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The Institute of Energy Economics, Japan

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New Oil and Natural Gas Landscape under USMCA

-Energy Provisions and Implications for Oil and Gas Business in North America-

Daisuke Nakamori*

1. Introduction

The United State-Mexico-Canada Agreement (USMCA), which replaced the North American Free Trade (NAFTA), entered into force on July 1, 2020. Former U.S. president Donald Trump delivered his initial promise to renegotiate NAFTA during the presidential campaign. After two-year negotiations, for the first time in over twenty years, the North American economic activities would develop under the new rules. The launch announcement gathered attention on what Trump claimed to be critical, such as rules of origin for automotive goods and labor provisions. Most of the studies of USMCA focus on such provisions and rules on digital trade which represent modernization of NAFTA.[1] The new rules over the energy sector, meanwhile, were not in the spotlight despite the interesting change, that is, NAFTA's "Energy" Chapter (Chapter 6) disappeared from the USMCA.

The primary awareness of the Energy chapter dates back to the Cold War era. When faced with the oil crisis in the 1970s, the U.S. realized that its dependence on Middle Eastern oil was a major national risk. During the NAFTA negotiations, the U.S. pursued efforts to secure oil supply as its bipartisan priority. The major objective of the U.S., securing oil from Canada and Mexico, was, thus, clearly reflected in the energy-related provisions, notably the "energy proportionality clause" discussed later in detail (Clarkson & Mildenberger 2011).[2]

At the time of the USMCA negotiations, however, the three North American countries had experienced dramatic changes in their energy sectors: the U.S. shale revolution, Canada's oil sands development, and Mexico's constitutional reform.[3] Especially, the U.S. shale revolution did not only solve the long-term U.S energy security concerns by promoting oil self-sufficiency but also had multiple impacts on the world energy market.[4] As Fig. 1 and Fig. 2 show, U.S. net oil imports noticeably decreased since 2010. The U.S. has increased its export volumes to Canada and Mexico, indicating its new role as an oil exporter.[5]

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[1] 参議院調査情報担当室「USMCA（新 NAFTA）の注目点~米国と各国との間の貿易交渉を検証する一材料として~」, https://www.sangiin.go.jp/japanese/annai/chousa/keizai_prism/backnumber/h31pdf/201917802.pdf (Accessed November 24, 2021) and Center for Strategic and International Studies. "The Road to Ratification: The U.S. ITC's Economic Analysis of the USMCA" https://www.csis.org/analysis/road-ratification-us-itcs-economic-analysis-usmca (Accessed November 24, 2021).

[2] The U.S. energy security policy mainly targeted oil because the country had been more self-sufficient in coal and natural gas resources. Fig. 2 shows the U.S. energy trade flows with its North American neighbors in 2019. Crude oil and petroleum products are still the main products although natural gas had been more prominent in recent years.

[3] As of 2019, the U.S. and Canadian oil production roughly doubled compared to the early 1990s (Fig. 1). Mexico had long suffered declining oil production, but the constitutional reform in 2013 had attracted international attention to Mexico's unexplored resources.

[4] For details, see O'Sullivan (2017) and Yergin (2020).

[5] The share of U.S. oil in Canada's oil import grew from 10% to 80% over the last decade. For Mexico, see Section 3. Canada Energy Regulator. "Market Snapshot: Crude Oil Imports Decreased in 2020, and so Did the Cost." https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2021/market-snapshot-crude-oil-imports-decreased-in-2020-and-so-did-the-cost.html (Accessed November 24, 2021).

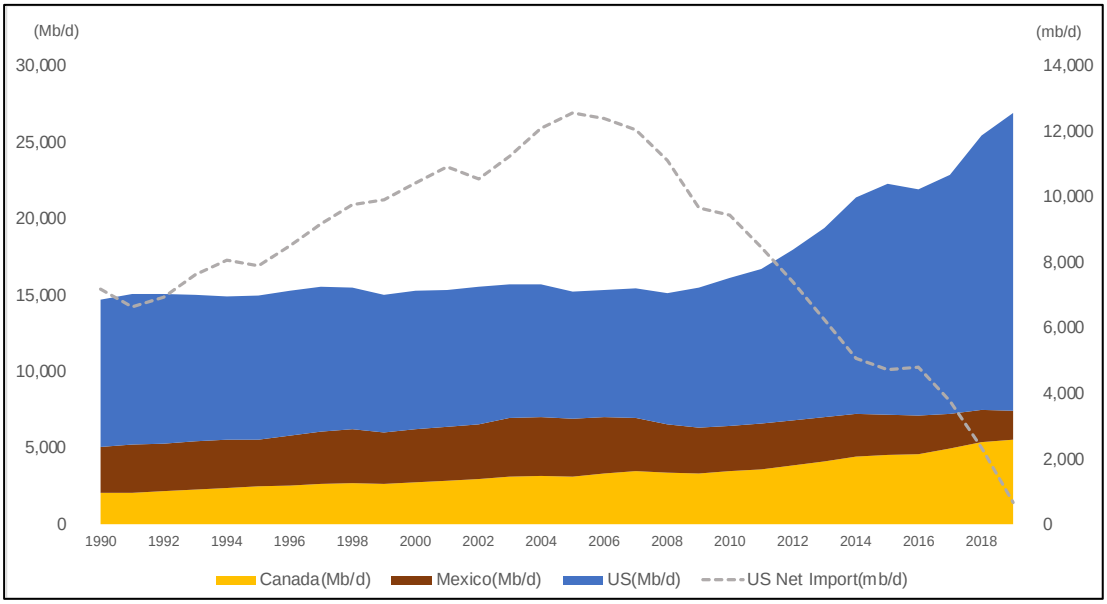

Fig. 1 Oil production in USMCA's parties and U.S. net oil import from 1990 to 2019

Source: U.S Energy Information Administration

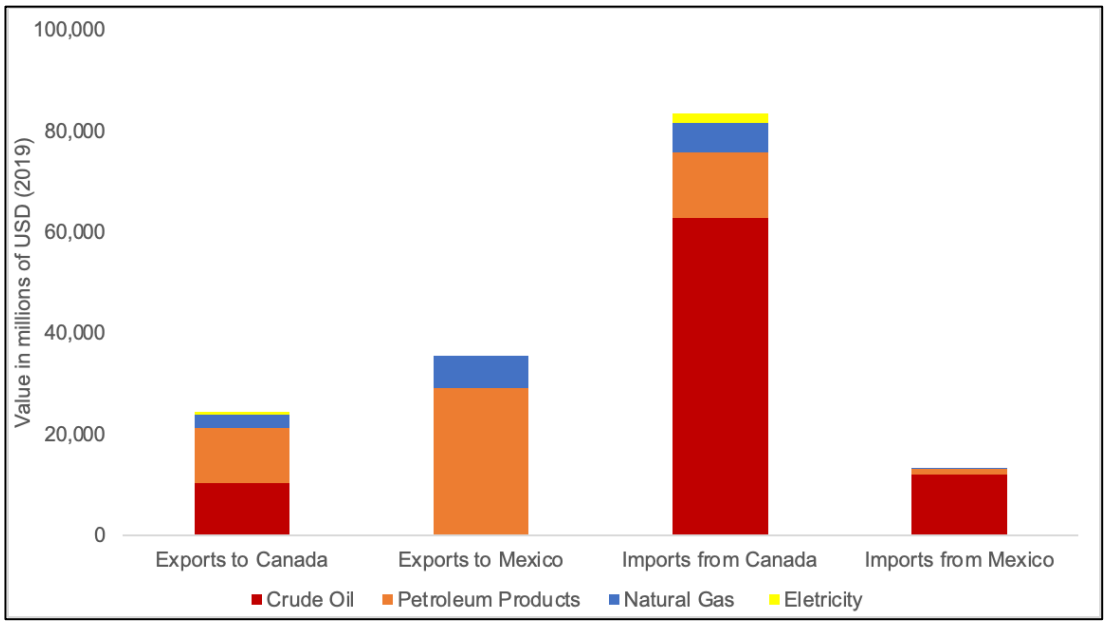

Fig. 2 Energy Trade Flow between North American Countries in 2019

Source: US Census Bureau[6]

The U.S. shale revolution led its members to reconsider potential energy cooperation in North America.[7] Canada and Mexico began to claim the increasing importance of regional energy security because fracking did not only promote U.S. oil and natural gas self-sufficiency but also increased their energy imports from the U.S. (O'Sullivan 2017).[8] In recent years,

[6] This graph refers to Mildenberger & Stokes (2021).
[7] Congressional Research Service. "Cross-Border Energy Trade in North America: Present and Potential." https://sgp.fas.org/crs/misc/R44747.pdf (Accessed November 24, 2021) and United States Government Accountability Office. "North American Energy Integration: Information about Cooperation with Canada and Mexico and among U.S. Agencies." https://www.gao.gov/assets/gao-18-575.pdf (Accessed November 24, 2021).
[8] The idea of aiming for energy independence through energy trade between the three North American countries is called "North American Energy

the North American countries have actively pursued efforts to expand the regional energy market by constructing transportation infrastructures, such as the U.S.-Canada Keystone XL Pipeline and the U.S.-Mexico Wahalajara System.[9] However, energy protectionism in Mexico has developed at a rapid pace while environmental and indigenous communities have opposed the pipeline construction in the U.S. and Canada. Joe Biden's presidency heightened additional uncertainty as to future energy cooperation in North America.

The study of the new energy provisions in USMCA is a key to look at what the three member countries learned from NAFTA's experiences described above, the goals they are aiming for, and the challenges they may face in the future. Addressing the question "What kind of energy landscape does the new energy-related provisions create?" has important implications for energy policy development in North America.

This paper reviews the major points of the USMCA's energy provisions and examines how the North American energy environment would develop under the new rules. In the next section, the focus is on Canada and Mexico. Compared to NATFA's provisions, the noticeable amendments occurred in the USMCA provisions regarding Canada. Canada has been a major energy supplier for the U.S. because NAFTA's provision obliged Canada to export fossil fuels to the southern neighbor. With the onset of the shale revolution, however, the U.S. no longer has severe energy security concerns. The perceptional change of the U.S. led to the modification of NAFTA's provisions regarding Canada. Meanwhile, although no significant change occurred in the provisions regarding Mexico, it is worth noting that Mexican president Andres Munuel Lopez Obrador (AMLO), who came into power during the USMCA's negotiation, claimed to preserve Mexican sovereignty in the energy sector and inserted the protectionist provisions which are more prominent than NAFTA's. Section 3, giving consideration to recent developments, looks at how the independent yet simultaneous U.S. engagement with Canada and Mexico could develop under the new USMCA provisions. Finally, this paper concludes with a discussion on the USMCA's implications for North American regional cooperation.

2. Energy-Related Provisions of USMCA

NAFTA superseded the United States-Canada Free Trade Agreement (USCFTA) signed in 1988 by having Mexico, which hoped to attract foreign investment, as a new party. Cameron and Tomlin (2000) argue that NAFTA's negotiators from the U.S. and Canada perceived Mexico as a latecomer to the established USCFTA. With this background, although the impetus for NAFTA was designed to facilitate free regional trade among the three countries, the agreement contained a mixture of independent provisions specific to U.S-Canada and U.S-Mexico. Clarkson (2008) describes this regional characteristic as "double bilateralism." The USMCA clearly reflects this "double bilateralism" structure of NAFTA. The energy provisions are no exception. Rather, the three countries were particularly eager to put their own interests in the energy provisions. Despite the elimination of the Energy Chapter, energy-related provisions lie scattered in different USMCA chapters. The U.S. had negotiated with Canada and Mexico independently to set these rules. This section summarizes each of them with careful attention to the changes from NAFTA.

2-1. U.S.-Canada Provisions

(1) Elimination of proportionality clause

The USMCA removed NAFTA's controversial provision known as the "energy proportionality clause" in Article 605. The clause required Canada to maintain oil and natural gas export to the U.S. "as compared to the proportion prevailing in the most recent 36-month period." Under this rule, Canada's oil producing states, especially Alberta, could not reduce export volumes to the U.S. and could not provide their oil to eastern Canada's importers even if an international oil crisis caused a

Independence." For the views of Canada and Mexico about this idea, see The Globe and Mail. "For Mexico and Canada, There's Room to Grow." https://www.theglobeandmail.com/opinion/for-mexico-and-canada-theres-room-to-grow/article5698332/ (Accessed November 24, 2021).

[9] Congressional Research Service. "Keystone XL Pipeline: Overview and Recent Developments." https://crsreports.congress.gov/product/pdf/R/R43787/8 (Accessed November 24, 2021) and US Energy Information Administration. "U.S. Natural Gas Exports to Mexico Set to Rise with Completion of the Wahalajara System." https://www.eia.gov/todayinenergy/detail.php?id=44278 (Accessed November 24, 2021).

supply shortage in Canada.

The U.S. raised the original idea of the proportionality clause. The reason is that, at the time of the NAFTA negotiations, the U.S. had energy security concerns due to increasing demand for foreign oil. No similar provision exists in other trade agreements including NAFTA's provisions between the U.S. and Mexico. Canada did not violate the obligation since the inception of NAFTA, but there was growing criticism against the clause in Canada because the rule forced the country to prioritize U.S. energy security rather than Canada's.[10] In recent years, U.S. and Canadian environmental groups also began to view the clause as a problematic factor of continuous oil sands exploration and increasing oil export.[11]

Canada proposed to remove the proportionality clause at the renegotiation; the U.S., which had once requested uninterrupted access to Canadian resources, did not ask to maintain the clause. The American Petroleum Institute (API), a lobbying group representing the U.S. oil and natural gas industry, had stated to the U.S. government that the country no longer needed the clause.[12] In light of the original purpose of the proportionality clause, the elimination demonstrates the revolutionary change in U.S. energy security perceptions after the shale revolution.

(2) Rules of origins for diluent

The rules of origin in the USMCA drew much attention regarding their impacts on automotive trade, but important changes can also be found in the energy sector, especially the rules for diluent. Canadian exporters of crude oil blend diluents to enable pipeline transportation. Canada imports the diluents from several countries–Peru, Bolivia, and Pakistan–and stores them together in domestic tankers. Such procedures made it difficult for Canadian oil exporters to prove the origin of diluents for tariff exemption.[13] Crude oil exporters, thus, accepted tariff payments for approximately 65% of crude oil exports, which is estimated to have amounted to $60 million a year.[14]

Against the backdrop of increasing crude oil export to the U.S and stagnant oil prices in recent years, the cost of tariffs became more damaging for the Canadian oil industry. Diluent transportation faced one of the few remaining tariff barriers between the U.S. and Canada; therefore, for the Canadian side, updating the rules for diluent was the main goal during the USMCA negotiations.[15]

In the outcome of the USMCA negotiations, the parties assented to the exemption of the rules of origin for diluents so far as the diluents do not account for more than 40% of crude oil export volumes.[16] This update technically eliminates the tariff on diluent because the agent generally accounts for 30% of crude oil export volumes. The upper limit in the USMCA presumably modeled the Trans-Pacific Partnership which both the U.S. and Canada joined.[17]

(3) Exemption of Investor-State Dispute Settlement

The USMCA also amended the investment provisions. Canada entirely withdrew from the investor-state dispute settlement (ISDS) mechanism stipulated in NAFTA Chapter 11. The ISDS mechanism allows a party's investors to sue another party's government. An investor can launch an international arbitration consisting of arbiters agreed upon by the

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[10] Gordon Laxer and John Dillon. "Over a Barrel: Exiting from NAFTA's Proportionality Clause." https://s3-us-west-2.amazonaws.com/parkland-research-pdfs/overabarrel.pdf (Accessed November 24, 2021).
[11] The Numbers. "The New NAFTA – What's the Deal with Energy." https://behindthenumbers.ca/2018/11/21/the-new-nafta-whats-the-deal-with-energy/ (Accessed November 24, 2021).
[12] Trusted Energy Intelligence. "New NAFTA shows U.S. no longer needs Canadian oil guarantees." https://www.jwnenergy.com/article/2018/10/3/new-nafta-shows-us-no-longer-needs-canadian-oil-gu/ (Accessed November 24, 2021)..
[13] Global Affairs Canada. "The Canada-United States-Mexico Agreement: Economic Impact Assessment." https://www.international.gc.ca/trade-commerce/assets/pdfs/agreements-accords/cusma-aceum/CUSMA-impact-repercussion-en.pdf (Accessed November 24, 2021).
[14] Government of Canada. "Energy Provisions Summary." https://www.international.gc.ca/trade-commerce/trade-agreements-accords-commerciaux/agr-acc/cusma-aceum/energy-energie.aspx?lang=eng (Accessed November 24, 2021).
[15] Financial Post. "Canada's Oilpatch Pays America $60 Million a Year to Export Crude – And New Trade Deal May Not Help." https://financialpost.com/commodities/energy/canadas-oilpatch-pays-america-60-million-a-year-to-export-crude-and-usmca-may-not-help (Accessed November 24, 2021).
[16] U.S. Department of Commerce. "Transporting Alberta Oil Sands Products: Defining the Issues and Assessing the Risks" https://crrc.unh.edu/sites/default/files/media/docs/noaa_oil_sands_report_09.2013.pdf (Accessed November 24, 2021).
[17] The U.S. decided to withdraw from TPP in January 2017. See Law 360. "Opportunities for the Oil Industry in NAFTA Renegotiations." https://www.thompsonhine.com/uploads/1137/doc/Opportunities_For_The_Oil_Industry_In_NAFTA_Renegotiations.pdf (Accessed November 24, 2021).

parties when a party's government is found to discriminate against an investor or impede its ability to earn profits.[18]

According to the Canadian Centre for Policy Alternatives, a Canadian think tank, Canada had been sued 41 times–48% of all cases–from NAFTA's launch in 1994 to January 2018.[19] Canada had paid out more than $314 million for investors' damages and legal costs. Not only had ISDS caused economic costs, but the Canadian side found it problematic that the companies used ISDS as a coercive tool to pressure the Canadian government. Canada thus made a claim against the economic and political costs of ISDS and sought to withdraw from ISDS at NAFTA renegotiations. Although U.S. industry initially opposed Canada's request, the USMCA reflected Canada's concern. As a result, the USMCA replaces ISDS except in certain causes regarding fossil fuel investments between the U.S. and Mexico.[20]

2-2. U.S.-Mexico Provisions

(1) Mexican sovereignty over domestic resources

The new agreement kept some of the NAFTA Chapter 6 provisions regarding Mexican sovereign right in USMCA Chapter 8. Chapter 8 stipulates that: in Section 1, "the parties confirm their full respect for sovereignty and their sovereign right ... in accordance with their respective Constitutions and domestic laws"; in paragraph (a) of Section 2, the U.S. and Canada recognize Mexico's "sovereign right to reform its Constitution and its domestic legislation"; and in paragraph (b) of Section 2, "Mexico has the direct, inalienable, and imprescriptible ownership of all hydrocarbons in the subsoil of the national territory ... pursuant to Mexico's Constitution." As in NAFTA, the USMCA confirms the special treatment for Mexico's sovereign right on its domestic resources.

Mexico's exclusive right in Chapter 8 stemmed from Article 27 and 28 of the Mexican Constitution, which restricted foreign activities over Mexican territory (Hufbauer & Schott 2005).[21] As exemplified by the nationalization of Petroleos Mexicanos (Pemex), the biggest petroleum company in Mexico, the governmental control over domestic resources was inseparable from Mexico's national identity and thus had been reflected in the Constitution. As mentioned above, NAFTA contained similar provisions concerning Mexico's sovereignty in Chapter 6. USMCA Chapter 8 was designed to succeed the NAFTA provisions and accept Mexico's exclusive right in the energy sector even though the agreement sought liberalization of energy trade (Herran & Poretti 2011).

It would, however, be reasonable for Mexico to remove the protectionist provisions in the USMCA given the fact that Mexico had been encouraging foreign investment in its energy sector since the 2013 Constitutional Reform. Here, current Mexican President AMLO exercised his power during the NAFTA renegotiations. President AMLO has been a prominent critic against the reform pushed through by former President Peña Nieto. During the electoral campaign, AMLO won public support by calling out the influx of foreign capital infringing Mexico's sovereignty over energy resources. After taking office, AMLO urged the USMCA's negotiators to keep the provisions regarding Mexico's sovereignty on its domestic resources, resulting in Chapter 8.[22]

(2) ISDS's protection for U.S. investors

As noted above, USMCA Chapter 8 recognizes Mexico's exclusive right to its domestic resources. Annex 14-E prevents abuses of such right. The Annex provides access to ISDS, abolished among three parties in the USMCA, for investment only in the hydrocarbon sector between the U.S. and Mexico.[23] The USMCA, therefore, allows U.S. companies investing

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[18] Article 1123 of NAFTA's Chapter 11 rules that the Tribunal comprises three arbitrators, one appointed by each of the disputing parties and the third appointed by agreement of the disputing parties.

