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The Ways Forward for Japan EPCOs in the New Energy Paradigm

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REI – Renewable Energy Institute

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EXECUTIVE SUMMARY

Japan electric power companies (EPCOs) are entering a new energy paradigm characterized by three key challenges; energy transition, electricity system reform (ESR), and internationalization with nothing less at stake than their survival.

The energy transition taking place in Japan following Fukushima nuclear accident has so far been marked by an impressive reduction in electricity consumption thanks to energy efficiency and savings; -11% in fiscal year (FY)[a] 2016 compared with FY2010, and a significant expansion of solar photovoltaic (PV), thanks to the introduction of a feed-in-tariff (FIT) scheme in July 2012; from 5 gigawatts (GW) at the end of 2011 to 42GW at the end of 2016, that is more than nuclear power capacity.

Until now, Japan EPCOs did not participate actively in the energy transition, particularly in the deployment of renewable energy (RE)[b] capacity. Instead, they have focused on deploying coal and gas capacity. Yet fossil power capacity is outcompeted by solar and wind power, which are to be dispatched first in the merit order due to their lower marginal costs.

ESR should be realized by 2020, legally unbundling Japan 10-EPCOs generation, electrical networks (transmission & distribution (T&D)), and supply activities. Generation and supply activities, which are competitive segments, may start facing significant pressures from the energy transition and ESR. Newly independent networks segments should benefit from good opportunities in advancing a successful energy transition in Japan.

Japan EPCOs have essentially been focusing on their domestic market so far. Yet, business opportunities also exist overseas. In non-OECD (Organization for Economic Co-operation and Development) Asia for example. Japan EPCOs are aware of those. Notwithstanding global trends in RE, they are, however, almost only investing in fossil power. Critical to successful internationalization of Japan EPCOs business will be their ability to deploy cost efficient RE.

To make their way through this new energy paradigm, Japan EPCOs have the chance to learn critical lessons from their European peers.

European EPCOs have already faced similar challenges to those Japan EPCOs are now confronted with. And European EPCOs have failed to adapt quickly. Japan is lagging behind, and that is not necessarily a bad thing. Indeed, it means that Japan EPCOs may benefit from their European peers painful experiences.

Struggling, several European EPCOs posted record losses and saw their market capitalization collapse in recent years. They were victims of low wholesale electricity prices resulting from sluggish electricity demand and dramatic expansion of wind and solar power with lower marginal cost, leading to overcapacity and pushing fossil power plants out in the competitive market merit order.

Embattled European EPCOs had thus no choice, but to advance new business models, which they started to implement in the past few years. These new business models focus on RE, energy networks and integration, and customers solutions.

Solar and wind power have strong advantages over fossil and nuclear power. From an economic point of view, with close to zero marginal cost they should always be dispatched first, and in terms

a FY in Japan starts on April 1 and ends on March 31.
b Throughout the report RE excludes hydropower unless otherwise noted.

of levelized cost of electricity (LCOE) they are often cost competitive with fossil and nuclear power. Independent of imported fuels, they also strengthen energy security, and they help improving air quality. These advantages make them attractive for many countries around the world and will keep driving their expansion worldwide, also in Japan.

On these grounds European EPCOs are now increasing their wind and solar portfolios by either building new capacity or acquiring existing capacity from other companies. They do so to the detriment of fossil power; European EPCOs closed or sold over 100GW of fossil power capacity between 2011 and 2016, and to the detriment of nuclear power which costs are increasing and fails at delivering new reactors without massive cost overruns and long delays.

These critical lessons should lead Japan EPCOs to give up on their plans to build over 22GW of coal and gas capacity and restart nuclear power in Japan in the years to come, and instead lead them to finally focus their efforts on turning to RE domestically and abroad.

A vital area of industrial and technological development after unbundling is energy networks and integration. With the energy transition, modernization, reinforcement, and expansion of electrical grids (including interconnections) will be needed. These activities are regulated and should be given conditions enabling independent grid companies to get fair returns on their investments, but lower returns than what can be assumed in competitive and higher risks segments of generation and supply.

Participating in the integration of the transportation and heating & cooling (H&C) sectors may also present opportunities for Japan EPCOs.

Another area of growth for Japan EPCOs may be the customers solutions business; from distributed energy generations services (distributed solar PV systems possibly bundled with battery storage) to energy usages optimizations tools (energy advisory services, efficient equipment, demand side management, and their financing) and choice of electricity supply mix (green power contracts offers).

While it is too early to accurately assess the success of all new business models, many seem quite sound with regard to the economics. These business models target growth areas with opportunities to increase revenues based on latest technologies. And they are more cost efficient compared with traditional business models, particularly fossil and nuclear power generation, which should result in improved profitability.

Japan EPCOs with unchanged business models should therefore redirect their strategies towards sustainable business areas now in order to remain profitable in the future.

There is still time to adjust, but not much.

INTRODUCTION

Japan EPCOs are at a crossroads entering a new energy paradigm characterized by three key challenges; energy transition, electricity system reform, and internationalization with nothing less at stake than their survival.

While the wording may seem a bit dramatic, European EPCOs having faced these challenges to greater extents and painfully failed to address them quickly – many of them losing billions of euros in the past few years – may recognize that the words used are not excessive, but rather appropriate.

Because EPCOs are central actors of the power system their collapse is not desirable neither in Europe, nor in Japan.

