooperation in Energy Research*.

SZ, Zeitungsanzeige Süddeutsche Zeitung (1993) Nr.152

CV Peter Hennicke

Prof. Dr. Peter Hennicke is economist with a focus on energy transition, climate mitigation and resource efficiency in Germany and internationally. He was President of the Wuppertal Institute/Germany and he served in many high level German and international expert commissions, e.g. as a member of the Management Board of the European Environment Agency (Copenhagen). He is full member of the Club of Rome and he received the Environmental Award of Germany (2014) and the Gothenburg Award of Sweden (2016). 2019 he received the JSPS Alumni Club Award (JACA). In 2019, the Japanese Government awarded him the Order of the Rising Sun. His publications include 25 books and more than 200 articles. He is Principal Advisor of the German-Japanese Energy Transition Council (GJETC), which he co-founded in 2016. Currently, Prof. Hennicke cooperates on a project base with the Wuppertal Institut/Germany as Senior Advisor.