[19] Scott Sinclair. "Canada's Track Record Under NAFTA Chapter 11." https://www.policyalternatives.ca/sites/default/files/uploads/publications/National%20Office/2018/01/NAFTA%20Dispute%20Table%20Report%202018.pdf (Accessed November 24, 2021).

[20] For investment during NAFTA era, the USMCA Chapter 14 rules that the Parties can access ISDS three years after NAFTA's termination.

[21] Article 27 established the nation as the direct owner of oil and all hydrocarbons disregarding its form, and Article 28 sets the exclusivity of national control over strategic areas including hydrocarbons. The 2013 Constitutional Reform encouraged private investment in the oil and gas sector and electricity sector by amending both articles and Article 25, which obliges the government to promote the public and private sectors.

[22] Reuters. "Mexico's Next Leader Says NAFTA Deal Preserves Energy Sovereignty." https://www.reuters.com/article/us-trade-nafta-mexico/mexicos-next-leader-says-nafta-deal-preserves-energy-sovereignty-idUSKCN1LC2BP (Accessed November 24, 2021).

[23] United States International Trade Commission. "U.S.-Mexico-Canada Trade Agreement: Likely Impact on the U.S. Economy and on Specific

in the oil and gas sector to sue the Mexican government in an arbitral tribunal in a case where investors were involved in a dispute with the Mexican government. The access to ISDS was critical for the U.S. side to protect its investors as the U.S. companies had invested heavily in Mexico's energy sector since the Constitutional Reform.[24]

(3) Licensing of Mexican energy products

In North America, the oil and natural gas trade had been liberalized to a considerable extent since NAFTA's launch. USMCA Chapter 2 outlines the principles for such free trade, but Annex 2-A sets out exceptions to the Articles restricting discriminatory measures against another party: Article 2.3 "National Treatment" and Article 2.11 "Import and Export Restrictions." Article 2.A.3 of the ANNEX authorizes import and export licensing of energy products pursuant to the Hydrocarbons Law. The listed items include petroleum products, natural gas, and propane. This Article succeeds NAFTA's Annex 603.6 which identified the hydrocarbon goods for which Mexico could grant import and export licenses. This special treatment for Mexico offers more specific measures based on Chapter 8.

3. North American Oil and Gas Trade under the USMCA

The amendments from NAFTA to USMCA demonstrate that Canada achieved its initial goals through the NAFTA renegotiation process. As for trade, Canada could successfully remove the proportionality clause and amend the rules of origin for diluent; as for investment, the country is no longer a part of ISDS and can avoid lawsuits from U.S. industries, especially over environmental issues. Also, President AMLO, inaugurated during the USMCA negotiations, successfully protected Mexico's sovereign right on the energy sector as promised. The USMCA's provisions clearly signals AMLO's protectionist energy policy. Given that Canada and Mexico have achieved their initial goals, what are the implications of the USMCA's provisions for the North American energy landscape? This section examines how the USMCA's energy provisions may affect the U.S.-Canada and the U.S.-Mexico relations, respectively.

Regarding Canada, the amendments to the rules of origin and ISDS would only reduce financial costs for the government and companies. The cost reduction would not have a large impact on resource trade between the U.S. and Canada. More attention, on the other hand, should be paid to the elimination of the proportionality clause because the clause determined the ratio of oil and natural gas exports from Canada. Amendment of the clause may create a new landscape for U.S.-Canada energy trade. This section argues that the impact of ongoing decarbonization in the U.S. and Canada would, with the removal of the proportionality clause, place more burdens on Canadian oil suppliers trying to increase export volumes to the U.S.

Meanwhile, the Mexican government will continue to promote the protectionist measures in its energy sector pursuant to the provisions of the USMCA. Among the USMCA parties, the U.S. has expressed more serious concerns about Mexico's energy policy than Canada because the shared border with Mexico allowed the U.S. to build a closer relationship with its southern neighbor. The ISDS mechanism, which remained effective between the U.S. and Mexico, is expected to mitigate the U.S. fears towards AMLO's protectionist policies.

3-1. Elimination of Proportionality Clause and Outlook for U.S.-Canada Oil Trade

(1) Proportionality Clause and Current Oil Export to the U.S.

The U.S. had tried to facilitate crude oil import from Canada by investing and expanding infrastructures–pipelines and railroads–to enable large-volume and low-cost transportation even before the making of NAFTA. Besides the economic and geographical advantages, the significance of Canadian oil for the U.S. laid upon the less political nature of trade with

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Industry Sectors." https://www.usitc.gov/publications/332/pub4889.pdf (Accessed November 24, 2021).

[24] Some point out that the ISDS mechanism in the USMCA has limited efficiency compared to NAFTA's because the USMCA mandates 30-month negotiations in Mexican courts before arbitration. Such process, however, is exempted for projects contracted with the Mexican Government, which include most investments in the energy sector. In addition, Article 32.11 of Chapter 11 prevents the Mexican hydrocarbon measures from being more restrictive than other international agreements such as the CPTPP. This Article works with ISDS to protect U.S. companies' business in Mexico. See Holland & Knight. "Demystifying Energy Investment Disputes in Mexico Through the New USMCA." https://www.hklaw.com/en/insights/publications/2019/04/demystifying-energy-investment-disputes-in-mexico-through (Accessed November 24 ,2021).

Canada, unlike the Middle East where state-owned enterprises intervened in trade with political intentions. As the proportionality clause in NAFTA prevented western Canada's suppliers from exporting to consumers in the eastern states, the large portion of crude oil produced from oil sands was forcibly directed toward the U.S., which led to building pipeline infrastructures (Fig. 3).[25]

As of 2019, Canadian crude oil accounted for 56% of total U.S. heavy oil imports. Notably, the U.S. Midwest and Rocky Mountain regions were 100% dependent on heavy oil from Canadian oil sands.[26] Even after the shale revolution reduces U.S. crude oil imports from OPEC countries, Canadian oil export to the U.S. has been gradually increasing due to its competitiveness and the advantages discussed above, confirming the important role of Canadian oil in U.S. energy supply (Fig. 4).[27]

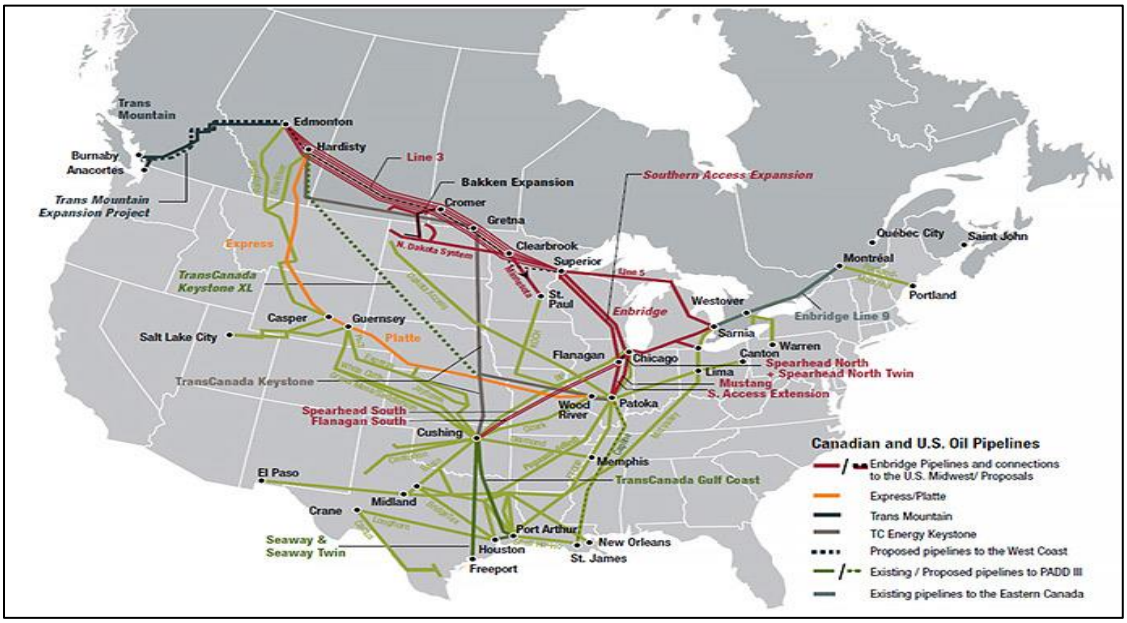

Fig. 3 U.S.-Canada Pipeline Map

Source: The Canadian Association of Petroleum Producers

[25] Clarkson & Mildenberger (2011).

[26] Venezuela had also been a major supplier of heavy oil to the United States, but U.S. import plummeted due to sanctions. Canadian oil has compensated for the decline in U.S. oil import from Venezuela. Also see Oil Sands Magazine. "Assessing America's Appetite for Canada's Crude: A look at Canadian Crude Usage by U.S. Refineries." https://www.oilsandsmagazine.com/market-insights/american-appetite-canadian-crude-usage-us-refineries (Accessed November 24, 2021).

[27] Shale (tight) oil does not compete with Canadian heavy oil, which positions Canada's oil as a significant share of U.S. oil import. U.S. Energy Information Administration. "U.S. Crude Oil Imports from OPEC Are Down, but Imports from Canada Remain High." https://www.eia.gov/todayinenergy/detail.php?id=47836 (Accessed November 24, 2021).

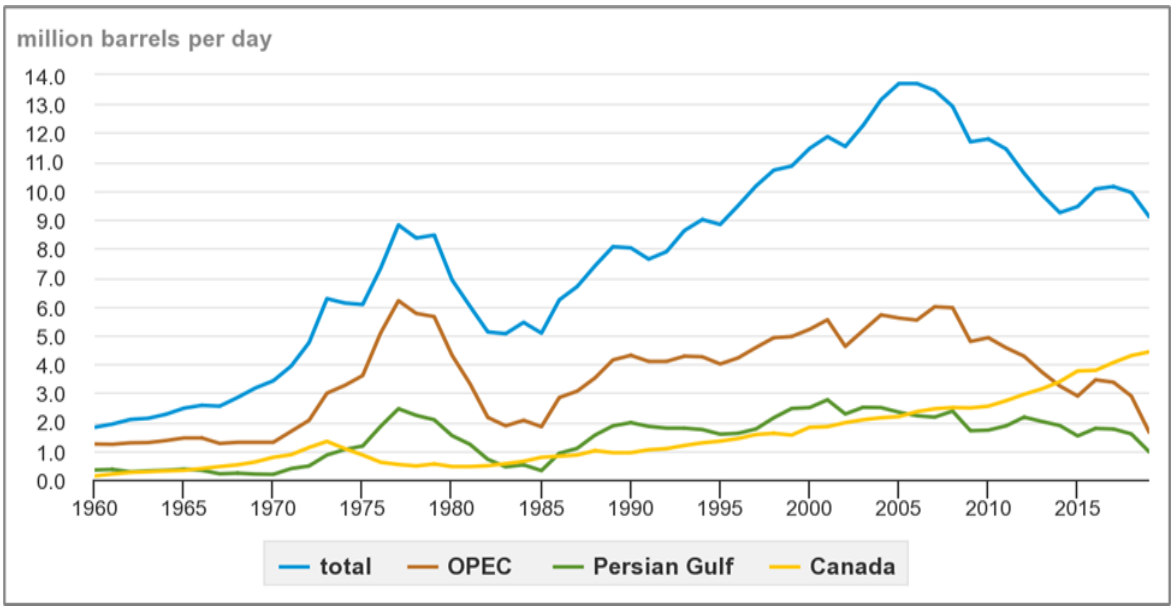

Fig. 4 International Comparison of Oil Export to the U.S. from 1960 to 2019

Source: U.S. Energy Information Administration

(2) Elimination of proportionality clause and outlook for Canada's oil export to U.S.

Canada is no longer required to export a certain proportion of oil and natural gas to the U.S. under the USMCA. Since suppliers do not need to follow the most recent three-year records, the volumes of Canadian oil and natural gas export to the U.S. can shift flexibly unlike the stable fluctuation under NAFTA. What changes, then, could the amendment to the USMCA bring about in Canada's crude oil export to the U.S?

One should first look at Canada's potential for increasing export volumes, a longstanding issue for Canada's oil industry. In recent years, the pipeline capacity in Canada has not met its increasing oil production. The stagnant export leads to a widening price gap between the Western Canadian Select (WCS) and Western Texas Intermediate (WTI). As Canadian provinces earned royalty income from the export of oil, this problem was not just for the oil industry.[28] The producers in Alberta, for instance, had to reduce oil outputs to prevent excess inventories for offsetting economic losses. The strengthening of pipeline capacity, thus, has been a major goal for promoting oil export business in Canada.[29]

[28] Brandon Schaufele and Jennifer Winter. "Measuring the Economic Impact of Alberta's Crude Oil Curtailment Policy." https://www.ivey.uwo.ca/media/3793185/iveyenergycentre_policybrief_dec2020_measuringeconimpactalbertacrudeoil_curtailment_2-9.pdf (Accessed November 24, 2021).

[29] 石油天然ガス・金属鉱物資源機構「カナダにおける原油パイプライン及びオイルサンド事業の最近の動き」、https://oilgas-info.jogmec.go.jp/_res/projects/default_project/_page_/001/007/950/1912_c_ca_oilsand_r.pdf (Accessed November 24, 2021).

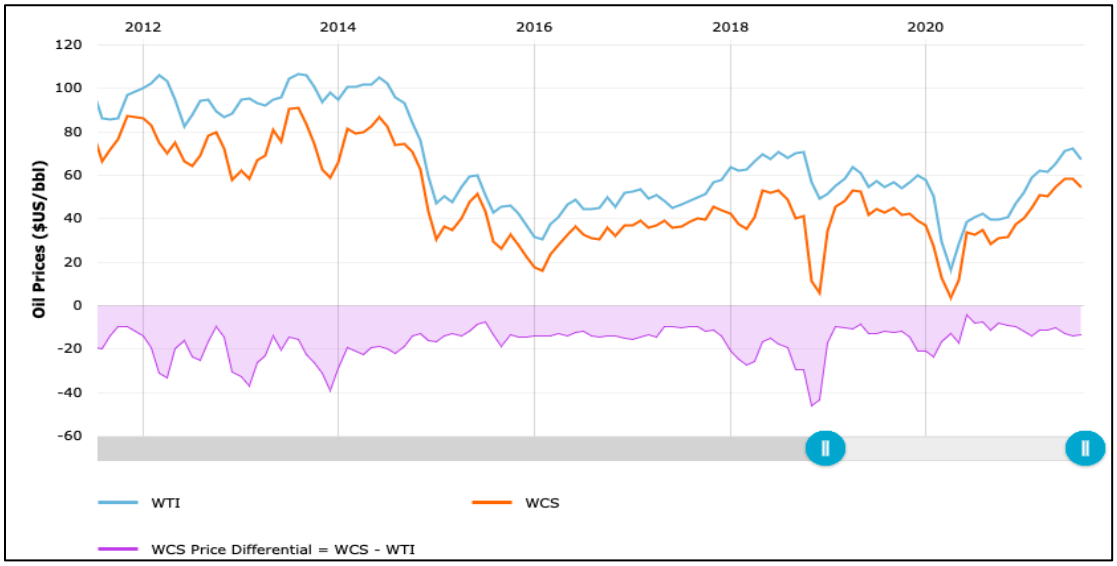

Fig. 5 WTI and WCS prices from 2011 to 2021

Source: Government of Alberta

However, the Canadian oil industry is facing a difficult situation in strengthening its export capacity with the setback of the Keystone XL pipeline project from Alberta to the Gulf Coast in June 2021 and with the environmental protests gaining momentum (Fig. 6). As well, Canada's future oil production and export volumes have become more uncertain due to stagnant investment in oil sands and climate change policies by the federal government. Facing such uncertain future, the Canadian oil industry is likely to have a hard time maintaining the current export volumes rather than increase its export. With the elimination of the clause, future efforts include diversifying export destinations such as the Trans Mountain Pipeline expansion which will increase oil export capacity from Alberta to the Canadian west coast.

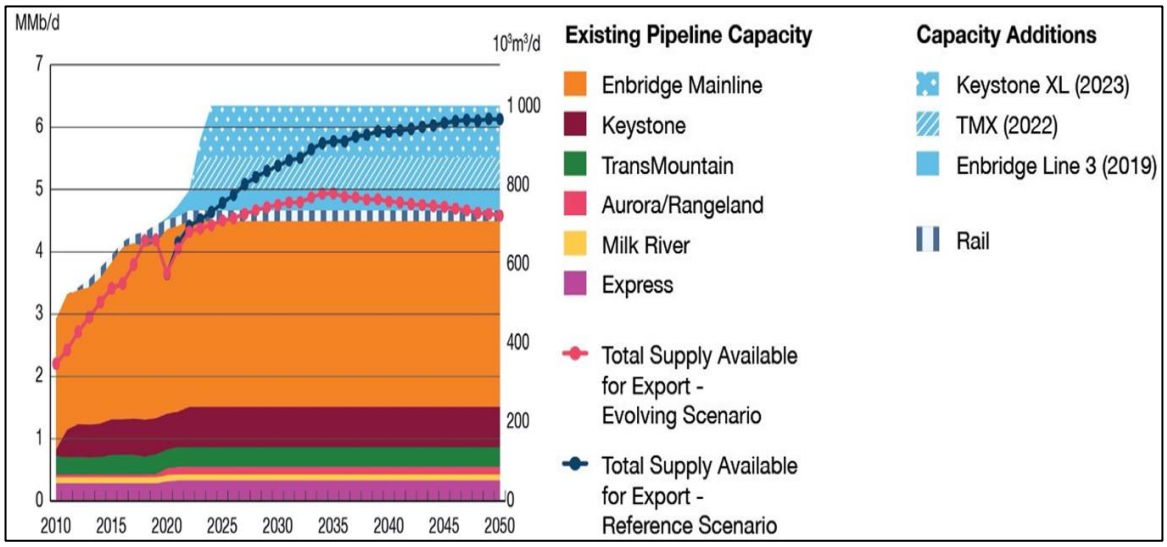

Fig. 6 Outlook for Canadian oil export and export capacity from 2010 to 2050

Source: Canada Energy Regulator

The future decline of oil export volumes will possibly become an imminent issue in the age of decarbonization. As previously pointed out, the proportionality clause mandated oil and natural gas export during NAFTA era, making it difficult

for Canada to take measures for reducing export volumes and avoiding emissions in the oil and natural gas sector. The removal of the clause, therefore, might create an environment where both the U.S. and Canada can actively develop decarbonization policies that could cause adverse effects on oil sands business. Although Canada's export volumes will largely depend on U.S. policies led by Joe Biden, who came into power six months after the USMCA took effect, and Canadian policies, there will be a greater likelihood of a decline in Canadian crude oil exports if the current trend continues.

The elimination of the proportionality clause and the accelerated decarbonization trend occurred in different contexts as described above. Nonetheless, if the former backed the direction of decarbonization, the Canadian oil business would have difficulty keeping current export volumes. Assuming that the proportionality clause survives in the USMCA, the growing momentum for decarbonization could have a limited impact on Canadian suppliers. If the Trump administration stayed in power, the potential for Canadian export growth would be higher because of the strengthening of pipeline capacity and stagnation of decarbonization policies regardless of the removal of the proportionality clause. From the discussion on removing the proportionality clause presented in the previous section, it could be inferred that the U.S. and Canada did not expect the possible difficulties that Canada's oil export business would face in the USMCA. Biden's victory, however, has accelerated decarbonization in both countries, and the negative impact on oil sands business has become more imminent.

(3) U.S. and Canadian Climate Change Policy Trades and Possible Impacts on Canada's Export

Canada's crude oil export to the U.S. will largely depend on the climate change policies in the U.S. and Canada, both of which aim for carbon neutrality by 2050. Whereas the climate change policies in both countries include uncertain variables including policy feasibility and technological development, the already implemented policies provide a glimpse into the challenges that the Canada's oil sand business would face amid the decarbonization trend.