It is in the interest of Japan EPCOs, and in the superior interest of all Japan electricity customers, whether commercial and industrial or residential and local authorities, that Japan EPCOs should not be slowing down progresses, but rather leading the way in the new energy paradigm.

It is in this state of mind that the author has spent two years of research, learning from hundreds of corporate documents totalling thousands of pages, to provide this up-to-date report for Japan EPCOs with constructive criticisms and ideas of strategies and new business models for the EPCOs to remain profitable in a dramatically changing environment.

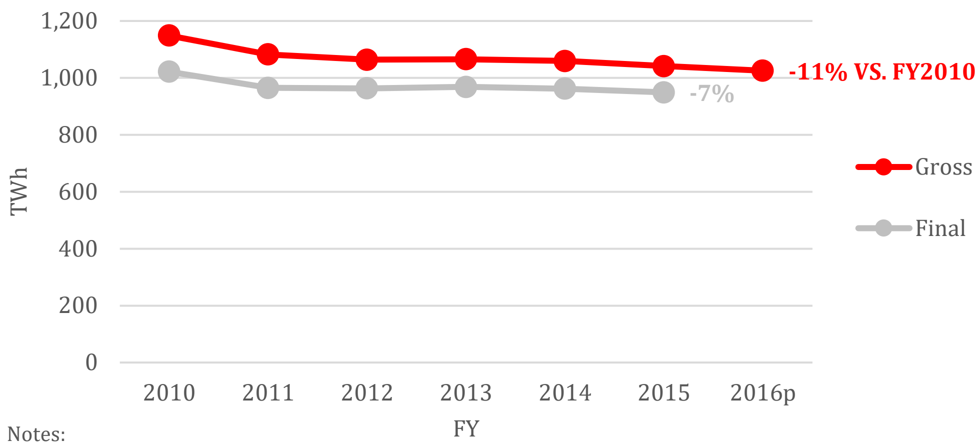
I CHALLENGES AND CRITICAL LESSONS

1) Key Challenges Faced by Japan EPCOs

A) Energy Transition

Following Fukushima nuclear accident in March 2011, clear trends have emerged in terms of electricity demand and supply in Japan. **From FY2010 to FY2016, gross consumption of electricity significantly decreased**; -123 terawatt-hours (TWh) or -11%[c] (Chart 1), **and gross electricity generation from RE (including hydro)**[d] **significantly increased**; +41TWh or almost +35% (Chart 2).

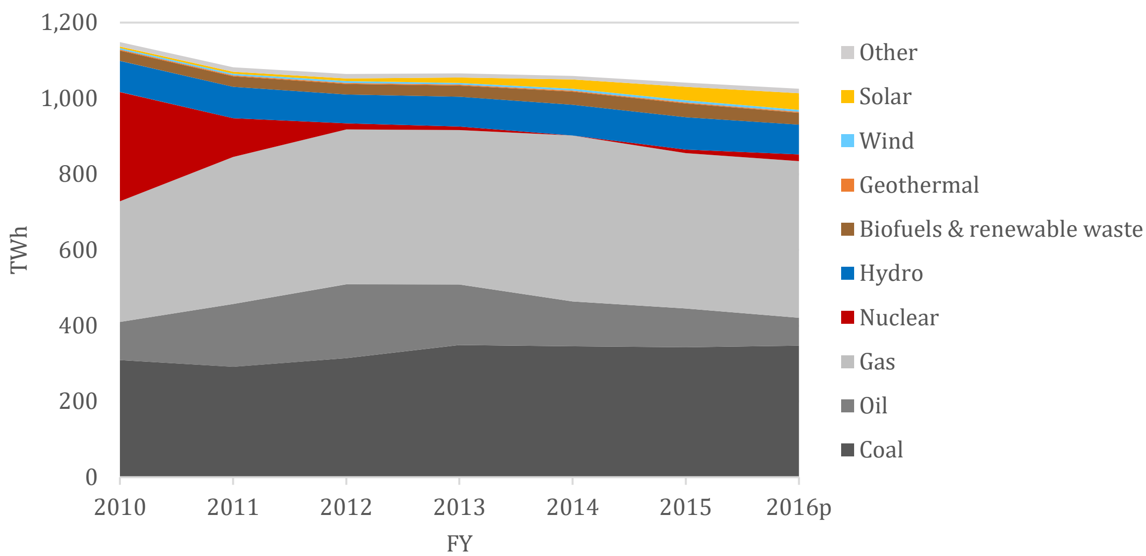
Chart 1: Japan Electricity Consumption FY2010-FY2016



Notes:
"Gross" consumption = gross generation + imports - exports
"Final" consumption = gross consumption - own use by power plants - transmission and distribution losses - electricity consumed by transformation industries for heating, traction and lighting purposes

Source: : IEA, Electricity Information 2017, and Statistics (online)