Canada's recent climate change policies have caused controversy between the ambitious federal government and oil and natural gas producers, prominently Alberta. Among such policies, Canada's carbon pricing, one of the most efficient means to reduce greenhouse gas emissions, has increased the costs for producers since the federal Parliament passed the Greenhouse Gas Pollution Pricing Act in 2018.[30] Producers had been criticizing the ambitious federal carbon tax as infringing states' sovereign rights, and claimed against a provincial carbon tax. The Supreme Court ruled, however, that the federal carbon pricing was constitutional in March 2021.[31] The judgement enabled the federal government to increase the carbon pollution price by $15 per year to $170 per tonne CO2e in 2030. The federal carbon pricing is charged if the Canadian provinces fail to create their own emission reduction mechanism which has the equivalent effect of the federal tax. The impact of carbon pricing presumably varies depending on the types of projects and tax collection methods; however, if Canadian producers suffer higher production and transportation cost due to the carbon tax, the oil sands business is likely to lose its competitiveness and be forced to reduce oil production and export.[32]

Simultaneously, the Biden administration has taken a tougher stance on the fossil fuel industry than Canada to accelerate decarbonization of its economy. The U.S. government has been aggressively regulating oil and gas exploration by halting oil and gas leasing on federal land and waters and by canceling drilling permits.[33] As of November 2021, the key policy action by the Biden administration towards Canada went no further than abandoning the permit for the construction of the Keystone XL pipeline. President Biden has never mentioned other oil sands and pipeline projects. However, the other controversial projects–the modernization of Enbridge Line 3, a crude oil pipeline between the U.S. and Canada, and

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[30] 石油天然ガス・金属鉱物資源機構「カナダにおける温暖化ガス排出規制：制度概要と課題」,https://oilgas-info.jogmec.go.jp/info_reports/1008604/1008775.html (Accessed November 24, 2021).

[31] Supreme Court of Canada. "References re Greenhouse Gas Pollution Pricing Act." https://www.scc-csc.ca/case-dossier/cb/2021/38663-38781-39116-eng.aspx (Accessed November 24, 2021).

[32] For the impact of carbon pricing on oil sands projects, see Branko Boskovic and Andrew Leach. "Leave it in the Ground? Oil Sands Development under Carbon Pricing." https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2920341 (Accessed November 24, 2021).

[33] Environmentalists in the Democratic Party and the Secretary of the Interior, Deb Haaland, have called for stricter regulations on fracking and may tighten fossil fuel regulations further. See The White House. "Executive Order on Tackling the Climate Crisis at Home and Abroad." https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/ (Accessed November 24, 2021).

Enbridge Line 5, a pipeline from Canada to Michigan–faced strong opposition from environmental groups.[34] Canadian suppliers cannot ignore the criticism against both new projects and existing infrastructures. If the heated environmental movement succeeds in halting or shutting down these infrastructures, Canada's exporters would face more severe challenges due to the lack of exporting capacity.

The progress of climate change policies, as noted above, depends on massive uncertain factors, and it is important to note that some of them may cause positive outcomes for the oil sands industry. The federal government of Canada, for example, is funding GHG reduction technologies: carbon dioxide capture and storage (CCS) and carbon dioxide capture, utilization, and storage (CCUS). The successful deployment of these technologies would mitigate the negative impact of carbon pricing on Canada's oil sands companies.[35] Moreover, unlike the Keystone XL, Enbridge Line 3 has not been recognized as a problem by the U.S. federal government, and it began to operate in October 2021, leading to export capacity expansion as shown in Fig. 5.[36] Even in the U.S., the EIA's low oil price scenario and low oil and gas supply scenario project the decline of U.S. oil production, under which the country may once again become a net importer of oil. In addition, if the U.S. Congress passes Biden's infrastructure bill, building new infrastructures, such as roads and bridges, would require Canadian heavy oil for producing bitumen. From these prospects, it may be too early to conclude that decarbonization policies lead to lower oil exports from Canada.[37]

Despite the myriad uncertainties listed above, however, even an optimists would only say that Canadian crude oil export to the U.S. could remain at the current level at best due to the lack of transportation capacity and pressures for decarbonization. The role of Canadian crude oil, which makes long-standing contributions to U.S. economic activities and energy security, under the USMCA deserves more attention as it helps to tell how seriously both countries will take climate change measures beyond the existing collaboration.

3-2. Effects of Mexico's Energy Protectionist Policy on U.S. Business

(1) U.S.-Mexico Energy Trade after the Constitutional Reform

The Mexican Constitutional Reform in 2013 opened up a major opportunity for U.S. companies to enter into Mexico's energy market. The reform failed to privatize the state-owned oil company, Pemex, but the company started several joint ventures with U.S. oil and gas companies in the Gulf of Mexico. Mexico called for more than 100 tenders for private investment. In the first three auctions, one held in 2016 and two held in 2017, more than $1 billion was awarded to U.S. firms.[38] With regard to trade, Mexico's market value increased as an export destination for U.S. oil and natural gas productions boosted by fracking and exploration of the Gulf of Mexico. The new transportation infrastructures have helped to increase U.S. oil and natural gas export to Mexico since the reform (Fig. 7).[39] Mexico surpassed Canada as the biggest importer of U.S. natural gas in 2015; meanwhile, U.S. oil export to Mexico amounted to $30 billion in 2018, a three-fold increase from 2008.

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[34] S&P Global. "Enbridge Moves Closer to Line 3 Construction While Line 5 Shutdown Is Threatened" https://www.spglobal.com/platts/en/market-insights/latest-news/oil/111620-enbridge-moves-closer-to-line-3-construction-while-line-5-shutdown-is-threatened (Accessed November 24, 2021).
[35] Government of Canada. "Budget 2021" https://www.budget.gc.ca/2021/report-rapport/toc-tdm-en.html (Accessed November 24,2021).
[36] Enbridge. "Line 3 Replacement Project Substantially Completed and Set to be Fully Operational." https://www.enbridge.com/media-center/news/details?id=123692&lang=en (Accessed November 24, 2021).
[37] Bloomberg Green. "Biden's Latest Surprise Boost for Oil Involves Lots of Asphalt." https://www.bloomberg.com/news/articles/2021-03-31/oil-sector-gets-surprise-boost-in-biden-s-roads-wells-plan(Accessed November 24, 2021) and U.S. Energy Information Administration. "Annual Energy Outlook 2021." https://www.eia.gov/outlooks/aeo/narrative/introduction.php (Accessed November 24, 2021).
[38] The U.S. companies participating in Mexican oil and gas exploration include Murphy Oil, Chevron, Fieldwood Energy, ExxonMobil, Talos Energy. See US Department of Commerce. "Mexico - Country Commercial Guide." https://www.trade.gov/knowledge-product/mexico-n-oil-and-gas (Accessed November 24, 2021) and USAID. "Institutional Framework for Auctions in Mexico." https://www.usaid.gov/energy/auctions-mexico (Accessed November 24, 2021).
[39] Congressional Research Service. "Mexico: Background and U.S. Relations." https://fas.org/sgp/crs/row/R42917.pdf (Accessed November 24, 2021) and US Energy Information Administration. "In 2019, the U.S. Imported $13 Billion of Energy Goods from Mexico, Exported $34 Billion." https://www.eia.gov/todayinenergy/detail.php?id=45756 (Accessed November 24, 2021).

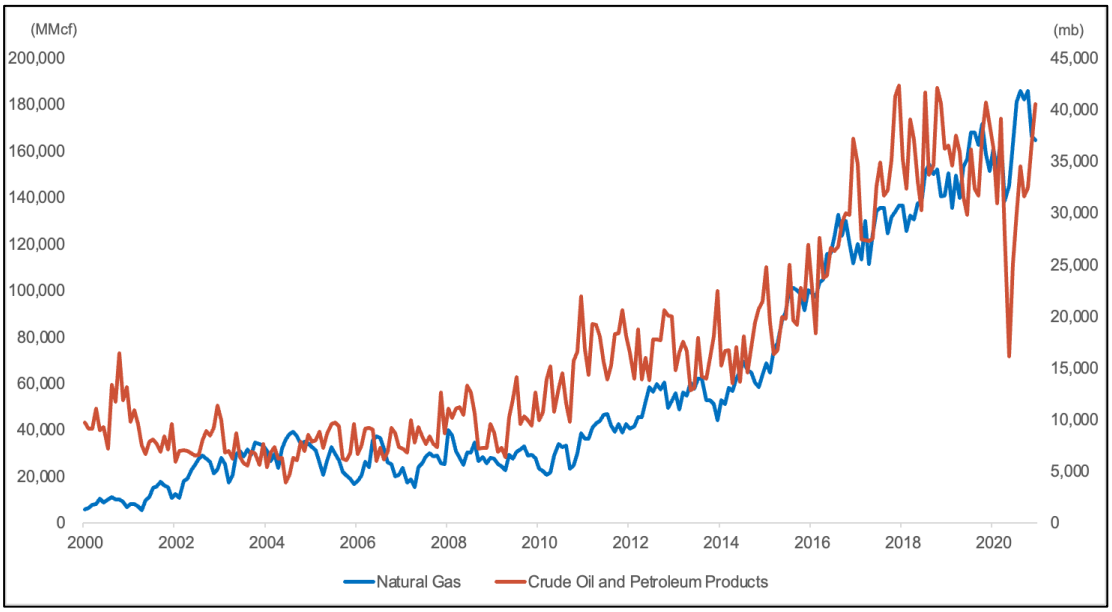

Fig. 7 U.S. oil and gas export to Mexico from 2000 to 2020

Source: U.S. Energy Information Administration

However, President AMLO, who came into power by criticizing the open market policies, actively pushed back incoming foreign investment in Mexico to protect domestic energy companies, prominently Pemex. At the very beginning of his presidency, AMLO successfully inserted Chapter 8 into the USMCA which reflects Mexico's exclusive right on its domestic resources. The Mexican protectionist policies have threatened the U.S. oil and gas industry due to possible adverse impacts. Backing such concerns, Mexico leaned toward protectionist measures and began to justify its policies by referring to Chapter 8 and its Constitution.[40]

(2) U.S. concerns about Mexico's protectionist policies

The U.S. fossil fuel industry began to feel conscious about Mexico's protectionism. The Chief Executive of the API, Mike Sommers, took the lead to express such concerns in a letter sent to U.S. government officials in June 2020, shortly before the USMCA entered into force. Following this letter, other stakeholders would send similar petitions to both the U.S. and Mexican governments. Sommers claimed that the recent measures taken by the AMLO administration undermined the success of the USMCA. He encouraged the U.S. government to use diplomatic channels to urge Mexico to assure the openness of energy markets.[41] Also, Sommers described AMLO's energy policy as "inconsistently applied or inconsistent with past practice" and expressed strong concerns about the negative impacts on the permits for fuel trade, storage facilities, and liquids and LNG terminals.[42] In July 2020, Sommers' concern became a reality when the U.S. Talos Energy and Pemex came into conflict over the operating rights in the Zama field of the Gulf of Mexico.[43] In October 2021, 43 members of the

[40] Mexico is the hardest-hit country by COVID-19, with Pemex downgraded to junk by a rating agency in April 2020. President AMLO attributed Mexico's economic downturn to the liberalization by the previous regime, and COVID-19 accelerated such claim and the policies targeting its private sector. As of early 2021, Mexico's protections targeted renewable energy by limiting access to the grid. The possible spillover to the U.S. oil and gas industry become more of a reality as AMLO seeks to rescue Pemex.

[41] American Petroleum Institute. https://www.api.org/~/media/Files/News/Letters-Comments/2020/API_Comments_Mexico_061120 (Accessed November 24, 2021).

[42] To confirm Sommers' concerns, Iberdrola, a Spanish electricity company, halted building a combined-cycle power plant in Mexico. Although the effect of Mexico's protectionist policy is not clear, AMLO has long expressed concerns about Iberdrola's influence in the Mexican electricity market. The company's announcement to withdraw from Mexico would suggest that the government's discriminatory intentions were at work. See Mexico News Daily. "Spanish Energy Firm Iberdrola Threatens to Halt Further Investment in Mexico." https://mexiconewsdaily.com/news/iberdrola-threatens-to-halt-further-investment/ (Accessed November 24, 2021).

[43] Reuters. "Mexico's Pemex, Talos Energy Told to Seek Deal on Shared Oil Find." https://www.reuters.com/article/us-mexico-oil-zama-idUSKBN249358 (Accessed November 24, 2021).

U.S. Congress sent a similar letter to President Trump.[44] Amid the worsened situation in January 2021, on the eve of the inauguration of the Biden administration, Secretary of State Mike Pompeo, Energy Secretary Dan Brouillette and Commerce Secretary Wilbur Ross wrote in a letter to Mexican officials that the Mexican energy policy threatened U.S. companies' investment.[45]

These letters clearly presented the U.S. intentions to negotiate with Mexico in accordance with the USMCA principle, committed to liberal practice. The virtual meeting between President Biden and President AMLO in March 2021 demonstrated that such intentions were passed on to the new U.S. administration.[46] It is worth noting, however, that there is a divergence of perceptions between the Biden administration and the U.S. fossil fuel sector over to what extent the government should protect its oil and natural gas industry.[47] As one prominent example, Biden's trade chief Katherine Tai argued for prioritizing the U.S. climate goals in protecting U.S. investment during the first USMCA Free Trade Commission in May 2021. With an eye to Biden's climate agenda, the API argued that the recent Mexican protectionism was in favor of its fossil fuel sector and that addressing the U.S. fossil fuel sector's complaints would "align with the White House priorities."[48] The reconciliation between the Biden administration–focusing primarily on the Mexican Government's regulation on renewable energy–and the U.S. fossil fuel sector–seeking protection against Mexico's infringement of its interests–will be the key to U.S. energy policy towards Mexico.

(3) Accelerated Protectionist Policies by AMLO Administration

The Mexican side, in response to the U.S. claims, has continued its discriminatory energy policies by highlighting USMCA Chapter 8. Facing U.S. lawmakers' complaints against the Mexican energy policies, President AMLO downplayed the criticism by saying the lawmakers were an "insignificant minority."[49] Despite such bold statement, however, Mexico has been suffering from a decline n energy self-sufficiency due to domestic resource depletion, which led to the increasing oil and natural gas import from the U.S. (Fig. 7). U.S. natural gas especially matters for Mexico because it substitutes more expensive liquified natural gas (LNG).[50] Given Mexico's increasing dependence on U.S. fossil fuels, it would not be desirable for the AMLO administration to undermine the relationship with the U.S., but the recent Mexican policies appear to neglect the reality of its energy market for protecting its own companies.[51]

As a significant step, President AMLO reiterated his intention to protect a nationally owned utility company, Comisión Federal de Electricidad (CFE), and to amend the Constitution in case the current legislation would not save the company. In October 2021, AMLO submitted a bill to Congress for amending the Constitution to strengthen government control over the electricity sector in Mexico. At that point, the bill was not likely to pass because the ruling coalition did not have enough seats in the Congress. If the government does not improve the status of nationally owned companies, however, President

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[44] Congress of the United States. https://gonzalez.house.gov/sites/gonzalez.house.gov/files/10.22.2020%20Cornyn%20VGonzalez%20POTUS%20Mexico%20Market%20Issues%20Ltr%5B3%5D%202_0.pdf (Accessed November 24, 2021).

[45] The Hill. "U.S. Officials Raise Concerns over Mexico's Handling of Energy Permits." https://thehill.com/policy/energy-environment/534506-us-officials-raise-trade-concern-over-mexicos-handling-of-energy (Accessed November 24, 2021).

[46] The White House. "U.S.-Mexico Joint Declaration." https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/01/u-s-mexico-joint-declaration/ (Accessed November 24, 2021).

[47] Bloomberg. "Biden Trade Chief Voices Strong Concern for Mexico Energy Policy." https://www.bloomberg.com/news/articles/2021-05-19/biden-trade-chief-voices-strong-concern-for-mexico-energy-policy (Accessed November 24, 2021).

[48] Mexico's restrictions on renewable energy led U.S. investors to increase their investment in Mexico's oil and gas sector. See Argus. "US Raises Energy Industry Complaints with Mexico." https://www.argusmedia.com/en/news/2215923-us-raises-energy-industry-complaints-with-mexico (Accessed November 24, 2021).

[49] Argus. "AMLO Shrugs Off US Lawmakers' Energy Complaints." https://www.argusmedia.com/zh/news/2236986-amlo-shrugs-off-us-lawmakers-energy-complaints?amp=1 (Accessed November 24, 2021).

[50] US Energy Information Administration. *U.S. Natural Gas Exports*.

[51] EIA's Low Oil and Gas Supply Case expects stagnant U.S. natural gas export to Mexico, and the export remains flat even in the High Oil and Gas Supply Case. Faced with uncertainty regarding U.S. natural gas supply in the future, Mexico may need to install more renewable generation and increase domestic oil and gas production to meet future demand. The market pressure, thus, could be a factor to change the protectionist policies. For the scenarios, see U.S. Energy Information Administration. "Annual Energy Outlook 2021." https://www.eia.gov/outlooks/aeo/narrative/introduction.php (Accessed November 24, 2021).

AMLO might seek to strengthen its protectionist orientation and try to win support from the opposition party.[52] The political development in Mexico is notable; for, the constitutional amendment, if achieved, will impose further restrictions on foreign companies investing in Mexico.[53]

In the short run at least, the AMLO administration is likely to follow the path of energy protectionism in contrast to the USMCA's principles. In this regard, compared to the NAFTA era, the ISDS mechanism is expected to play a more important role for protecting U.S. companies from Mexico's discriminatory policies. When the level of Mexican protectionist policies reaches unacceptable, U.S. companies will seek to protect their own interests by accessing ISDS.[54] While the ISDS mechanism was primarily effective between the U.S. and Canada during the NAFTA era, the mechanism will become more influential in oil and natural gas trade between the U.S. and Mexico under the USMCA.

4. Conclusion

This study summarized the USMCA's energy provisions and provided possible outlooks for the two bilateral relations, U.S-Canada and U.S-Mexico, respectively. The USMCA's energy provisions present that both Canada and Mexico succeeded in reflecting their interests in the new agreement. It is worth noting, however, that the elimination of the proportionality clause creates an environment where the Canadian oil sands industry could face stagnant oil export volumes to the U.S. The protectionist provisions regarding Mexico, on the other hand, threaten the U.S. oil and natural gas sector which has been investing in Mexico since the 2013 Constitutional Reform. The energy relationship between the U.S. and Mexico does not only unfold internationally but also develops as domestic political issues in the U.S. because the frictions have already become intense between the Biden administration and the fossil fuel industry. The ISDS mechanism, which remained only effective between the U.S. and Mexico, would presumably play a more important role in case the domestic coordination efforts failed. As the "double bilateralism" of North America indicates, the implications of the USMCA's provisions differ between U.S.-Canada–in which new provisions amend the institutional foundations of oil and natural gas trade–and U.S.-Mexico–in which the provisions endorse the concerned Mexican protectionist policies on its fuel sector. Given such differences, this last section looks at how the North American regional energy landscape could develop in the age of the USMCA.

The USMCA is likely to stall any U.S. moves for pushing oil and natural gas supplies from Canada and Mexico, as has been the case for more than two decades since NAFTA's launch. Since the shale revolution radically increased U.S. oil and natural gas production and decreased the importance of Canadian and Mexican fossil fuels for U.S. energy supply, the USMCA was not designed to encourage oil and natural gas imports from the U.S. neighbors, especially Canada. Furthermore, the elimination of the proportionality clause does not only mean that Canadian crude oil is less significant for the U.S. but also creates a tough business environment for Canada's oil exporters due to the U.S. decarbonization push. The AMLO administration, on the other hand, uses the USMCA provisions as justification for continuing discriminatory policies in the energy sector, which implies that U.S. companies may suffer adverse effects from their investments in Mexico. The USMCA provisions, although created in different contexts of the two bilateral relations, share a common implication that the U.S. may face difficulty in deepening cooperation in the oil and natural gas sector with Canada and Mexico.

The last comment touches upon the absence of climate change countermeasures, which have growing relevance to North American countries, in the USMCA. Due to the absence of climate change provisions, the role of the USMCA for climate change will presumably be limited to providing a platform for discussion, as was the case at the USMCA's ministerial-level meeting in May 2021.[55] The climate change initiatives in North America will likely develop outside the USMCA's

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[52] The ruling coalition had 57.8% of the Senate's seats and 55.5% of the House of Representatives' seats. The constitutional amendment requires a two-thirds of members present in both the Senate and House. See「日本貿易振興機構「AMLO 大統領、電力分野の国の影響力強化する憲法改正案を国会提出」、https://www.jetro.go.jp/biznews/2021/10/755d978f9785466e.html (Accessed November 24, 2021).

[53] Reuters. "UPDATE 1-Mexico Could Change Constitution to Strengthen Pemex President." https://jp.reuters.com/article/mexico-energy/update-1-mexico-could-change-constitution-to-strengthen-pemex-president-idINL2N2F01KA (Accessed November 24, 2021).

[54] To deal with the dispute with Pemex over the Zama field, Talos Energy has notified the Mexican government in writing that if the dispute cannot be resolved through negotiations, this conflict may develop into an ISDS process.

[55] The USMCA contains provisions on environmental protection in Chapter 24, which mentions the Montreal Protocol and the Washington

framework such as the "Roadmap for a Renewed U.S.-Canada Partnership" which includes climate change measures.[56] One of the future challenges for Mexico–a country prioritizing its hydrocarbon sector–is to follow the U.S. and Canadian leads for decarbonization. Although the U.S. and Canada appear to be aligned in their efforts for decarbonization, both countries will face difficulties in promoting cooperation given the competition of domestic political parties as well as the frictions between the federal and state governments (Mildenberger & Stokes 2021). As the Keystone XL case indicates, the climate policies in one country easily cause conflicts in North America where the interdependence of oil and natural gas sectors has matured. Undeniably, domestic issues could turn into a regional conflict if the U.S. or Canada were to launch a series of climate change measures independently. The regional cooperation over climate change may, thus, prove challenging in the age of the USMCA. One needs to keep a close look on how the development of energy policies and the change in supply-demand structures inside the three member countries will affect the debate over the USMCA.

The USMCA aims to deepen economic cooperation among the three countries in the spirit of NAFTA. In energy field, however, the updated agreement does not offer a framework that enables the cooperation for two important practices: first, oil and natural gas business; and, second, climate change measures. U.S. legislators already expressed their complaints about the first point in a letter condemning Mexico. Similar concerns may be expressed against the U.S. and Canadian policies in the future. Regarding the second point, even though North America now produces as much oil as the Middle East, the USMCA does not encourage the regional cooperation to tackle climate change.[57] Considering the potential impacts on the global energy landscape, close attention, therefore, should be paid to whether the USMCA's provisions impede U.S. leadership as well as the regional cooperation or whether the U.S. will take the lead for cooperation over fossil fuel and decarbonization under the USMCA.

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Convention but makes no reference to international climate change agreements such as the United Nations Framework Convention on Climate Change and the Paris Agreement. See JURIST. "Dissecting and Unpacking the USMCA Environmental Provisions: Game-Changer for Green Governance." https://www.jurist.org/commentary/2020/06/malkawi-kazmi-usmca-environment/ (Accessed November 24, 2021).

[56] The White House. "Roadmap for a Renewed U.S.-Canada Partnership." https://www.whitehouse.gov/briefing-room/statements-releases/2021/02/23/roadmap-for-a-renewed-u-s-canada-partnership/ (Accessed November 24, 2021).

[57] As of 2019, OPEC's oil production was 29.3mb/d while the three countries produced 25.8mb/d. See OPEC. "Annual Report 2019." https://www.opec.org/opec_web/static_files_project/media/downloads/publications/AR%202019%20for%20web.pdf (Accessed November 24, 2021).

Impacts of COVID-19 pandemic on Japan's CO_2 emissions in FY2020

Ryo Eto*

1. Energy-related CO_2 emissions in FY2020 decreased by 5.9% on a year-on-year basis but mainly due to the COVID-19 pandemic

According to the FY2020 Comprehensive Energy Statistics based on a wide range of energy-related statistics published in April 2022 by the Ministry of Economy Trade and Industry, energy-related CO_2 emissions in FY2020 were 967Mt-CO_2, a 61Mt-CO_2 (5.9%) fall from the level of FY2019 and the smallest since FY1990 when statistically available (Fig.1). This is the equivalent of 21.7% below the level of FY2013 and the reduction pace is ahead of the target, 45% below the level of FY2013 in FY2030 published in the revised strategic energy plan October 22, 2021.

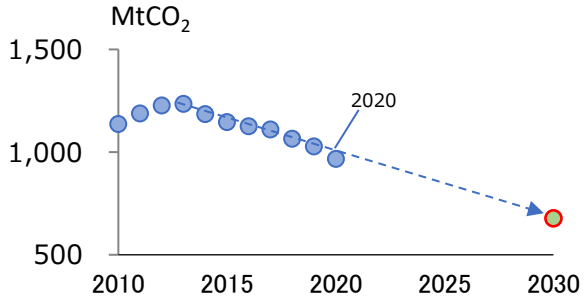

Fig. 1 CO_2 emissions and the target

Source: Ministry of Economy Trade and Industry "Comprehensive Energy Statistics"

Note: Actual data from FY2010 to 2020. Target of strategic energy plan for FY2030.

When the changes in CO_2 emissions from FY2013 are decomposed into three factors, a GDP factor, energy intensity factor[1], and a carbon intensity factor[2], while the GDP factor contributed to a 40Mt-CO_2 increase in FY2019 from the level of FY2013, it turned out to contribute a 6Mt-CO_2 decrease in FY2020 (Fig.2). CO_2 emissions decreases in FY2020 were achieved by economic depression triggered by the COVID-19 pandemic.

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[1] Energy consumption divided by GDP. If it gets smaller, it indicates an energy decrease, and if it gets bigger, it indicates an energy increase.

[2] CO_2 emissions divided by energy consumption. If it gets smaller, it indicates low carbon, and if it gets bigger, it indicates high carbon.

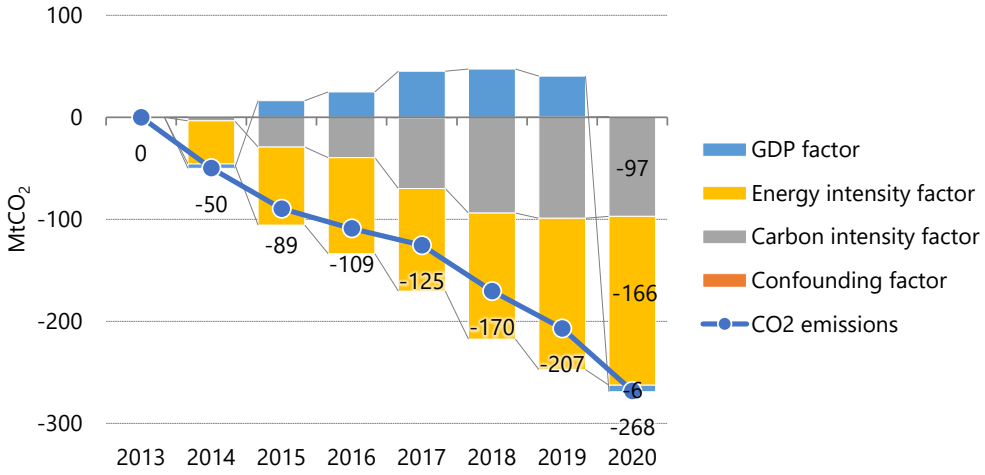

Fig. 2 Decomposition analysis of CO_2 emissions

Source: Ministry of Economy Trade and Industry "Comprehensive Energy Statistics"

This article develops a case where there was no COVID-19 pandemic and evaluates the impacts of the COVID-19 pandemic on CO_2 emissions in FY2020. Economic activity and energy consumption in this case are based on economic and energy outlook estimations of FY2020 published on December 23, 2019, by the Institute of Energy Economics, Japan, before the COVID-19 pandemic. In this regard, however, we use actual data of FY2020 for temperature which affects consumption in commercial and household sector, and plans of electric power supply such as the timing of restart of nuclear power generation and the start of operation of renewable energy and coal-fired power generation because they are considered unrelated to COVID-19.

2. Passenger transport and crude steel production were largely affected by the COVID-19 pandemic

When actual data is compared to the case without the COVID-19 pandemic, real GDP fell greatly (-5.0%) (Fig.3).

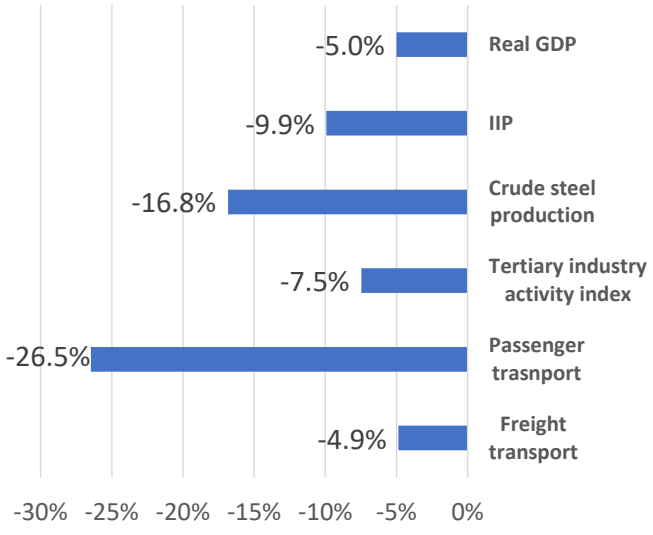

Fig. 3 Effects of COVID-19 on economic activity indicators in FY2020
(Actual data compared to the case without the COVID-19 pandemic)

Passenger transport was affected most among energy-related economic indicators due to stay-at-home advisories (-26.5%). Crude steel production was affected most among energy intensive industries (-16.8%). This was due to automobile factory production halts and delayed construction due to COVID-19 infection control. The tertiary industry activity index fell 7.5% with shortened opening hours of restaurants and entertainment services.

3. Coal decreased most among fossil fuel consumption due to COVID-19 pandemic

Fossil fuel in FY2020 decreased due to the economic activity fall caused by the COVID-19 pandemic (Fig.4).

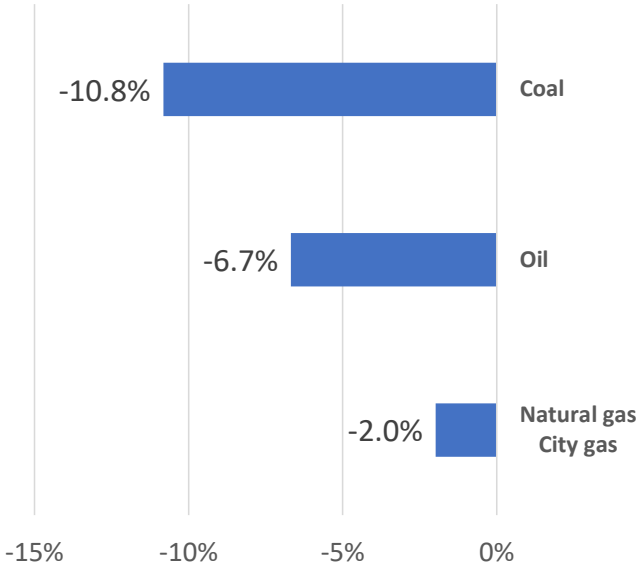

Fig. 4 Effects of COVID-19 on fossil fuel consumption in FY2020
(Actual data compared to the case without the COVID-19 pandemic)

Coal decreased by 10.8% reflecting falls in coal-fired power generation in addition to decreases in crude steel production. Oil decreased by 6.7% along with a fall in passenger transportation. Natural gas/city gas decreased by 2.0% along with falls in electricity and city gas demand in the industry and commercial sectors.

4. Energy intensity factor and carbon intensity factor contributed to reducing CO_2 emissions as well as the GDP factor due to the COVID-19 pandemic

CO_2 emissions were estimated to be 1,039MtCO_2 in FY2020 in the case without the COVID-19 pandemic, a 1.0% increase from FY2019. This indicates that 72MtCO_2(6.9%) in emissions were reduced by the COVID-19 pandemic. With the decomposition analysis of this 72MtCO_2, the GDP factor contributed the most to the decrease (-51MtCO_2) (Fig.5). In addition, the carbon intensity factor and the energy intensity factor contributed to the decrease. The carbon intensity factor contributed to the decrease because energy consumption decreased due to the COVID-19 pandemic and most of that decrease came from fossil fuels. In addition, the energy intensity factor contributed to the decrease because passenger transportation which has a small correlation with GDP fell. This indicates that in the rebound process from the COVID-19 pandemic, the energy intensity factor and the carbon intensity factor will contribute to increased CO_2 emissions in addition to the GDP factor.

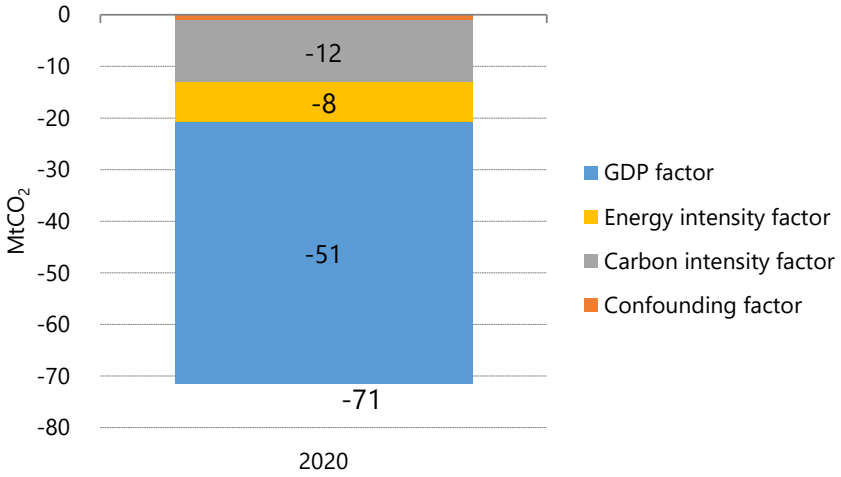

Fig. 5 Decomposition analysis of CO_2 emissions due to the COVID-19 pandemic (Actual data compared to the case without the COVID-19 pandemic)

5. Conclusion

While CO_2 emissions in FY2020 decreased 5.9% from the level of FY2019, this was caused by decreases in fossil fuel consumption mainly coal by COVID-19 pandemic. In the case without the COVID-19 pandemic, CO_2 emissions reach 1,039MtCO_2 in FY2020, an increase of 1.0% from the level of FY2019. The reduction pace, in that case, would be behind 45% below the level of FY2013 in FY2030. While the COVID-19 pandemic caused changes in consumption behavior, economic activity will be expected to be close to the case without the COVID-19 pandemic as back to a normal economic situation, fossil fuels will rebound and CO_2 emissions will increase. It is required for Japan to cut renewable energy costs and facilitate the restart of nuclear power plants in addition to energy saving investment in each sector.

Impacts of the Russian invasion to Ukraine on Japan's energy policy From the viewpoint of 3E+S

Ryo Eto*

On October 22, 2021, the Cabinet approved the Sixth Strategic Energy Plan. After the Fifth Strategic Energy Plan was approved by the Cabinet on July 3, 2018, the issue of climate change has been recognized as an urgent problem common to mankind. On October 26, 2020, Japan declared Japan's 2050 carbon neutral goal along with Japan's new target of a 46% cut by fiscal 2030 in GHG emissions compared to 2013 and to strive toward the higher goal of 50% announced on April 22, 2021. In addition to the growing interest in the climate change issue, changes in the lives of people due to the rapid spread of COVID-19 infections and the economic security environment in response to the changes in geopolitical and geo-economic situations are taken into account at the Sixth Strategic Energy Plan. In this regard, however, the geopolitical and geo-economic situations mainly focus on the US-China conflict and the situation in the Middle East. LNG prices on spot surge risk focus on changes in China's demand and oil prices surge risk to focus on the situation in the Middle East.

The aim of the energy policy is to first and foremost ensure stable supply ("Energy Security"), and realize low cost energy supply by enhancing its efficiency ("Economic Efficiency") on the premise of "Safety." It is also important to make maximum efforts to pursue environment suitability ("Environment"). Geopolitical and geo-economic issues that have arisen from the Russian invasion into Ukraine are required to be newly added to the viewpoint of 3E+S.

In the Sixth Strategic Energy Plan, Russia is recognized as increasing its military presence in the Middle East in terms of geopolitical and geo-economic issues. However, with the Russian invasion into Ukraine on February 24, 2022, new geopolitical and geo-economic issues arose only four months after approval by the Cabinet. In March, the European Union's Council decided to exclude seven Russian banks from the SWIFT (The Society for Worldwide Interbank Financial Telecommunication) system. With heightened concern regarding Russian energy exports, Brent crude hit over $130/bbl, which was the highest in 13 and half years since September 2008. With this surge, current energy price levels are beyond the scope of the assumption in the phase of creating the Sixth Strategic Energy Plan (the final report from the Working Group on generation costs[1]).

Energy Security is the most affected viewpoint among 3E+S. Using fossil fuels increases CO_2 emissions and price rises cause an outflow of national wealth and higher electricity prices. However, fossil fuels are necessary for the transition to carbon neutral in 2050 to secure installed capacity with sufficient supply capacity to respond to instantaneous and/or continuous drops in electricity generated by renewable energy on the supply side and heat utilization on the demand side and will account for 70% of primary energy supply in the 2030 target. Because Japan is dependent on the Middle East for about 90% of its crude oil imports and LNG imports account for most gas demand, Japan carried forward independent development of oil and natural gas, which Japanese companies are directly engaged in the development and production of, and developing domestic resources with the promotion of comprehensive resource diplomacy in terms of securing stable supply.

With this background, the Sakhalin 1 and 2 projects are important for contributing to diversifying suppliers and raising the independent development rate because they are geographically extremely close to Japan. However, sanctions against Russia have been tightened since the Russian invasion into Ukraine, and many Western companies withdrew from Russia. As well. Shell and ExxonMobil declared to withdraw from Sakhalin 1 and from Sakhalin 2 in the energy field. Japan needs to make careful consideration for stopping importing and developing from Russia since this will increase disadvantages in terms of energy security.

While the EU is dependent on Russia for about 45% of its natural gas imports, the EU made a plan to reduce the

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1 Fossil fuel prices are estimated with the trends in the new IEA policy scenario "World Energy Outlook 2020."

dependency rate to zero by 2030. To achieve the target, the EU will increase LNG imports as well as enhance energy efficiency and increase the use of renewable energy and nuclear. Since LNG is difficult to store and has little capacity to increase supply, supply and demand will be very tight if the EU increases LNG imports. Thus, stable LNG supply for Japan will be a more significantly important issue. In addition, the EU might seek postponement of the shutdown and restart of coal-fired power generation in order to reduce gas dependency on Russia. The EU imports half of its steam coal from Russia and thus is starting to move to Asia and Oceania such as Australia to switch from Russia. While Japan eyes diversifying energy sources and reducing import dependency, the importance of upstream investment besides in Russia will further increase.

The view of the Environment is important because the world trend toward carbon neutral will be unchanged even if concerns on stable supply become a bigger issue. Note that gas might be switched to coal with the postponement of shutdown and restart of coal-fired power generation as a consequence of more focus on stable supply in the short term. We need to look at how a focus on the importance of energy security due to the Russian invasion into Ukraine will affect the discussion of global warming. Japan will seriously consider early introduction as well as lowering prices of non-fossil energy such as hydrogen, ammonia, methanation, and offshore wind which will contribute to stable supply as well as decarbonization. In addition, if nuclear can restart earlier, it will contribute to stable supply and curbing electricity price rises as well as decarbonization.

In the view of Economic Efficiency, Japan also imposed economic sanctions on Russia, which negatively impacts Japanese manufacturers such as through revocation of the most favored nation status for Russia, halting Japanese automakers' production in Russia, and export regulations on machinery such as semiconductors and communication equipment. In the middle and long terms, manufacturers in Japan will suffer from higher production costs caused by high fossil fuel import prices induced by a tightened energy market due to the EU increasing LNG imports. Note, however, that while it is a concern that private investment will be postponed due to higher uncertainty arising from the unstable international situation and economic depression, higher fossil fuel import prices will enhance economic efficiency of energy-saving and decarbonization investment. In the transportation sector, introduction of electric vehicles is expected for decarbonization and if fossil fuel import prices rise, the competitiveness of electric vehicles will be higher. Note that the rare-earth metals required for electric motors and batteries are mainly located in Russia and China; thus, it will be required to cope with concerns about reducing the economic efficiency of energy-saving and decarbonization investment brought by price hikes and unstable supply of rare-earth metal.

While nuclear is one of the options to contribute to reducing fossil fuel dependency and 3E, Russian forces attacked the Zaporizhzhia nuclear power plant in Ukraine and military attacks on nuclear have come to pose a real threat. Discussions on nuclear will be held with increasing interests in this new risk. In Japan, emergency facilities that will remotely control a reactor in the case of a terrorist attack, natural disaster, or aircraft collision are required to be built for restart. What is first necessary is to strengthen and ensure nuclear safely by adjusting new nuclear safety regulations, then to take measures in view of the national defense that will be required against military attacks.