Chart 2: Japan Gross Electricity Generation FY2010-FY2016



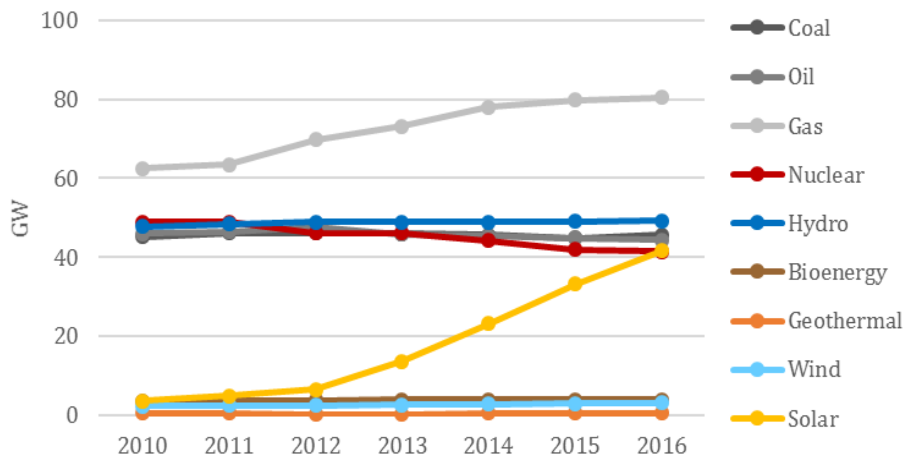
Note: "Other" includes pumped storage, non-renewable waste, and other (e.g. fuel cells, electricity from chemical heat)
Source: IEA, Electricity Information 2017, Renewables Information 2015-2017, and Statistics (online)

c Without assuming constant electricity intensity.
d Throughout the report RE excludes hydropower unless otherwise noted.

As a result, the share of RE (including hydro) in electricity supply reached 15% in FY2016, from below 9% in FY2010.[1] In FY2016, hydro accounted for 7.7%, solar 4.7%, bioenergy 1.4%, wind 0.9%, and geothermal 0.2%.[2]

These remarkable results were made possible thanks to on the one hand progresses in energy efficiency and savings, on the other hand the introduction of a FIT scheme in July 2012, which initially offered particularly generous tariffs for solar PV (Chart 3).

Chart 3: Japan Electrical Capacity 2010-2016



Sources: BNEF, Japan Country Profile for fossil fuels, Japan Atomic Industry Forum, Nuclear Power Plants in Japan (6 April 2017) for nuclear, and IRENA, Renewable Capacity Statistics 2017 for renewables

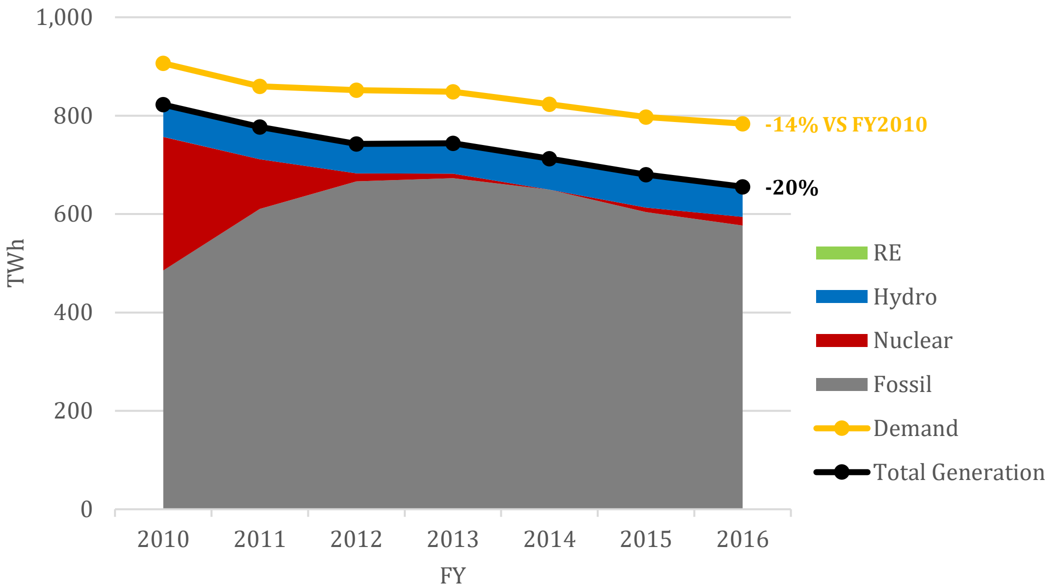
Progresses in energy efficiency and RE expansion are the two main drivers of what is called the "energy transition." This new energy paradigm towards more sustainable and affordable energy systems is happening globally, at various scales and paces depending on countries development stages. It is enabled thanks to dramatic cost reduction in wind and solar PV notably. This deep transformation of the energy landscape significantly impacts business models of EPCOs for which business as usual has become synonym of death spiral.

In Japan, already negatively affected by lower electricity demand, the 10 historical EPCOs; Tokyo, Kansai, Chubu, Kyushu, Tohoku, Chugoku, Hokuriku, Hokkaido, Shikoku, and Okinawa EPCOs, cornerstone of Japan electricity system for decades, have until now not managed to address challenges on the supply side either (Map 1 and Chart 4 both on next page).

Map 1: Japan 10-EPCOs Headquarter Locations

Source: Created by REI

Chart 4: Japan 10-EPCOs Electricity Demand and Generation FY2010-FY2016



Note: "Fossil" includes other

Source: METI, Electric Power Statistics

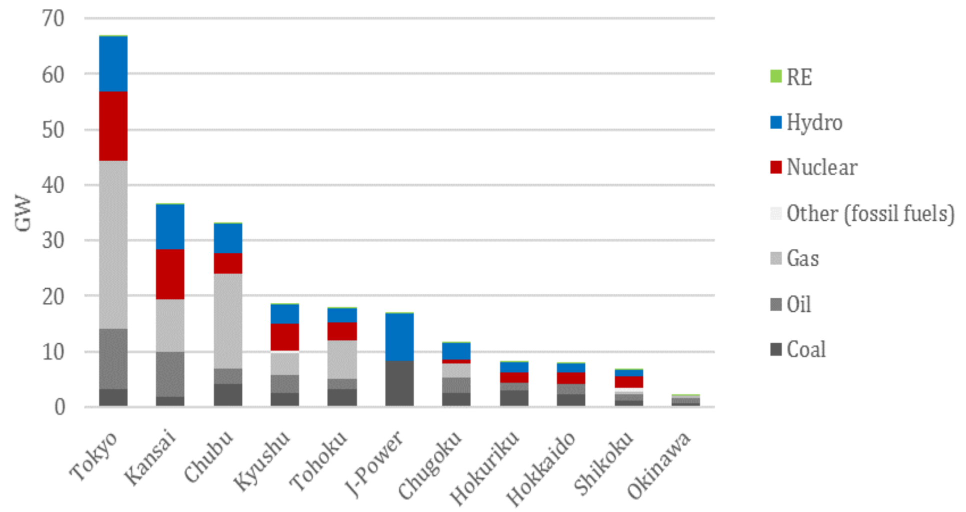
Indeed, decrease in Japan 10-EPCOs electricity generation from their own power plants has been larger than the decrease in demand from their customers; -167TWh or -20% against -123TWh or -14% from FY2010 to FY2016.

This is because **the answer of Japan 10-EPCOs to address the energy transition has so far been; serve a lower electricity demand with more power capacity, which are outcompeted**

by other generators (roughly 40GW of solar PV and wind capacity were added by other generators between 2010 and 2016)**.**

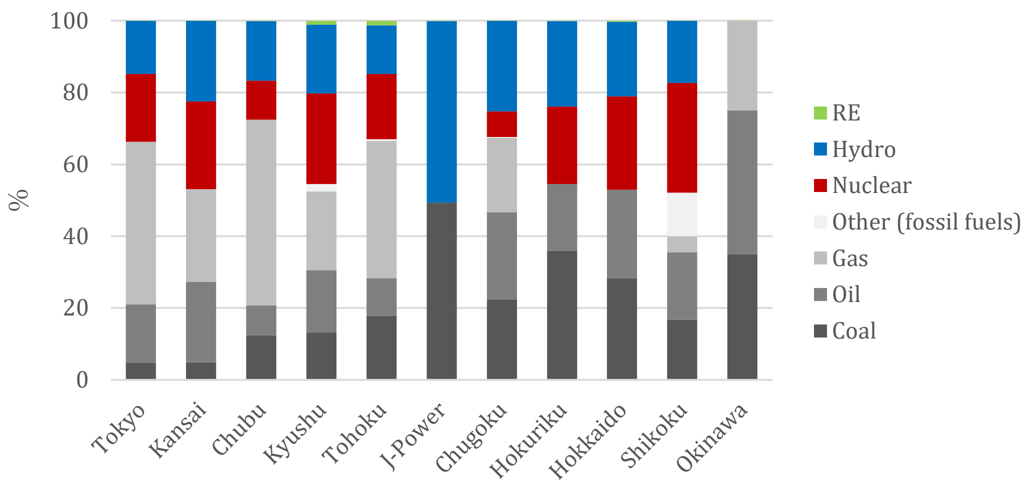
Whereas large scale deployment of RE has started Japan 10-EPCOs, essentially reliant on conventional power (fossil fuels, nuclear, and hydro) – with some differences (Chart 5 & Chart 6[e], also including J-Power another major actor in the sector), only added few megawatts (MW) of RE to their power plant portfolios in recent years; 54MW, a very minor contribution at the country scale.

Chart 5: Japan 10-EPCOs & J-Power Power Capacity FY2015



Sources: EPCOs and J-Power's Annual Reports and other corporate materials publicly available online

Chart 6: Japan 10-EPCOs & J-Power Power Capacity Share by Technology FY2015

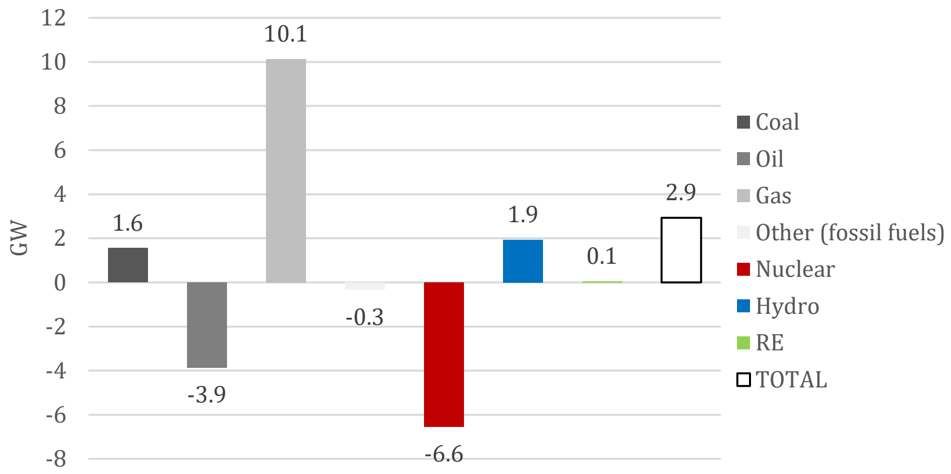


Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

Worse, notwithstanding alarming trends regarding electricity consumption and RE expansion nationwide they slightly increased their conventional power plant portfolios by notably adding gigawatts of liquefied natural gas (LNG)-fired and coal-fired power plants – with the idea of partly replacing nuclear power and reducing oil power (Chart 7 on next page).

e Attributable capacity to Tokyo EPCO from Eurus Energy (273MW of wind and 99MW of solar) not included. Attributable capacity to J-Power (153MW of coal, 95MW of oil, 212MW of gas, and 415MW of wind) not included.