In this way, it is expected to examine individual policies against geographical issues which are not assumed in the current Strategic Energy Plan before revising it as well as incorporating the issues into the next one.

The Potential & Challenges of Renewable Energy Deployment in Japan

By Hiroko Nakamura*

Author
Hiroko Nakamura

In fiscal 2020, Japan's total power generation was 1,001 terawatt-hours (TWh), with 19.8% of the electric power supply generated from renewable energy (hereafter "renewable power"), including large scale hydropower. The share of renewable power has almost doubled from fiscal 2011 levels (10.4%). The Feed-in-Tariff (FIT) scheme introduced in July 2012 has contributed greatly to this massive increase. However, given the high surcharges under the FIT scheme shouldered by consumers, amounting to a total of around 2.7 trillion yen in fiscal 2021, an auction scheme was introduced for larger projects in 2017. In April 2022, a Feed-in-Premium (FIP) scheme will be introduced with the intention of encouraging power generators to act more in line with market trends.

With Cabinet approval of the Sixth Strategic Energy Plan, Japan has welcomed the new year with a new renewable deployment target for the electric power mix in 2030. This paper will examine current trends and challenges of renewable energy deployment in Japan.

How Challenging Are Japan's Renewable Energy Targets?

The Sixth Strategic Energy Plan, approved by the Cabinet in October 2021, renewed Japan's renewable energy targets. The new overall target aims to have an "ambitious" renewable power mix of 36-38% in 2030 compared to the previous target of 22-24% set out in the Strategic Energy Plan published in 2018. This amounts to a total of 336-353 TWh of renewable power, calling for installed capacity of 103.5-117.6 gigawatts (GW) of solar power, 23.6 GW of wind power (17.9 GW onshore, 5.7 GW offshore), 1.5 GW of geothermal power, 50.7 GW of hydropower, and 8 GW of biomass.

How does this compare to previous targets? The renewed targets do not call for significant increases in hydropower and geothermal power, but require efforts to upscale solar power, wind power, and biomass for which previous targets were 64 GW and 10 GW, and 6.02-7.28GW, respectively *(Chart 1)*. The installed capacity of these sources stood at 62.4 GW, 4.6 GW and 5.4 GW, respectively, as of June 2021. Taking into consideration the capacity of facilities already approved under the FIT scheme yet to be commissioned, an additional 22.6-36.7 GW will be needed to meet the renewed target for solar power, and an additional 7.7 GW for wind power. However, even the offshore wind projects for which winning bidders were recently selected will only come online in 2028 at the earliest.

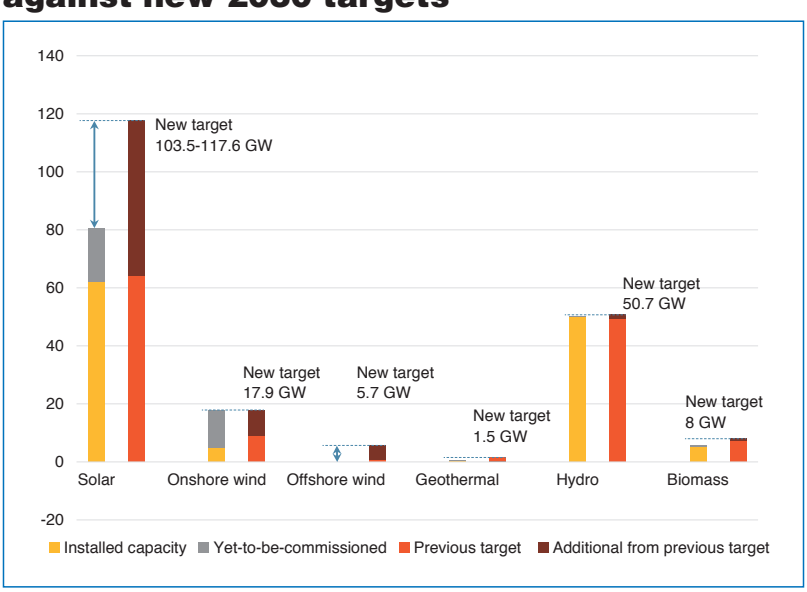
This paper will focus on the three sources that require significant efforts in increased deployment: solar power, wind power and biomass.

Solar Power – Main Driver of Renewable Energy Deployment

Solar power has been the main driver of renewable energy deployment in Japan *(Chart 2)*. Japan's increases in renewable energy will need to continue to rely on solar power in the short term, due to the shorter lead time required to install solar power generation facilities and the cost reductions already achieved for this technology. In order to achieve the renewed 2030 target, Japan will

CHART 1

Status quo of renewable energy deployment against new 2030 targets



Source: Compiled by the Institute of Energy Economics, Japan based on published METI data

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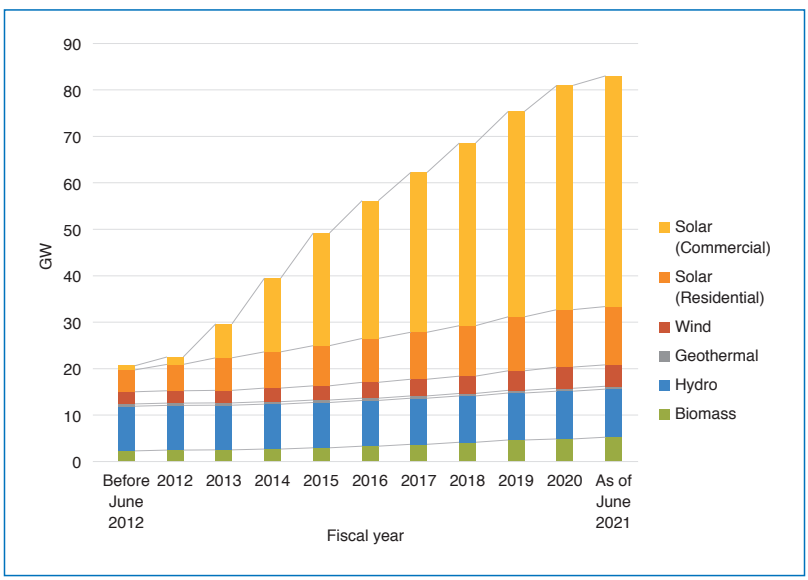
have to deploy 4-5.5 GW every year during the coming decade. However, with a FIP scheme to be newly introduced this year, a wait-and-see mood is expected to prevail in solar investments this year.

CHART 2

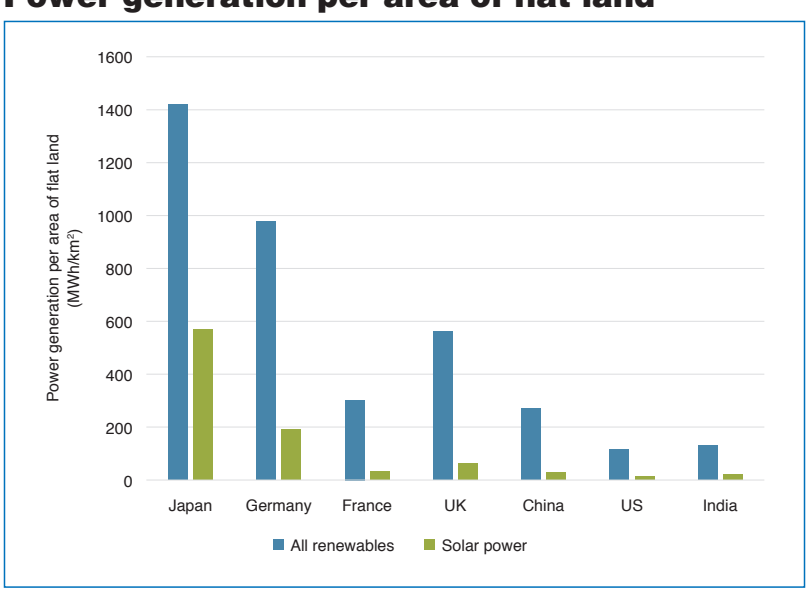
Renewable energy increases in Japan under the FIT scheme



Source: Compiled by the Institute of Energy Economics, Japan based on published METI data

CHART 3

Power generation per area of flat land



Source: Compiled by Institute of Energy Economics, Japan based on published METI data and IEA (2021) Renewables 2020

Overcoming land restrictions

Further increases in solar power entail many challenges. Japan already has the third-largest installed capacity of solar power in the world, only after the United States and China. The amount of solar power generated per area of flat land tops all other countries with 570 MWh/km^2. Germany follows with 190 MWh/km^2, or only one-third the figure for Japan *(Chart 3)*. This indicates the limits faced by Japan in increasing solar power generation.

Social acceptance has become another challenge. Natural disaster-induced accidents and landscape conservation issues have aroused local resistance against utility-scale solar power projects. This has led to a recent increase in the number of local ordinances that regulate the siting of solar power facilities. Therefore, in addition to the objective judgment of whether an accident is really attributable to the siting or if there were problems with the construction, there is a growing need for fostering good relations with the local community, which often have a sense of ownership of local natural resources or the landscape and ecosystem that it is a part of. Developers should make efforts to foster a win-win relationship with local communities, for example by demonstrating how the facility can be counted on for disaster relief. Local governments can play a key role in representing local values and ethics. To this end, the government seeks to initiate positive zoning measures and support local development plans for renewable energy.

In 2021, the Ministry of Agriculture, Forestry and Fisheries eased a requirement for farmers who install solar panels on abandoned farmland to produce 80% or more crops per square meter compared with the regional average. This will help promote agrophotovoltaics, which have become mainstream in many parts of Europe where such projects now represent a large share of winning bids in renewable power auctions. The Cabinet has recently approved a bill to facilitate the utilization of land plots with unknown owners. When this bill becomes law, more land area will be available for the installation of renewable power facilities.

Future applications

With the end of the FIT scheme for projects exceeding 1MW, onsite power purchase agreements (PPAs) are expected to continue to increase in the short term, mainly for self-

TABLE
Results of 2021 offshore wind power auctions

Area (capacity)	Goto (16.8 MW)			Akita Noshiro Mitane Oga (478.8 MW)			Akita Yurihonjo (819 MW)			Choshi (390.6 MW)		
Winning bidder	Toda Corp-led consortium			Mitsubishi Corp-led consortium			Mitsubishi Corp-led consortium			Mitsubishi Corp-led consortium		
Bidders	T	P	F	T	P	F	T	P	F	T	P	F
1)	207	120	87	208	120 (13.26)	88	202	120 (11.99)	82	211	120 (16.49)	91
2)	–			161.52	87.52 (18.18)	73	156.65	83.65 (17.00)	73	185.6	87.60 (22.59)	98
3)	–			157.77	93.8 (16.97)	64	149.7	58.73 (24.50)	91	–		
4)	–			149.35	71.4 (22.30)	78	144.73	78.2 (18.40)	66	–		
5)	–			127.04	69.0 (27.00)	68	140.20	62.58 (23.00)	78	–		

Notes: 1) – 5) indicate the ranking of bids. T stands for total; P for price score (total 120 points); F for feasibility score (total 120 points). Prices (yen/kWh) are provided in brackets for each bidder, calculated based on the price score, which represents the ratio to the winning bid.
Source: Compiled by the Institute of Energy Economics, Japan based on the joint press release by the Ministry of Economy, Trade and Industry (METI) and the Ministry of Land, Infrastructure and Transport (MLIT) dated Dec. 24, 2021

consumption in the industrial and commercial sectors. PPAs, which do not require upfront capital costs, will be an attractive option for public buildings, for which the government seeks to make the installation of solar panels mandatory by 2040. In the residential sector as well, a real estate developer has announced that it will install solar panels on all new residential buildings, using a PPA model.

Promising future applications for solar power are building facades, automobiles, roads and greenhouses. Innovative solar photovoltaic technologies can enable the application of solar modules to places that we could never imagine before due to their lightweight and flexible features. At the end of last year, a national research and development agency, the New Energy and Industrial Technology Development Organization (NEDO), announced plans to allocate 20 billion yen for the development of perovskite photovoltaic technologies, for which Japanese companies have demonstrated world-leading power conversion efficiency levels and innovating coating methods that greatly reduce production time and costs.

Offshore Wind Momentum

Japan initially introduced onshore wind power in the 2000s, but its deployment has been slow, accounting for only 0.9% of total power generation in fiscal 2020. According to the Japan Wind Power Association (JWPA), Japan bears the potential for around 128 GW of fixed offshore wind power in shallow ocean areas 10-50 meters deep and around 424 GW of floating wind power in areas 100-300 meters deep. Most of these areas are located in the regions of Hokkaido, Tohoku and Kyushu.

The year 2021 was a landmark year for offshore wind power, a promising technology for Japan, given its limited flat land area with optimal wind conditions. The government held the first round of auctions for offshore wind projects in sites designated as promotion zones under the Act on Promoting the Utilization of Sea Areas for the Development of Marine Renewable Energy Power Generation Facilities. The first auction was held for a project off the coast of Goto city in Nagasaki Prefecture. Only one bidder responded to the call and the result was finalized in June. Auctions were also held for three projects in the sea area offshore Noshiro city, Mitane town and Oga city, all in Akita Prefecture; the sea area offshore Yurihonjo city in Akita (northern and southern sides of the prefecture); and the sea area offshore Choshi city in Chiba Prefecture. The winning bidders for all three projects were announced on Dec. 24, 2021 *(Table)*.

The auction results for the three projects aroused both optimism and concerns for the future of offshore wind power development in Japan. The price target for offshore wind power in 2030-35 has been set at 8-9 yen/kWh. This had been considered an ambitious target compared to the FIT price of 36 yen/kWh for fixed-bottom offshore wind power initially determined in fiscal 2014. The winning bid for the Akita Yurihonjo project (11.99 yen/kWh) was less than half of the bid cap (29 yen/kWh) and offered reality to the feasibility of the 2030-2035 target.

Hopefully, the fact that consortiums led by the same corporate group won all three auctions with an outstandingly competitive price will not discourage future bidders from working closely with local stakeholders to foster good relations. A significant feature of the current Japanese auction scheme is that once a promising area for offshore wind projects is selected, a council comprising interested

parties, including local government and fishery cooperatives, is assembled to discuss the designation of a promotion zone and aspects the auctions should consider. The price score and feasibility score, which includes local considerations, are equally allocated 120 points. As aforementioned, fostering local understanding is essential for successful renewable power projects. While we have yet to see how these projects will play out, hopefully the Japanese auction model will set a promising example for other Asia-Pacific countries sharing similar circumstances, including those pertaining to local resource management.

Commenting on the auction results, Minister of Economy, Trade and Industry Koichi Hagiuda mentioned his idea to consider a scheme that would facilitate the participation of other players. The large-scale deployment of offshore wind power, which requires as many as 10,000-20,000 components, promises to have positive impacts on domestic industry. As turbines get larger, suppliers will have a larger incentive to develop and enhance local supply chains to reduce transportation costs. A wider range of project operators would allow for the diversification of the supply chain. However, the recent auction results could be a sign of early market consolidation in Japan.

Revisiting the Value of Domestic Biomass Resources

Biomass power generation accounted for 2.9% of Japan's total electric power generation in fiscal 2020. It used to have the largest renewable share in Japan's electric power mix before it was surpassed by solar power in fiscal 2014. The government has promoted the deployment of biomass power generation through the FIT scheme, but biomass power generation facilities of 10 MW and more will be covered by the FIP scheme from April 2022. "Locally integrated" projects contributing to enhancing local resilience and/or promoting the consumption of local products will remain eligible for the FIT scheme.

Japan faces several challenges in increasing biomass power generation, which requires a stable fuel supply. Many large-scale biomass-fired power plants currently rely on imported palm kernel shell (PKS) and wood pellets that can be procured stably. However, not only are these imports expensive, the use of PKS, in particular, is internationally debated from the perspective of socially and environmentally ethical supply chains.

With around two-thirds of its land covered with forest, Japan is home to a promising source of domestic woody biomass. Using domestic resources will increase the energy self-sufficiency rate, improve its resilience against natural disasters and contribute to the management and utilization of domestic forests, much of which have been left unmanaged for many years. Biomass power generation therefore promises to bring enormous local economic benefits, including employment. Government efforts to promote the use of forest residue and thinned wood have led to their increased use. However, fuel costs, which account for 70% of biomass power generation costs, still need to be reduced to ensure continued operation after the FIT expires.

The current forestry system has been developed mainly for high-value building materials, mostly made of conifers. Much domestic woody biomass for energy use is produced from thinning residues and other material that could not be used for building purposes. Because woody biomass for fuel use is a byproduct, it is difficult to forecast supply. Furthermore, the collection and transport system has been tailored to the needs of bulky lumber and should be made more cost-efficient for woody biomass for fuel use. This has disincentivized many biomass power generators from using domestic biomass and instead rely on more stable imported supplies.

Broadleaf trees, which comprise around 30% of forest accumulation in Japan, are not widely used for construction because they tend to grow crookedly. Therefore, systems to transport woody resources out of broadleaf forests are underdeveloped in many parts of Japan. We have yet to seek ways to harness these abundant domestic resources in a sustainable way. Thinning unmanaged forests will contribute to sustainable forest management and thus local water management. Securing demand would also contribute to the stable development of the local forestry industry. Domestic hardwood pulp materials may also be used in the pulp and paper industry, which also relies heavily on imported resources.

Planting fast-growing trees exclusively for fuel use can also save time and costs. The commercial use of fast-growing trees will lead to increased revenue for local forestry workers. Local procurement of woody biomass for power generation can create a sustainable win-win relationship between the forestry and power sectors.

Challenges pertaining to the use of woody biomass in power generation include retaining the quality of woody biomass resources, such as the moisture content which can affect the capacity factor. Local providers of biomass may develop drying processes or secure storage facilities to increase the value of their woody biomass products. Yet there is no standardization scheme in place to evaluate the quality of these products.

It will also be important to verify lifecycle GHG emissions, as well as to certify that woody biomass products are from sustainably managed forests. While biomass is considered a carbon neutral energy source, it should be kept in mind that if large amounts of fossil fuels are used along the supply chain, its CO_2 emissions could exceed the amount absorbed during photosynthesis. The government has been addressing such supply chain issues. Currently, there is limited information on the availability and distribution of woody biomass products. A transparent system visualizing supply and demand, tracing the origin of resources and tracking GHG emissions will be called for as more biomass is used in the power sector.

Other Challenges & Potential Solutions

Increasing renewable energy – especially variable renewable energy – in the power grid entails various challenges, including those associated with power transmission, supply-demand balancing and energy storage.

As aforementioned, offshore wind power is found in the Hokkaido, Tohoku and Kyushu regions, located far from the major urban electric power consumption areas. A masterplan for a transmission network based on the Sixth Strategic Energy Plan and the potential project areas is being discussed under METI. Related cost allocation is another topic of ongoing discussions.

Energy storage is also an issue to be highlighted in the massive integration of variable renewable energy in the power grid. Pumped storage and battery technologies are key solutions to providing flexibility to the grid. Grid-scale battery energy storage systems (BESS) can smooth out output fluctuation and thus contribute to accommodating high shares of renewable energy. Japan is a global leader in the development of various battery technologies but further cost reductions are called for.

Surplus renewable power can also be used to produce hydrogen, which can be stored for longer periods of time in fuel cells. A power-to-gas (P2G) system using a water electrolysis process to use electricity to split water into hydrogen and oxygen can provide grid balancing services and demand management. A hydrogen utilization business model that optimizes the exploitation of hydrogen both as a commercial commodity and an energy source for balancing the supply and demand of the electricity grid is currently being demonstrated at Fukushima Hydrogen Energy Research Field (FH2R), which only recently supplied fuel for the relay torch and hydrogen-powered vehicles used at the Tokyo Olympics and Paralympics Games. Since hydrogen can be used in sectors other than power generation, the P2G model is an optimal solution for energy system integration, or sector coupling.

Another issue often overlooked is the secure procurement of metals that will be required in large quantities as the world shifts to low carbon forms of energy and to the massive deployment of renewable energy. In addition to the rare earth and rare metals required for various battery and fuel cell technologies, metals such as copper will be required in greater amounts not only for electric mobility but also for wind and solar power facilities.

New Frameworks for Promoting Renewable Energy

The year 2021 saw many demand-driven changes in the market framework of renewable power procurement. Amid the growing momentum for achieving carbon neutrality, this trend was largely led by major companies seeking to procure large amounts of renewable power with “additionality” in Japan.