Chart 7: Japan 10-EPCOs & J-Power Power Capacity Change FY2015-FY2010

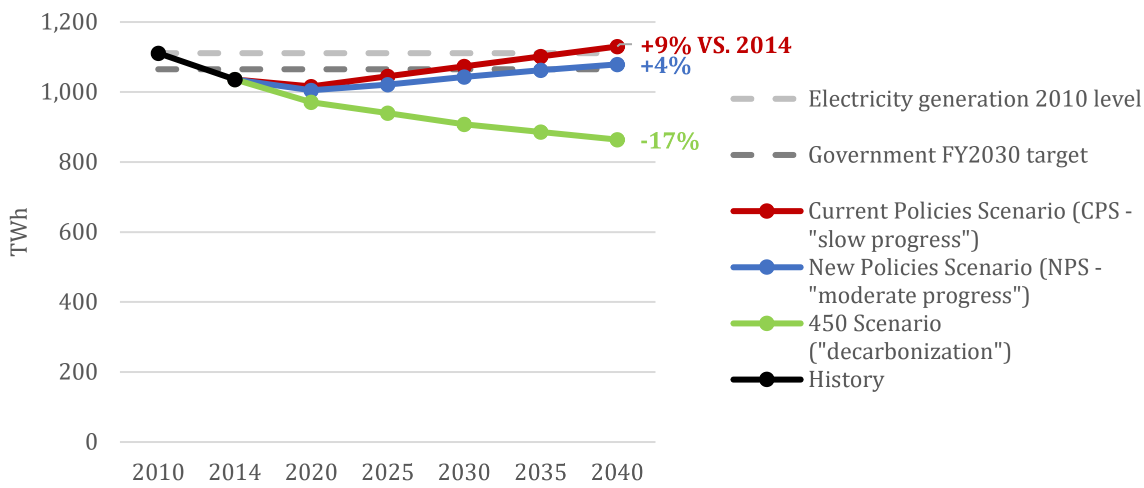


Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

Coal and LNG not only present a number of critical medium- and long-term issues such as fuel prices volatility and limited access, but also a major short-term issue in terms of cost competitiveness when it comes to "immediate" electricity generation. Indeed, neither coal nor gas can compete on a marginal cost basis with technologies such as wind and solar PV because the later ones do not require costly fuels to generate electricity. Coal and gas power plants are thus not to be dispatched first from a cost optimization perspective.

Considering the future of the energy transition in Japan now, the IEA (International Energy Agency)'s projections demonstrate that: (1) much more efficiency gains are still very achievable in Japan (in the industry and buildings sectors especially) (450 – "decarbonization"), and one may argue these should be pursued in priority since they offer the lowest cost option and strengthen Japan energy security, and that: (2) only in a conservative scenario, that is not desirable with regard to climate change, electricity generation could reach back to its 2010 level but not before 2040 (CPS – "slow progress") (Chart 8).

Chart 8: Japan Electricity Generation Projections

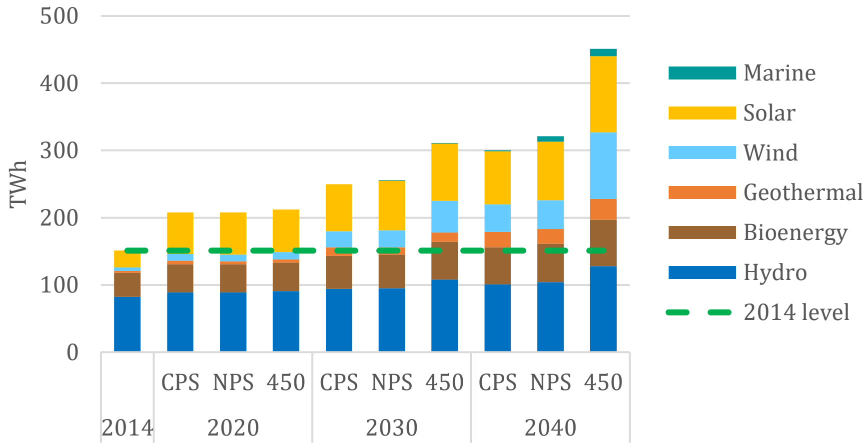


Sources: IEA, World Energy outlook 2012 and 2016, and METI, Long-term Energy Supply and Demand Outlook

As such, the unambitious target – with regard to IEA's decarbonization scenario (450) – set by Japan METI (Ministry of Economy, Trade and Industry) for FY2030 also demonstrates limited expectations for electricity generation recovery; -83TWh or -7% compared with FY 2010, or +50TWh or +5% compared with FY2015.