Japan’s Renewable Energy Value Trading Market held its first auction in November 2021. Renewable energy value had been traded in the Non-fossil-Value Trading Market, open only to electricity retailers, who purchase credits to fulfill their obligation under the Act on Sophisticated Methods of Energy Supply Structures to achieve a non-fossil electricity ratio of at least 44% in their electricity sales by 2030. The newly launched market, which was detached from the Non-fossil-Value Trading Market, allows consumers to directly purchase renewable energy value certificates.

Some key discussion points in launching the Renewable Energy Value Trading Market were the nature of the FIT certificates – whether they would simply guarantee renewable energy sources or if they would function as a guarantee of origin – and price levels. The development of a permanent tracking scheme for certificates is underway.

Japan saw a significant increase in onsite and physical (offsite) PPAs in 2021. A number of milestone physical PPAs between developers and consumers were signed with registered retailers under the Electricity Business Act. METI changed the rule in November 2021 so that corporate consumers can use the self-wheeling program for electricity generated at new sites owned by other companies. The benefits of the self-wheeling program, which include a smaller wheeling fee and exemption from surcharges, could previously only be enjoyed for transferring self-generated electricity to other locations through the grid. Sometime in the near future, a deregulation of Non-fossil Value Credits market rules may allow direct virtual PPA contracts between developers and consumers.

Conclusions

It is often speculated whether or not the ambitious goals set out in the new Strategic Energy Plan can be met. However, in our drive toward a decarbonized society, the question is how we can achieve it. Despite the various challenges associated with massive deployment and integration of renewable energy, there is still much unlocked potential. Creative market and business models, as well as innovative technologies, will help harness our renewable resources in a sustainable way. JS

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FIT Auction Trends for PV Power Generation

Hideaki Obane*

1. Recent clearing prices are roughly double the international average

Japan revised Feed in Tariff (FIT) in April 2017 to Photovoltaic (PV) system price above a certain scale based on auctions. Up to now, eleven auctions have been held. The capacity of the PV systems offered for bidding, the price cap, and its disclosure or non-disclosure have been reviewed several times. The most recent auction, the eleventh, was held with a price cap of 10.25 yen/kWh (disclosed in advance) for facilities with a capacity of 250 kW or more.

The supply price trends from the first auction held from September to November 2017 through the most recent auction, the eleventh, indicate that the price has halved in the roughly three-year period from a weighted average of 19.64 yen/kWh at the first auction to 9.99 yen/kWh at the eleventh (Fig. 1). Further, the price was 12.98 yen/kWh (for 500 kW or higher) at the fourth auction held in FY2019, which was below the generation cost target of NEDO's solar power generation development strategy of 14 yen/kWh through FY2020.

Though declining, however, Japan's supply price remains high at more than double the global average bidding price for PV[1] (3.72 ¢/kWh). Despite having the world's third largest installed PV capacity, Japan's bidding price for PV is indeed high compared with just 6.79 ¢/kWh in Europe (2020 average), where irradiance tends to be lower than in Japan. With its total FIT surcharge expected to exceed 4.5 trillion yen in FY2030[2], Japan needs to reduce its PV generation costs efficiently.

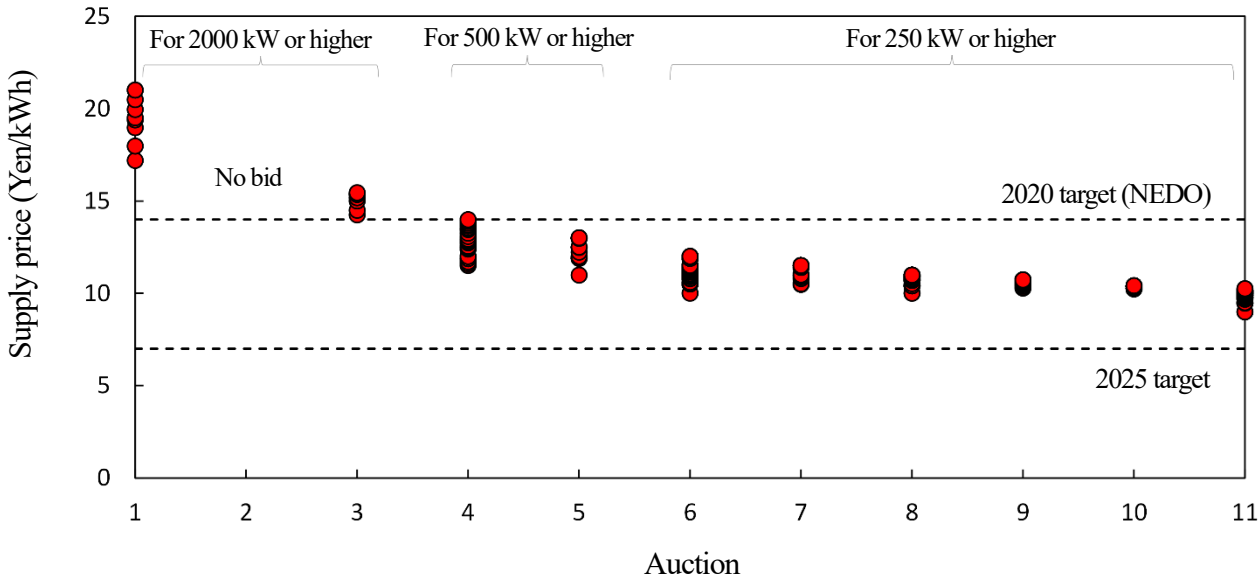

Fig. 1 Trends in supply prices at PV FIT auctions [yen/kWh]
(estimate based on various results from the bidding system based on the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources, OCCTO)

2. Awarded capacities have fallen below auctioned capacities in seven of 11 auctions so far

The purpose of the auction system is to reduce costs efficiently by securing opportunities for competition and facilitating price competition. However, if we compare the total capacity offered at the first to the eleventh auctions and the capacities

* Senior Economist, Energy and Economic Analysis Group (EEA), Energy Data and Modelling Center (EDMC), IEEJ
[1] International Energy Agency, Average auction prices for solar PV by region and commissioning date, 2016–2022
[2] Kenji Asano, Hideaki Obane, *"Estimate on the Installed Capacity and Purchase Price of Renewable Energy in 2030,"* Socio-Economic Research Center publication Y19514, 2020

that were awarded, the awarded capacities were lower than the auctioned capacities in seven of the 11 auctions. In particular, bids were placed for only 10% of the auctioned volume at the seventh auction (Fig. 2). Moreover, though the total capacity of bids placed was larger than the auctioned capacity and counted 81 bids in total at the tenth auction, many bidders were placing multiple bids, and the number of actual participants was just 45 companies.

Unlike offshore wind power in which plants have to be installed at designated sites, PV generation operators have a lower risk of losing business to competitors in areas which they are planning to develop. This allows them to place bids at relatively high prices, and if they lose, to try again at the next auction. As such, when bids repeatedly fall short of auctioned volumes, the situation tends to create an incentive to place bids at prices as close to the price cap as possible. Indeed, a comparison of the weighted average of the highest bidding prices and the clearing prices shows that the highest bidding prices were extremely close to the clearing prices at all eleven auctions (Fig. 3). This suggests that the bidding prices have been declining so far not because of cost reductions induced by competition, but because the price cap itself has been declining. To reduce costs through competition going forward, it will be important to revise the system, such as expanding the scale of eligible generation facilities and changing the auctioned volume.

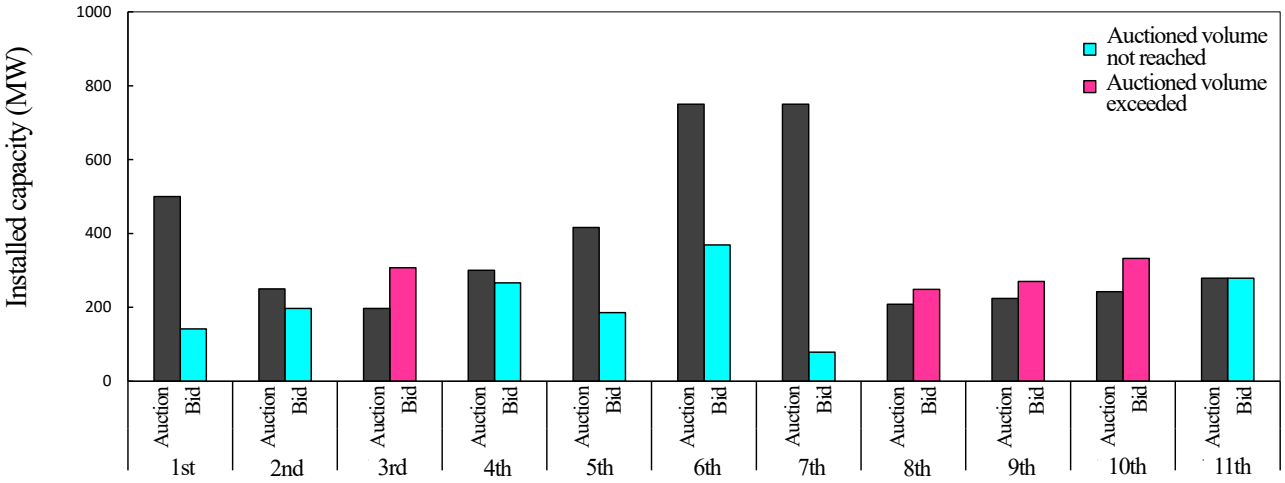

Fig. 2 Auctioned volume versus total volume of bids placed [MW]

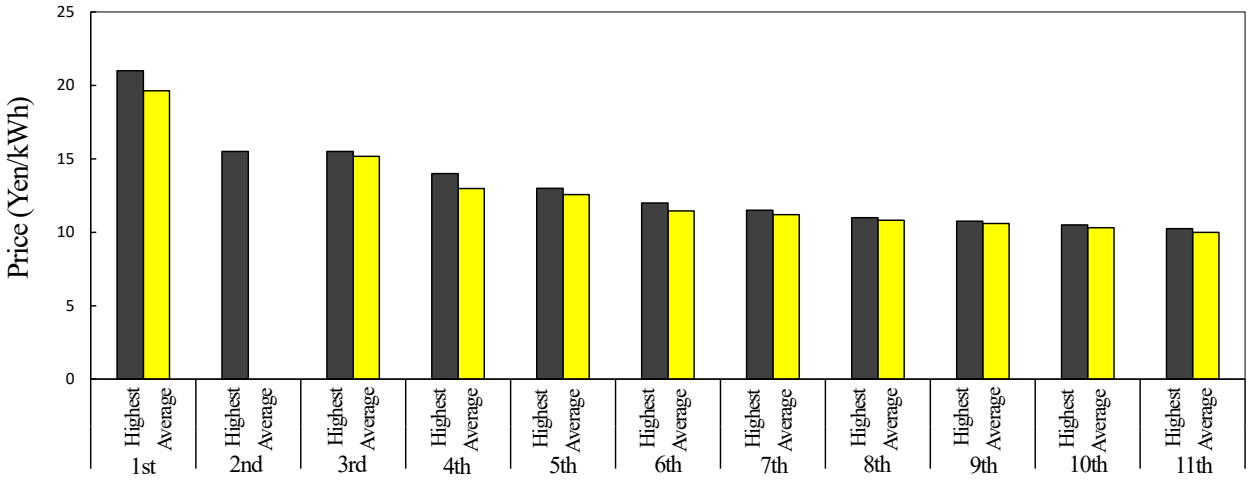

Fig. 3 Comparison of highest bids and clearing prices (weighted averages) [yen/kWh]

3. Future cost reductions must proceed simultaneously with siting guidance and ensuring reliability

As described earlier, the clearing price for the eleventh auction (9.99 yen/kWh, weighted average) was roughly double the global average bidding price and has not reached the 2025 target generation cost (7 yen/kWh) sought by the Japanese government. While further reductions in PV generation costs are desired, the following matters must also be considered.

First is the change in locations of PV plants. Utility PV plants have so far been installed largely in residential areas (not on buildings) close to the power grid to lower installation costs, or in forests and woods with low land prices. According to the Forestry Agency, approximately 90 km^2 of forests had been modified by 2019 to install PV systems[3] under its forest development permit system. However, installation in residential areas and forests is set to face tougher regulations going forward based on amendments to municipal ordinances and positive zoning that the Ministry of the Environment has been planning in recent years. As such, it will be increasingly important to install PV panels in places that are less susceptible to regulations, such as rooftops of buildings. Meanwhile, PV panels installed on buildings will tend to be smaller in size and more complex to install compared to ground installations. Whether costs can be reduced for these locations will be key.

Second is ensuring reliability. While PV generation costs have fallen significantly in some cases, many PV system-related accidents have also occurred, such as PV panels being ripped off during typhoons and torrential rains. According to a survey by the Commerce Distribution and Industrial Safety Policy Group of the Ministry of Economy, Trade and Industry[4], about 40% of the 79 installations surveyed did not have their calculated strength, did not meet their design basis wind speed, or their design basis wind speed was unknown. While not all inexpensive installations have issues, it is important to ensure reliability simultaneously when reducing costs.

As described above, given the expected changes in circumstances and the design requirements for PV systems going forward, there is no guarantee that PV power generation costs will continue to decrease as they have done so far; in fact, these factors could even drive up costs. It is hoped that the reduction of PV generation costs will proceed simultaneously with the siting guidance through municipal ordinances and zoning, as well as ensuring reliability.

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[3] Forestry Agency, *"Forestry Agency's Efforts regarding the Development of Forests to Install Solar PV Facilities,"* September 2021

[4] Ministry of Economy, Trade and Industry, Commerce Distribution and Industrial Safety Group, Electric Power Safety Division, Strengthening Efforts to Ensure Safety of Solar PV Facilities

What is Happening Now in the Flow Battery Space?

A Growing Demand for Long-duration Energy Storage, and the Rise of New Players

Masato Yoshida*

1. Introduction

Published in an April 2021 IEEJ publication[1], this paper looks at the technical characteristics, costs, global market size, and role at Japanese companies of vanadium redox flow batteries (VRFBs), which are seeing commercial use in power grids worldwide. It also explores cases of commercial applications and presents issues requiring resolution if the market is to see further proliferation and growth. Recent years have seen unprecedented changes happen in the flow battery space as it matures into a business domain. This paper provides an overview of characteristic changes taking place with respect to flow batteries, and examines the implications and impact of these changes.

2. Expanding investment in batteries as a clean energy technology

To begin, we will look at the amounts being invested in the clean energy technologies needed to achieve greenhouse gas neutrality by 2050, as well as the role of batteries in this endeavor. As part of the Net Zero Emissions by 2050 Scenario in its World Energy Outlook 2021, the International Energy Agency (IEA) estimates that 4 trillion dollars of annual clean energy technology investment will be needed by 2030. It further estimates that a total investment of 27 trillion dollars will be needed by 2050, more than 60% of which will be in batteries, and sees three terawatt hours of battery capacity being deployed worldwide by 2050 (including automotive batteries, Fig. 1)[2].

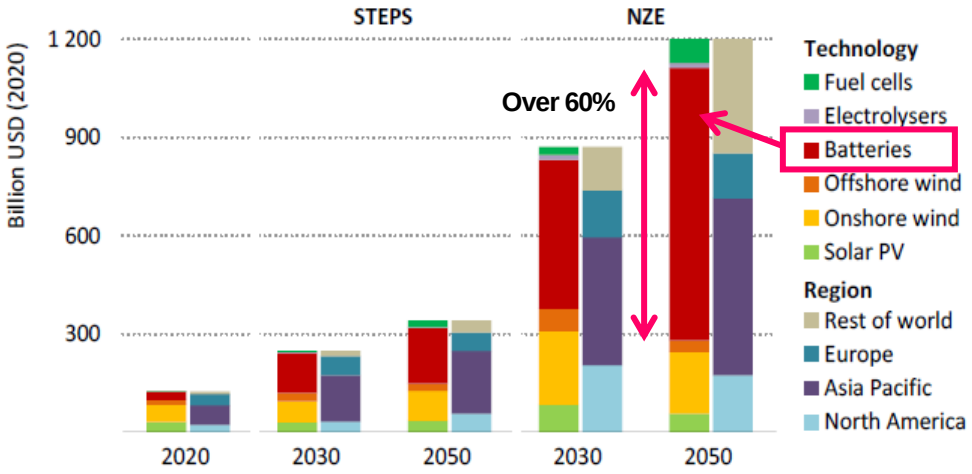

Fig. 1 Clean energy investment market size (by technology and region, 2020-2050)

Note: Stated Policy Scenario (STEPS): A scenario that accounts for all publicized policies and targets

Source: IEA, *World Energy Outlook 2021* (October 2021)

The Announced Pledges Scenario, announced by the IEA at WEO2021, continues to diverge significantly from the Net Zero Emissions by 2050 Scenario and points to a need to fill gaps by prioritizing the reduction of emissions in the electricity

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[1] Yoshida (April 2021), *What Would Be the Most Suitable Battery for Utility-scale Energy Storage?- Redox Flow Battery Has Great Potential -*, Institute of Energy Economics, Japan

[2] IEA (October 2021), *World Energy Outlook 2021*, International Energy Agency, p.30.

sector, improvement of energy efficiency, reduction of methane emissions, and investment in hydrogen fuels and other low-carbon fuels, along with clean energy technologies. Low-carbon power[3] accounted for roughly 28% of global emissions as of December 31, 2020. Citing a need to increase this to 61% by 2030 and 88% by 2050, the Net Zero Emissions Scenario predicts that **batteries for the power grids needed to achieve that goal will, by 2030, grow to 18 times the 2020 level under the Announced Pledges Scenario and to 30 times that level under the Zero Emissions Scenario[4].**

A sharp decline in the costs of solar PV and wind power generation over the last 10 years has driven this increased deployment worldwide. Similarly, costs are expected to drop considerably for long-duration (8-24 hours) energy storage technologies. **Assuming a conservative learning curve, the equipment costs for long-duration energy storage technologies are predicted to conceivably decline by up to 60% per unit output ($/kW) and up to 40% per unit energy ($/kWh) over the 15-year period beginning in 2025 (Fig. 2).**

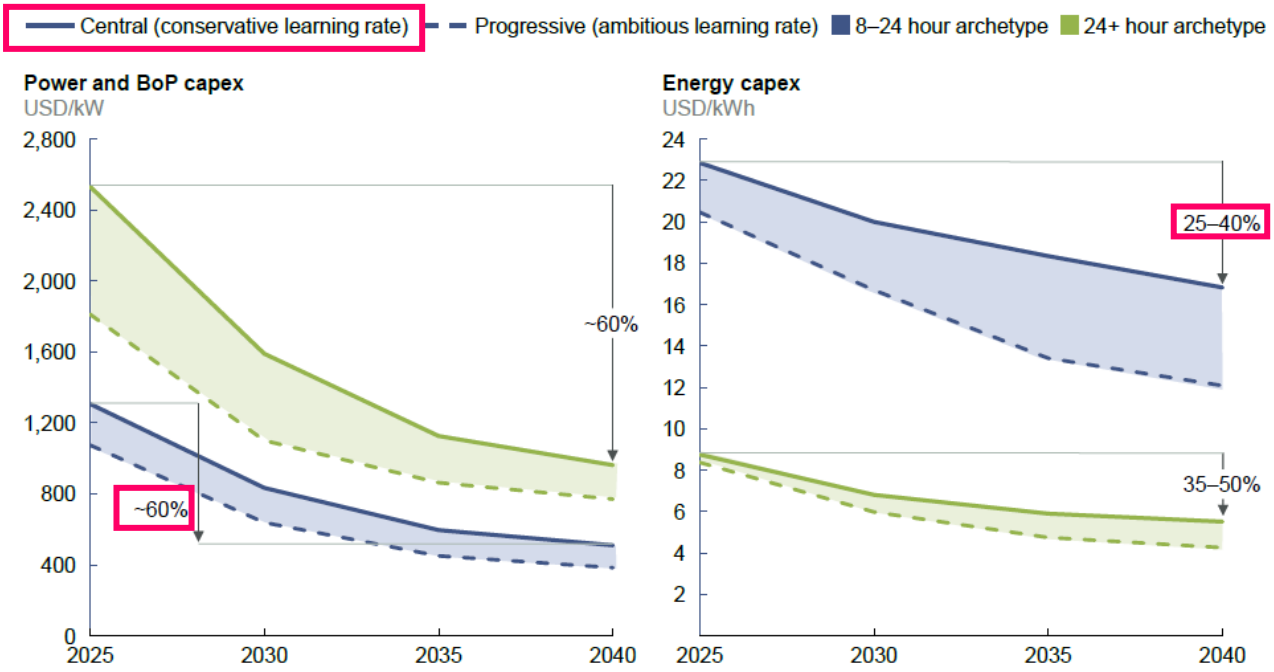

Fig. 2 Outlook on long-duration energy storage technology costs (2025-2040)

Source: LEDS Council (November 2021)[5]

3. Mature sectors - Characteristic changes in the vanadium redox flow battery space

This section will look at characteristic trends and changes happening in the vanadium redox flow battery space, which is making advances both in terms of technology and the market.