In addition, on the supply side, further penetration of increasingly cost competitive close to zero marginal cost RE in Japan is a given; at the end of FY2016 about 105GW of RE (including small hydropower) capacity were registered under FIT out of which about 70GW were still not operational – new rules effective from April 2017 will result in the cancellation of 27GW though – leading to expectations that 43GW will begin operation in a very near future (essentially solar PV and biomass).[3] These will need to be built to meet the country 2030 target of 22-24% of its electricity needs from RE (including hydropower). In this regard, it is interesting to highlight that all IEA's projections show significant increases in electricity generation from RE (including hydropower) – roughly at least +100TWh or +66% by 2030 (Chart 9).

Chart 9: Japan Electricity Generation from RE – Projections



Source: IEA, World Energy Outlook 2016

Conclusion, **it is likely that Japan electricity consumption keeps declining and that it will increasingly be met by RE, leading to a substantial increase in the share of RE in electricity generation**. And consistent with these trends IEA's projections do not say anything else. Indeed, in IEA's conservative and moderate scenarios the share of RE (including hydropower) reaches almost 25% of Japan electricity generation in 2030, and even over 33% in its decarbonization scenario, against 15% only in 2014.

In light of these developments one may question not only Japan EPCOs desperate attempts to restart their nuclear power plants; in terms of power capacity strictly speaking these plants are not needed, their cost competitiveness is certainly shrinking as costly safety upgrades are necessary for restart, and gaining social acceptance for their operation is quite challenging (without even mentioning future issues such as lifetime extensions, decommissioning, and waste management & storage), but also their plans to construct more than 22GW[f] of coal and gas power plants (discussed in II 1) B) "Fossil Power, Heavy Pressures to Come").[4]

This first subsection depicts a gloom future for Japan 10-EPCOs, and particularly their generation segments, if they decide to keep running their business as usual.

The next challenge faced by Japan 10-EPCOs is the completion by 2020 of ESR which will set free each segments of their activities. With different perspectives regarding the energy transition significant impacts on the business of each segments are to be expected.

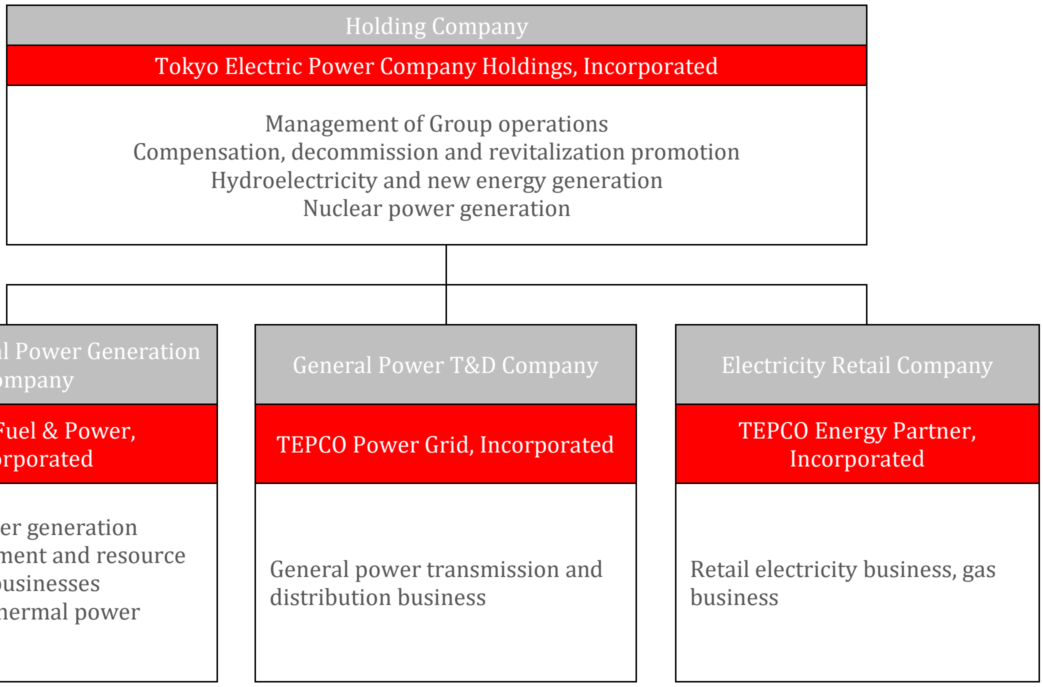
f Construction plans of J-Power included.

B) Electricity System Reform

In the aftermath of World War II, 9 out of today's Japan regional 10-EPCOs[g] were established (1951).[5] They were entrusted with the responsibility of generating, transmitting, distributing, and supplying electricity to each region. For over 65 years they have thus been fully vertically integrated electric utilities and enjoyed a monopoly situation in their balancing area[h].

This era is coming to its end with the completion of the ESR by 2020. Indeed, **the ESR will realize the legal unbundling of Japan 10-EPCOs generation, networks (T&D), and supply activities** (following the introduction of full retail market liberalization from FY2016) (Chart 10). Legal unbundling will introduce independent transmission & distribution operators (ITDOs)[i]. An ITDO is a T&D system operator that owns the power grid assets and belongs to a vertically integrated company, with special rules to guarantee its independence.[6] Generation and supply activities are recognized as competitive segments, that is not the case of networks activities. ESR is of particular importance with regard to the energy transition, and particularly the grid integration of variable renewable energies (VRE) solar and wind.

Chart 10: Tokyo EPCO, an Example Toward Unbundling in Japan



Source: TEPCO, Annual Report 2016

The generation and supply segments of Japan 10-EPCOs may start facing significant pressures from the energy transition and the ESR. Regarding the ESR, non-EPCOs already "captured" 3.3% of electricity retail sales volume for low voltage customers (below 50 kilowatts (kW)) to the 10-EPCOs in just 9 months following full retail liberalization in April 2016 (Chart 11 on next page).[7] And combining all customers segments[j] non-EPCOs were accounting for 8.6% of retail sales volume in December 2016, against 2.2% only in FY2010.[8] And Japan 10-EPCOs loss of retail sales volume has even been accelerating since 2015 when non-EPCOs became more active toward the full liberalization.

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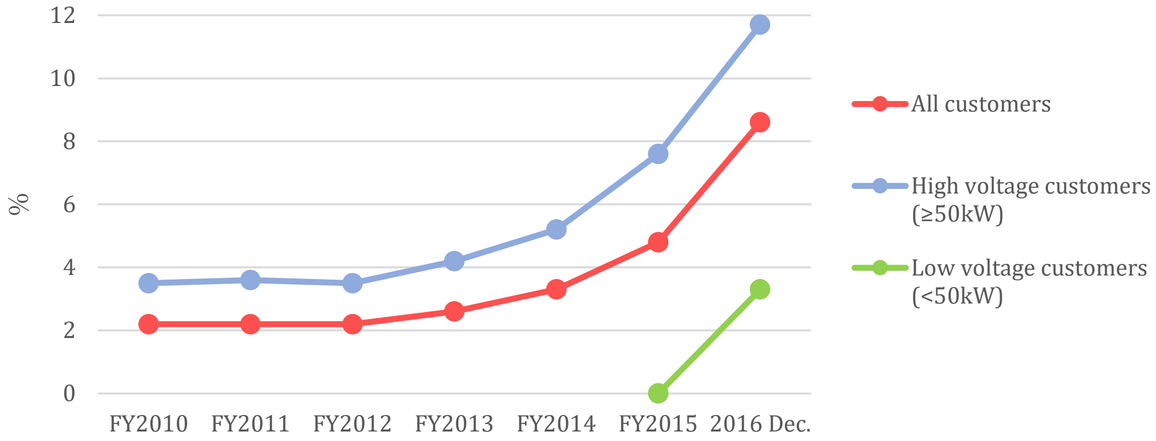
g With the return of Okinawa to Japan in 1972, Okinawa EPCO joined as a tenth member.
h A few small steps were made in liberalizing Japan electricity wholesale and retail markets at the end of the 1990s and beginning of 2000s, nothing comparable with the current ongoing reform though.
i T&D activities are not to be unbundled.
j Retail sales to high voltage customers (50kW and above) have been liberalized since 2000.

Chart 11 Non-EPCOs Share of Electricity Retail Sales Volume FY2010-December 2016



Source: METI, Progress of Electricity Retail Liberalization (21 April 2017)

These pressures will probably be amplified as the new energy paradigm moves forward since these processes do not happen overnight, but rather require at least a few years to make substantial impacts. This is true both when it comes to build many new power plants, and stimulate market competition and go through the educational process of the possibilities offered by the freedom of choosing an electricity supplier[k]. However, this does not mean that there is plenty of time for EPCOs to take action. Indeed, once the wheels of change are set in motion it is often too late to repair costly strategic mistakes.

Following completion of the ESR the independent networks segments of Japan 10-EPCOs will face a quite new reality, and should benefit from good opportunities in advancing a successful energy transition. Indeed, once set free and made responsible for neutral and optimized grid operations regardless of any generator interest, ITDOs will not have to fight possible internal conflicts anymore regarding which generation assets should be dispatched to deliver electricity to the power grid or to slowdown or deny grid access to new generating facilities from new entrants.

Furthermore, successful integration of VRE will require investments to strengthen and expand Japan power grid. As regulated businesses, for their efforts in redesigning and modernizing the grid ITDOs will get a fair return on their investments. The future for these organizations is thus rather bright. However, on the downside it must also be acknowledged that networks activities being low risks potential profits should be positive, but probably lower than in generation and supply activities where competition is fierce and thus present higher risks and offer consequently possibilities of higher rewards.

It is important to note that a critical precondition to ensure the success of the ESR, and allow the network segments of EPCOs to be rewarded for their efforts in helping to realize the energy transition Japan will benefit from, is the monitoring by the government of ITDOs independency.

In addition of the energy transition and ESR, internationalization is the third key challenge Japan EPCOs are facing today. Indeed, confronted with lower electricity consumption in their domestic markets which is increasingly competitively being served, Japan EPCOs may increasingly seek growth opportunities overseas.