(1) Largo Resources - Vanadium product manufacturers getting into VRFB production and sales through vertical integration

Largo Resources (Canada) supplies customers in the steel, aviation, and chemicals industries with highly purified vanadium products. In December 2020, the company announced that it would establish Largo Clean Energy and acquire from VionX Energy a group of patents related to vanadium redox flow batteries[6]. This enabled Largo Clean Energy to sell

[3] Refers to zero-carbon energy or extremely low-GHG energy
[4] IEA (October 2021), *op.cit.*, pp.37-40
[5] LDES Council (November 2021), *Net-Zero Power Long Duration Energy Storage for a Renewable Grid*, Long Duration Energy Storage Council, p.27
[6] Largo Clean Energy (December 10, 2021), "Largo Resources Launches Largo Clean Energy," https://www.largocleanenergy.com/post/manage-

VRFBs under the VCHARGE +/- brand. Meanwhile, Largo Clean Energy hired core members from VionX Energy's technical team and succeeded in self-developing the kind of VRFB expertise and core technologies that took VionX Energy many years to achieve. Along with VRFB technologies that have been proven commercially viable, this deal has also seen the groundwork laid for scaling up in the future, including VionX Energy's investment of over 150 million dollars toward optimizing operations. These deals have led to the advent of vertically-integrated VRFB companies by major vanadium industry players. (Fig. 3)

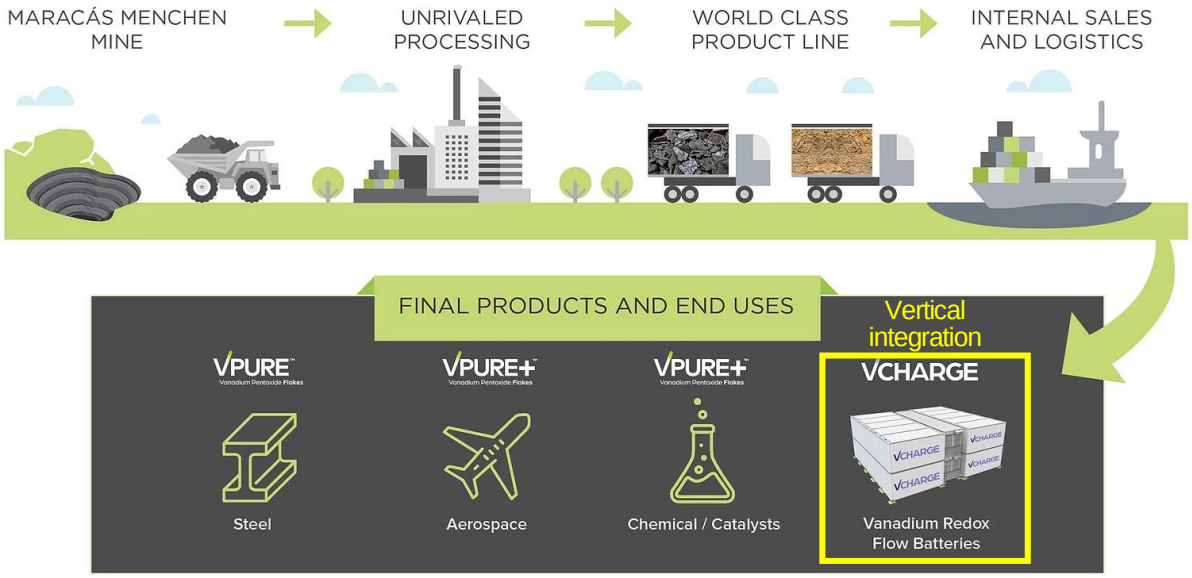

Fig. 3 Entry into the VRFB manufacturing industry by Largo Resources (vertical integration)

Source: Prepared by the author based on data from Largo Clean Energy[7]

Largo Resources' vertically-integrated approach, which consists of a combination of using patented VRFB electrolyte processing technologies and industry-leading flow battery stack technologies, and supplying the highly-purified vanadium needed for vanadium electrolyte production, is a competitive one that will enable the company to reduce VRFB production costs by up to 40%. In July 2021, it was agreed that Largo Resources would supply its first-ever VRFB system (5 hours, 6.1 MWh) to a Spain-based subsidiary of Italy-based Enel, with operations to commence in 4Q 2022[8]. Largo Resources is planning to boost its VRFB production to 180 MW / 1,400 MWh by 2025 by fully leveraging the strengths of its vertically-integrated approach.

(2) Bushveld Minerals - A vanadium mining company that produces and sells VRFB through a combination of horizontal and vertical integration

Bushveld Minerals (South Africa) is a major miner, exporter, and supplier of vanadium. It had been indirectly involved in vanadium supply as well as VRFB production and supply through horizontal investments in Austria-based Enerox GmbH (50% stake), a producer of VRFB and supplier of VRFB under the CellCube brand, and UK-based Invinity Energy Systems (less than 3% stake), a major manufacturer and supplier of VRFB. In 2016, however, **it became directly engaged in the VRFB production and sales industries with the establishment of Bushveld Energy (vertically integrated) (Fig. 4)**.

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[7] Largo Clean Energy, "About Us," https://www.largocleanenergy.com/about

[8] Largo Clean Energy (July 21, 2021), "Largo Enters into its First Battery Sales Contract with Enel Green Power España for VCHARGE± System," https://www.largocleanenergy.com/post/largo-enters-into-its-first-battery-sales-contract-with-enel-green-power-espa%C3%B1a-for-vcharge-system

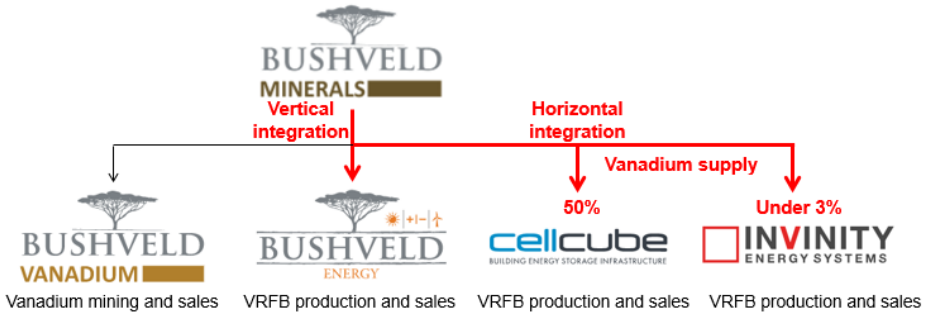

Fig. 4 Bushveld Minerals' expansion of the vanadium business domain (horizontal-vertical integration)

Source: Prepared based on data from Bushveld Energy's website[9] and various other data[10,11]

Bushveld Energy is starting by opening the vanadium market in South Africa. Working with the Industrial Development Corporation of South Africa Ltd (IDC) Bushveld Energy is supplying VRFB systems (120 kW, peak energy 450 kWh) to state-owned power utility Eskom, and is currently conducting a proof of concept for the systems Furthermore, at its vanadium mines, the company is building mini-grids consisting of both solar PV (3 MWp) and VRFB systems (1 MW, 4 MWh) with the goal of reducing power costs and peak usage (Fig. 5).

Fig. 5 VRFB project by Bushveld Energy (Vametco Hybrid-Mini-Grid)

Source: Bushveld Energy's website[12]

4. Maturing sectors - Paving the way for more venture companies with new technologies and possibilities of early scaling up

In the previous section, we looked at characteristic trends and changes happening with vanadium flow batteries, a technically mature space and rapidly expanding market. This section will summarize trends and changes happening in the flow battery space due to new and technically immature technologies.

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[9] Bushveld Energy, https://www.bushveldminerals.com/bushveld-energy-3/
[10] Mining Weekly (November 13, 2019), "Bushveld group advances vanadium redox flow battery plans through Enerox deal," https://www.miningweekly.com/article/bushveld-group-advances-vanadium-redox-flow-battery-plans-through-enerox-deal-2019-11-13/
[11] Energy Storage News (April 6, 2021), "Vanadium producer Bushveld invests in scale up of Enerox flow battery manufacturing," https://www.energy-storage.news/vanadium-producer-bushveld-invests-in-scale-up-of-enerox-flow-battery-manufacturing/
[12] Bushveld Energy, "Projects - Vametco Hybrid-Mini-Grid," https://www.bushveldenergy.com/company/projects/

(1) U.S.-based ESS Inc. - A specialized venture company that deals in iron flow batteries and that has the attention of even Bill Gates

ESS Inc.[13] was listed on the New York Stock Exchange through a SPAC[14] merger. Shockingly, despite having no revenues, the company was valued at ¥110 billion at the time of its listing. As an indication of the considerable expectations investors had for its growth, its stock price went up 70% on the first day of trading.

ESS Inc. is a venture company that specializes in iron flow batteries (Is). What exactly are IFBs and why is so much attention being given to ESS' IFBs, despite their immaturity as a technology?

Fig. 6 shows the principle of operation for ESS' IFBs, while Fig. 7 shows their cell unit and power module. ESS' IFBs have a carbon substrate with carbon material used for the positive electrode and carbon composite substrate with polypropylene spacer for the negative electrode. A pump injects electrolytes (in aqueous solution containing iron chloride ($FeCl_2$), and charging and discharging occur from the resulting oxidation-reduction reactions. According to ESS, as with VRFBs, IFBs can charge and discharge without limit as they suffer no degradation, even from over-discharging[15]. Furthermore, since they are made primarily from iron, salt, and water, they are a non-toxic, highly-safe battery with zero fire risk.

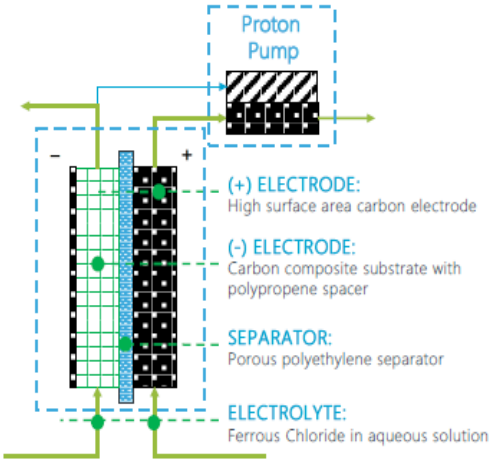

Fig. 6 Principle of operation for IFBs

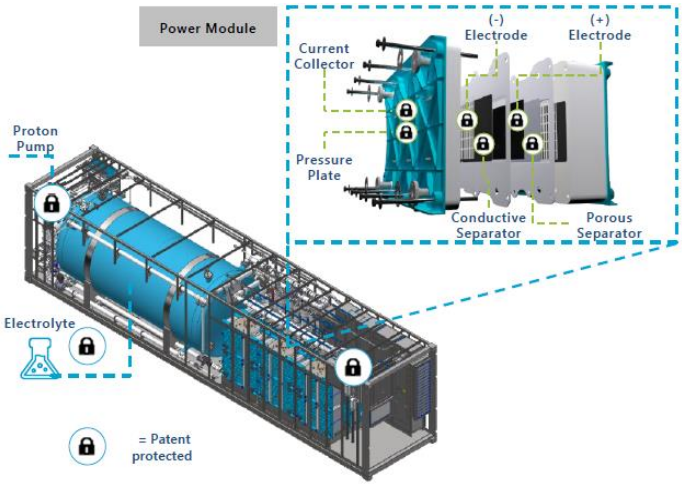

Fig. 7 Cell unit and power module

Source: ESS Inc.[16]

The most groundbreaking thing about ESS' IFBs is their cost. ESS is targeting the market for power grids and other such large-scale markets that require long-duration energy storage of four to twelve hours, which is something for which lithium-ion batteries (LiBs) are ill-suited. LiBs lead the market and have found widespread adoption, primarily in automotive and household applications, due to their high energy density, small size, and light weight[17]. However, they are not well-suited to a larger form factor as the rising cost of the lithium inside them would compromise their cost competitiveness. Moreover, they can only charge and discharge for up to about four hours. In general, VRFBs are said to be more cost competitive than LiBs when their charge and discharge time exceeds eight hours. On the other hand, **IFBs are said to be cost competitive**

[13] Its ticker symbol is "GWH" (gigawatt hours)
[14] A special purpose acquisition company (SPAC) is a publicly traded company created in order to merge with an existing company in the future. Many SPACs have been listed in the U.S. because of the relatively simpler procedures and shorter time frame involved in getting listed relative to the conventional listing process.
[15] Refers to an extremely low-voltage state in which discharge continues even after the voltage falls below the discharge cut-off voltage (the lowest discharge voltage at which discharge can still be safely done)
[16] ESS Inc., "Long Duration Energy Storage Systems for a Cleaner Future," https://essinc.com/wp-content/uploads/2021/08/ESS_Analyst-Day-Presentation-8-30-21.pdf
[17] Ibid., Yoshida (April 2021), Institute of Energy Economics, Japan

versus LiBs in systems where charge and discharge time exceeds four hours (see Fig. 8). Electrolyte costs account for around 40% of the cost of producing VRFBs (this cost rises as a percentage of total battery cost as charge and discharge time increases), and the cost of vanadium, which is the primary component of electrolytes, accounts for about 45% of electrolyte costs. This makes reducing electrolyte costs key to reducing overall VRFB system costs. Unlike lithium, where resources are unevenly distributed, vanadium are ubiquitous worldwide. However, vanadium, the primary component of VRFB electrolytes, exists only in low concentrations in ore due to the many byproducts of mining activities such as phosphate rock, magnetite, and uranium that are produced when it is mined. Furthermore, the export market for vanadium is oligopolistic, with three countries - China (60%), Russia (17%), and South Africa (7%) - accounting for roughly 85% of all vanadium production. Furthermore, vanadium prices are rising[18] in the international commodities market due to rising demand for long-duration energy storage as a means to achieve net zero GHG emissions by 2050. Vanadium producers therefore face two risks: resource constraints and rising procurement costs. In contrast to VRFBs, IFBs suffer from no resource constraints as they are made from iron, salt, and water - all widely available and readily usable resources. Being relatively more stable in price and easier to procure gives them a significant advantage. **By scaling up, it is said that they could be capable of achieving a lifecycle cost of storage (LCOS) of 0.02 $/KWh in 12-plus-hour systems (Fig. 8)**.

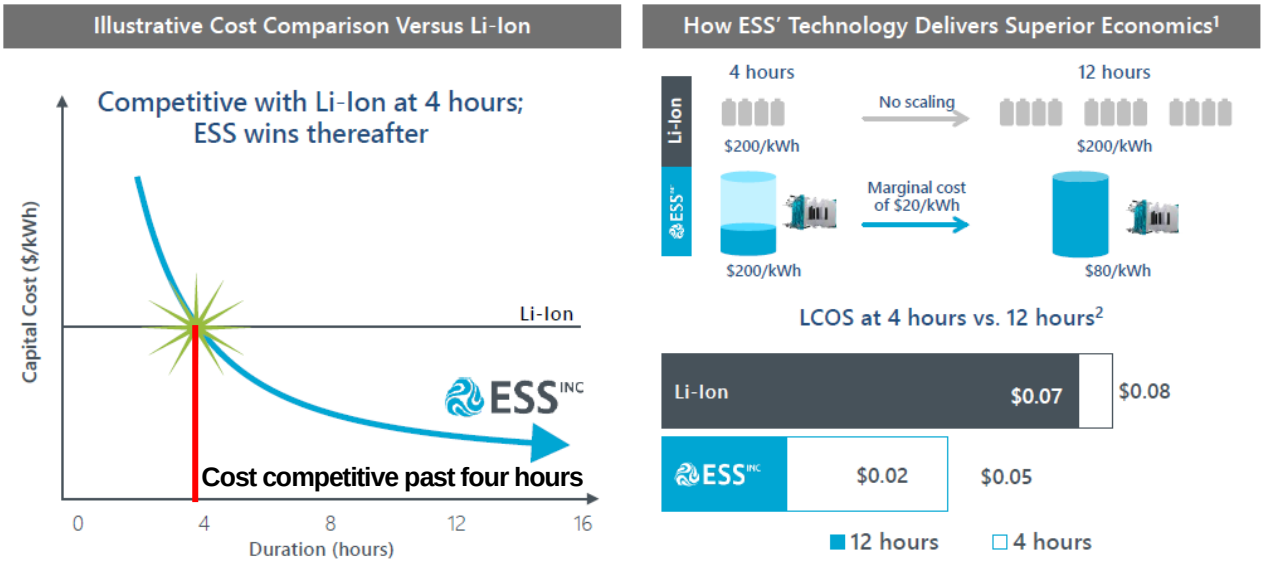

Fig. 8 Iron flow battery cost competitiveness (compared to LiBs)

Source: ESS Inc.

Using the 300 million dollars it has raised through its listing, ESS plans to rapidly scale up its business. Specifically, it will bring the production capacity of its IFB manufacturing facility in Oregon, which is currently at 250 MWh, to 2 GWh by the end of 2022 and 6 GWh by the end of 2023, achieving a 24x increase over the next two years. Moreover, in addition to expanding its facility in the U.S., the company is currently thinking about making the most of the aforementioned lack of resource constraints and building new IFB production facilities in Asia and Europe.

[18] https://www.investing.com/commodities/ferro-vanadium-80-min-europe-futures-streaming-chart

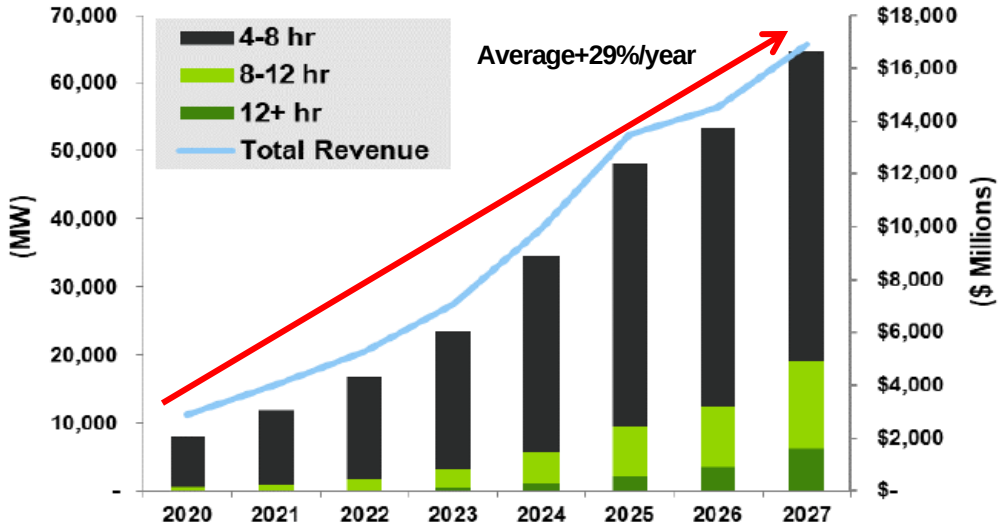

Fig. 9 Deployed nameplate capacity and market size of long-duration energy storage batteries (2020-2027)

Source: Guidehouse[19]

ESS' haste to scale up is to meet rapidly growing market demand. In recent years, California has been conducting large-scale planned power outages in order to prevent major forest fires caused by aridness and strong winds. Texas saw cold snaps in 2021 that far exceeded expectations and led to a power failure that lasted several days. These frequent outages and power failures caused by frequent natural disasters, themselves partly the product of global warming, have shaken the world's confidence in the United States' power grids, creating an urgent need to deploy long-duration energy storage technologies for use in backup applications. California estimates that it will need to deploy up to 11 GW of batteries capable of four-plus hours of charge and discharge time by 2030, and to deploy you can also get on up to 55 GW by 2045 to achieve climate change mitigation targets[20]. The increasing magnitude of natural disasters is a growing concern around the world. Consequently, **demand for batteries with a four-plus hour charge and discharge time is expected to increase at an annual average rate of more than 29% over the next seven years (Fig. 9)**.

Based on the above, ESS estimates that the market for long-duration batteries could grow to 700 billion dollars by 2027. ESS signed numerous large sales contracts in 2021, indicating that expectations are indeed high for the company's IFBs. SoftBank subsidiary SB Energy signed a contract with ESS to purchase up to two gigawatts of IFBs through 2026[21]. Similarly, Italy-based Enel concluded an agreement to buy 17 Energy Warehouse systems (a consumer-side battery system; ESS will also supply Energy Center as a front-of-the-meter product; Fig. 10) through a renewables subsidiary in Spain[22]. Taking advantage of a technical characteristic of IFBs whereby they do not degrade after repeated charges and discharges, ESS will work with Munich Re, the world's largest reinsurance company, to provide quality assurance for 10 years. Developments such as these illustrate the visionary and convenient sales methods being implemented[23].

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[19] Guidehouse (October 20, 2021), "White Paper: Energy Storage for the Decarbonizing Grid," https://guidehouse.com/-/media/www/site/insights/energy/2020/gh_eos_whitepaper_decarbstoragelongduration_2020.pdf?la=en

[20] California Energy Storage Alliance (December 8, 2020, press release), "New research finds California alone will need deploy 2-11 GW of long duration energy storage by 2030, and up to 55 GW by 2045," https://www.storagealliance.org/pr_long-duration

[21] ESS (September 30, 2021, press release), "ESS and SB Energy Sign Agreement to Deploy Two Gigawatt-hours of Long-Duration Storage," https://essinc.com/ess-and-sb-energy-sign-agreement-to-deploy-two-gigawatt-hours-of-long-duration-storage/

[22] ESS (September 23, 2021, press release), "ESS Inc. Contracts With Enel Green Power España to Deliver 17 Energy Warehouse™ Long-Duration Iron Flow Battery Systems," https://essinc.com/ess-inc-contracts-with-enel-green-power-espana-to-deliver-17-energy-warehouse-long-duration-iron-flow-battery-systems/

[23] S&P Global (October 13, 2021), "ESS seeks to expand energy storage universe after stock market blastoff," https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/ess-seeks-to-expand-energy-storage-universe-after-stock-market-blastoff-67058674

Fig. 10 ESS' iron flow battery product lineup

Source: ESS Inc.

(2) Form Energy - A venture company specializing in "iron-air batteries" led by a former Tesla executive

U.S.-based Form Energy is a venture company specializing in iron-air batteries (IAB) and was launched by a former head of the stationary energy storage business for Teslaa. Since Form Energy has been taking a passive stance on disclosing information, no information important to assessing the technological characteristics of IABs have been released. Despite this, the company has captured the interest of many investors with its IAB technologies, and succeeded in procuring 240 million dollars in the latest funding round[24].

The principle of operation for IABs is a simple one: it can reverse the chemical process whereby iron oxidizes and rusts. More specifically, when discharging they take in oxygen from the air, oxidize it, and convert it to rust. When charging, they apply an electrical current to turn rust back into iron and release oxygen in the process (Fig. 11 and 12)[25].

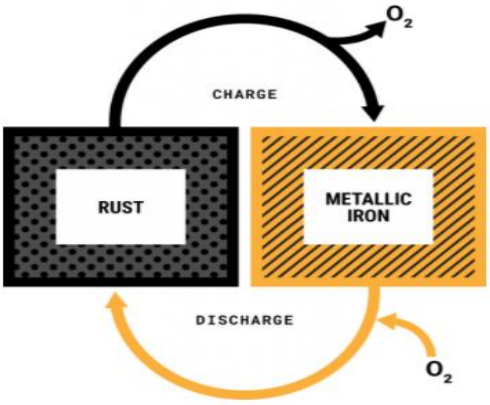

Fig. 11 Principle of operation of iron-air batteries

Source: Form Energy

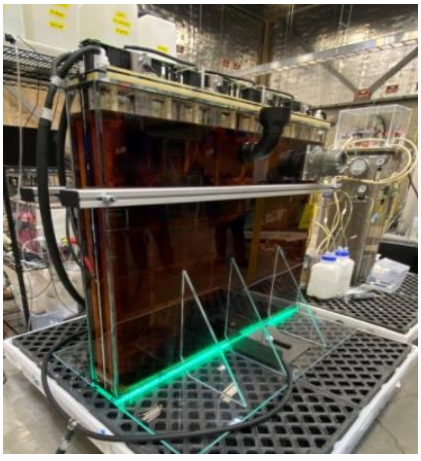

Fig. 12 Form Energy's iron-air batteries

Source: Form Energy

[24] Energy Storage News (August 25, 2021), "Iron-air long-duration battery startup Form Energy closes US$240 million funding round," https://www.energy-storage.news/iron-air-long-duration-battery-startup-form-energy-closes-us240-million-funding-round/

[25] Form Energy, "Technology –The Battery Cycle-,"https://formenergy.com/technology/battery-technology/

According to Form Energy, IAB's greatest technical advantage lies in its use of iron, water, and air, which are low cost and exist in abundance all over the world, and it aims to get the production cost to 20 $/KWh. With such non-flammable and safe components, IABs can be used even in urban areas. Along with not degrading with repeated charging and discharging, IABs are well-suited to scaling up as the lack of resource constraints involved enables them to be produced anywhere in the world. Form Energy's IABs can also be used in long cycles of 100-plus hours. As such, the technologies to compete with IABs are not LiBs but rather hydrogen and other long-duration energy storage technologies.

As previously discussed, despite the technical immaturity of IABs, expectations are high among users looking for a low-cost, long-duration energy storage technology. In the state of Minnesota, Form Energy is working with Great River Energy, a cooperative of electricity producing, transmitting, and distributing companies to prepare for the launch of a pilot project in 2023 that will see the installation of a 1 MW module at a natural gas-fired power plant (Fig. 13). In the winter of 2019, temperatures in Minnesota dropped to -10°C. This caused wind turbines to shut down, resulting in the shutdown of wind farms in the Upper Mid West as well as coal and natural gas plants in the area. Preparing for these sorts of tragedies is the goal of the pilot project and, if Great River Energy obtains conclusive technical proof, it is thinking about expanding its IAB systems to 300 MW. Form Energy's pilot project using IABs is that the results could lead to advancing IAB technology and stimulating market growth, thereby spurring development of Minnesota's steel industry[26].

Fig. 13 Pilot plant operated in conjunction with Great River Energy (1 MW module)

Source: Form Energy

IAB's technologies are not especially new, and have a simple principle of operation. Furthermore, they are seen as commercially viable from the perspective of raw material costs. However, due to the fact that Form Energy is refusing to release performance data, many doubt the feasibility of it achieving its target production cost of 20 $/KWh[27].

5. Characteristic changes taking place in the flow battery space - An examination of implications and impact

(1) Mature sectors - Those with access to core resources will stake their survival on vertical integration

[26] Renewable Energy World (September 3, 2021), "Minnesota utility co-op sees big battery as piece of grid reliability puzzle," https://www.renewableenergyworld.com/storage/minnesota-utility-co-op-sees-big-battery-as-piece-of-grid-reliability-puzzle/

[27] CNBC (August 25, 2021), "Stealthy battery company backed by Bill Gates, Jeff Bezos has a lot to prove," https://www.cnbc.com/2021/08/25/form-energy-raises-240-million-on-iron-air-battery-promise.html

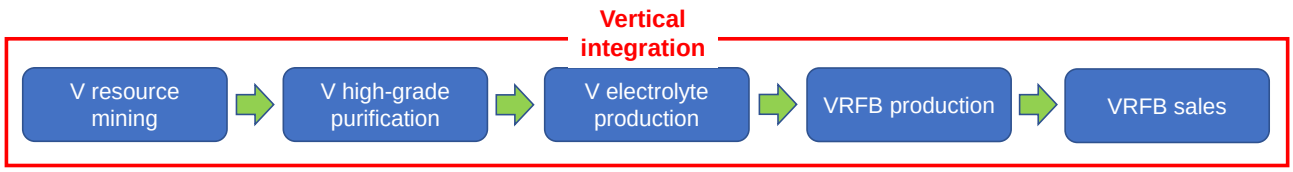

Fig. 14 Example of vertical integration in the mature sector of the flow battery space

Note: Prepared by the author

VRFBs are what represent the mature sector for flow batteries. As discussed above, in this space, industry players with access to core resources and technologies in the form of vanadium mines and production technologies are strengthening their control in the market by expanding their business domains through vertical integration (Fig. 14). Their aim here is the pursuit of a strategy centered on cutting costs in order to survive amid fierce competition. VRFBs have seen dramatic cost decreases over the last several years. This trend is expected to continue, and should galvanize further VRFB proliferation (Fig. 15). The commercial use of VRFBs is expanding around the world, a trend that is likely to only accelerate. This will make it easy for those who have access to core resources, particularly vanadium, to establish an advantageous position relative to those who do not. As renewables deployment grows around the world, demand for the long-duration energy storage technologies that support them (especially batteries) is expected to rise even further, just as has been seen with LiBs for electric vehicles. With demand predicted to grow for VRFBs as a viable and mature technology, companies with access to the vanadium that goes into them and the core technologies to process vanadium are taking the initiative to cut costs by reducing middlemen margins in order to survive amid market competition that is likely to intensify. Vertical integration is one traditional means of prevailing in mature market competition.

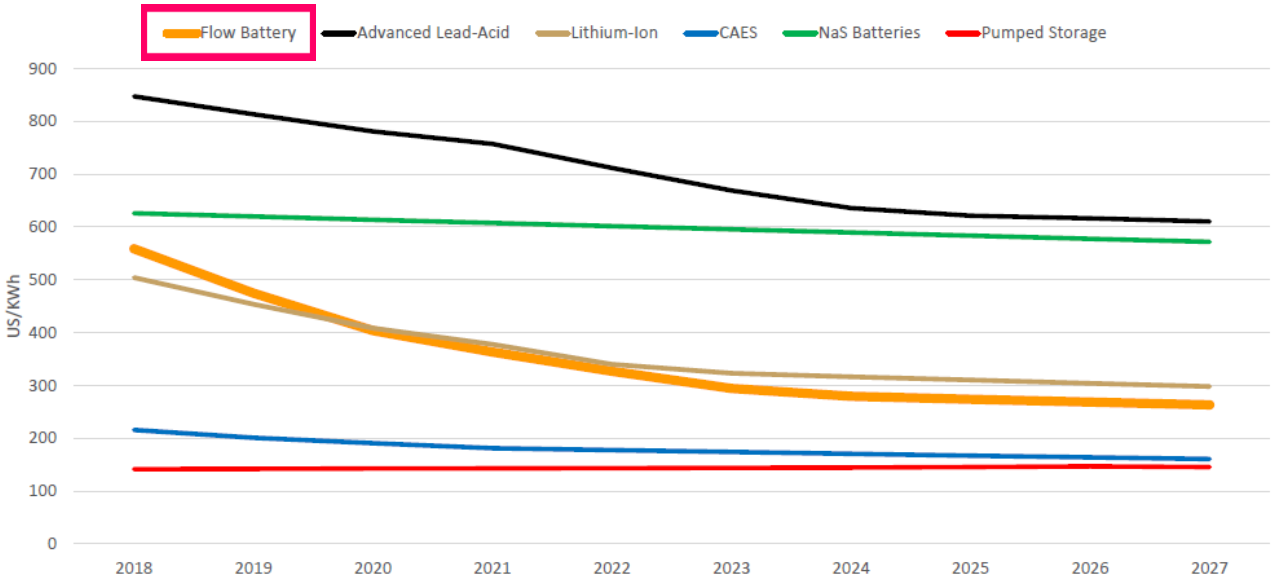

Fig. 15 Projected energy storage technology equipment costs (2018-2027)

Source: Guidehouse

(2) Maturing sectors - A bid to scale up over the shortest possible time horizons by those with core technologies

This section provides an outline of the characteristic changes happening at specialized venture companies with IFBs and IAFBs in maturing industries. Keywords that apply to both are "core technologies" and "scaling up over shortest time horizons."

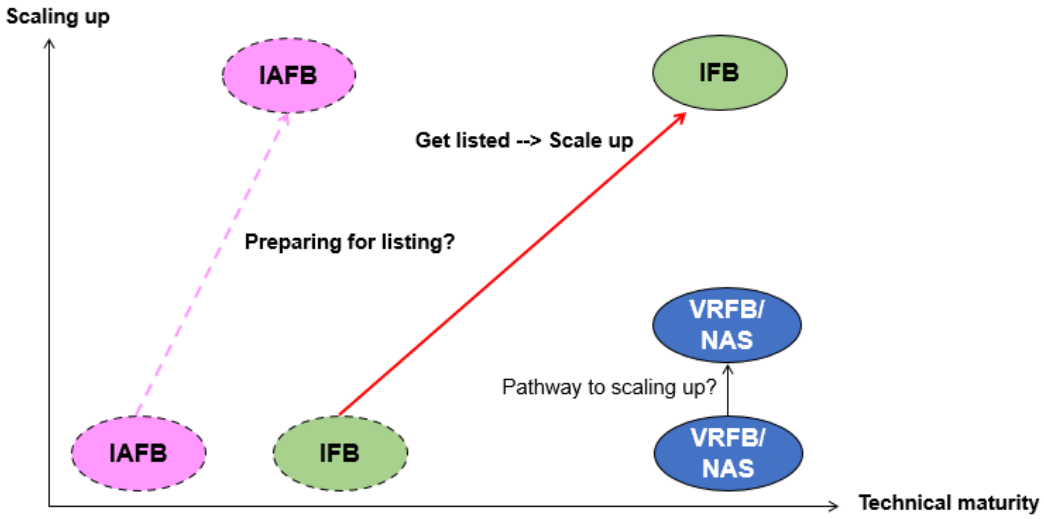

Fig. 16 Positioning of new players in the flow battery space

Source: Prepared by the author

With the Y axis showing scaling and X axis indicating technical maturity, Fig. 16 presents a comparison of changes brought by new flow battery players to NAS batteries and to VRFBs, a grid-scale battery. Technically, ESS' IFBs are arguably immature. However, by scaling up over the shortest possible time horizon using funds procured through the stock market, the company is attempting to jump straight to full technical maturity. Sumitomo Electric Industries and NGK Insulators have been developing VFRB and NAS technologies, respectively, for many years, and while pilot projects and other accomplishments they have made around the world have put them in a better position than their competitors, they have no clear path for scaling up. One could say that ESS and Form Energy are taking a completely different approach from Sumitomo Electric Industries and NGK Insulators.

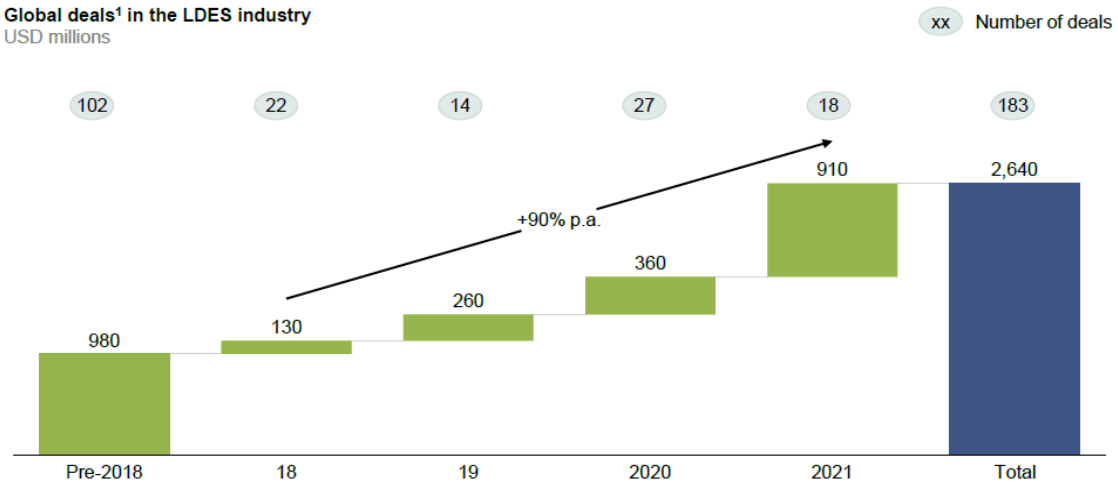

Fig. 17 Number and total amount of investments in long-duration energy storage technologies

Note: Applies to heat, mechanical, chemical, and electrochemical energy storage technologies with durations beyond eight hours

Source: LDES Council[28]

[28] LDES Council (November 2021), *op.cit.*, pp.11-12

ESS has been focused on the global market since its founding, with green energy investors and the venture development ecosystem pushing the company's vision along. According to the LDES Council, investments in the long-duration energy storage technologies grew having nearly tripled in the last four years over the four-year period from 2018 to 2021, from 980 million dollars to 2.6 billion dollars (Fig. 17). Along with Breakthrough Energy, a clean energy investment fund being supported by Microsoft founder Bill Gates and Amazon founder Jeff Bezos, SoftBank subsidiary SB Energy and Germany-based BASF are also investing in ESS (Breakthrough Energy has also made investments in Form Energy). Italy-based ENI and Thailand-based PTT are also investing in flow batteries in the oil and gas industries, while BASF is investing as a diversified chemicals industry player. Such investments illustrate a broadening of venture investment and the scope of development ecosystems to now cover batteries for use in long-duration energy storage. They also make clear that conditions are coming together for a considerable scaling up of these technologies (Fig. 18).

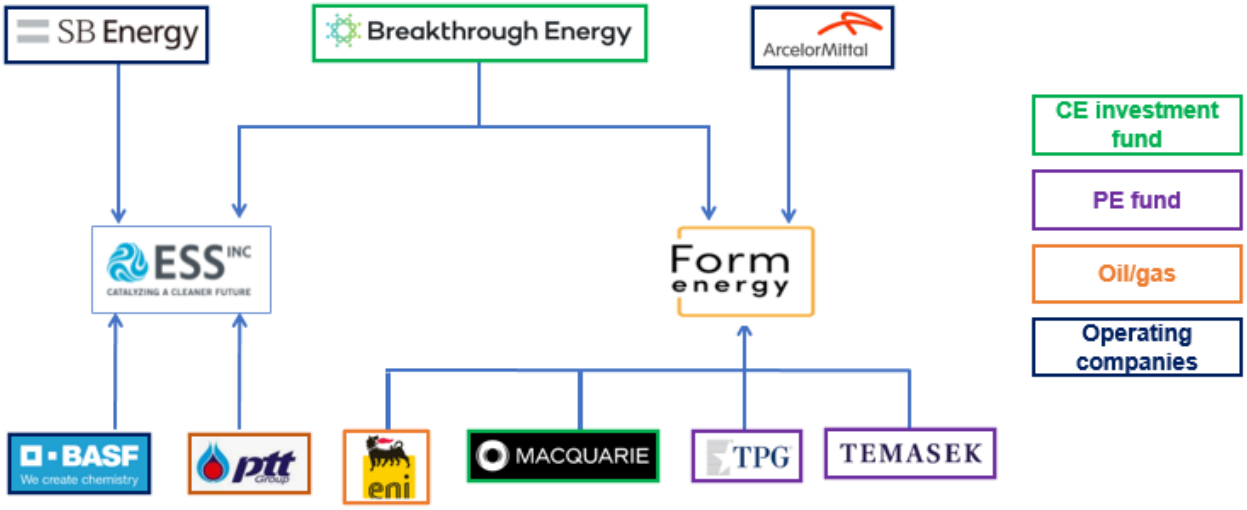

Fig. 18 New venture investment and development ecosystem in the flow battery space

Source: Prepared by the author based on various data

6. Conclusion

This paper has presented an overview of characteristic changes happening in the flow battery space based on technical maturity levels, and has examined the implications and impact of these changes. We have seen that mature sector players who have access to resources are taking the initiative and vertically integrating in order to further strengthen their positions, while those in immature industries are focusing on the global market from the start and laying ambitious groundwork for scaling up in the future. This seems to foreshadow interest growing even further for flow battery space.

In Japan, mass adoption of electric vehicles, the renewal of expired solar FIT agreements, a great enthusiasm among companies to conclude corporate PPA, and other such developments indicate that demand is only going up for renewables aimed at decarbonization. Meanwhile, further development of the IoT and IoE is spurring explosive growth in data volume and driving tremendous demand for data centers. Data security problems are prompting businesses to bring their data centers back into the country from overseas, but they are faced with the need to use clean energy in their operations. With the battle over renewables already underway, we can expect to see an acceleration in the deployment of the long-duration energy storage technologies that will support the fight. Despite the flow battery space being an area in which Japanese companies excel, it would seem that there is yet no pathway to scaling up. As the global market for flow batteries expands on the back of rising demand, survival amid international competition will require that public and private sectors work together to build and strengthen supply chains while working to scale up business.

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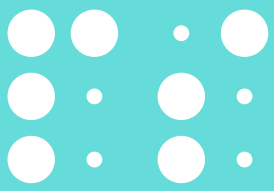

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