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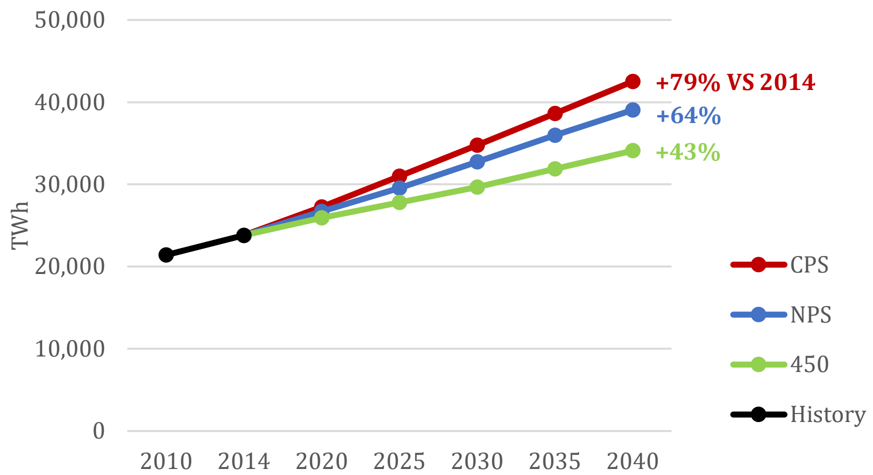
k The end of the obligation for the 10-EPCOs to provide regulated tariffs for low voltage customers once the ESR is realized in April 2020 (granted there is enough competition in the retail market) may spur further competition as customers will have to select new supply contracts to meet their needs. This will happen at a time when a number of customers will already have experienced changing electricity suppliers and confidence in newcomers grown likely easing similar decisions.

C) Internationalization

It is very likely that Japan electricity consumption will not substantially increase in the foreseeable future and that fiercer competition will take place at the generation and supply levels. **Confronted with a more challenging business environment domestically, Japan 10-EPCOs are starting to look more aggressively for overseas business opportunities**, at the generation level especially. **This makes sense.**

Indeed, according to IEA's projections global electricity generation is expected to increase by at least more than 40% and almost up to 80% by 2040 compared with 2014 (Chart 12).

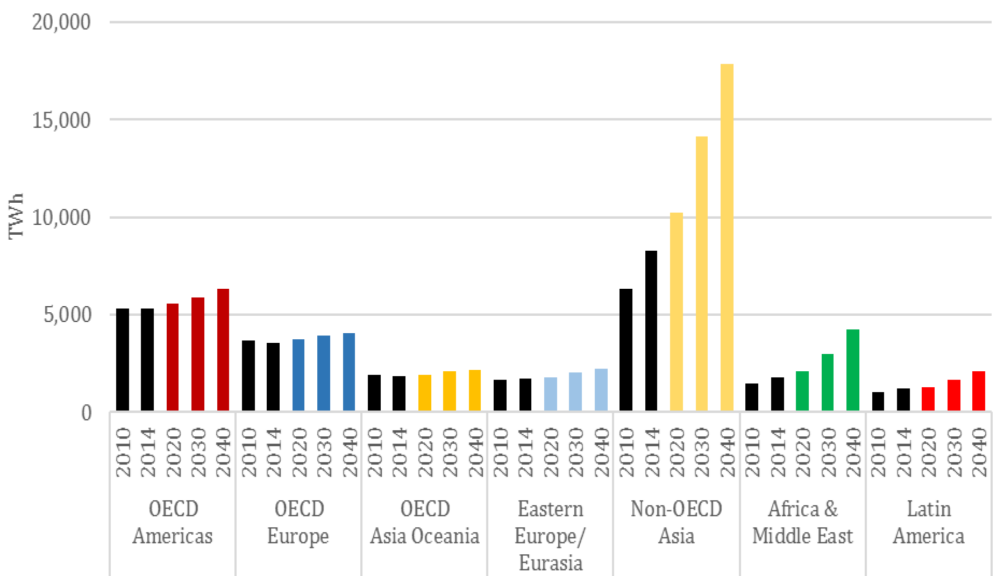
Chart 12: Electricity Generation Projections by Region in IEA NPS



Source: IEA, World Energy Outlook 2012 and 2016

And still according to IEA's projections the large majority of this growth is to take place in Non-OECD Asia (Chart 13). Other regions which are expected to notice significant growth in electricity generation are Africa & the Middle East and the Americas (OECD and Latin).

Chart 13: Electricity Generation Projections by Region in IEA NPS

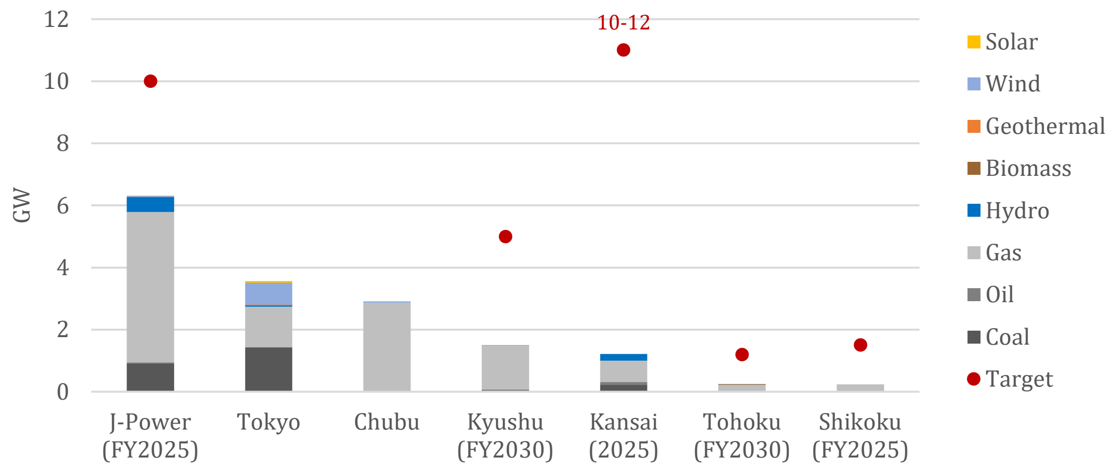


Source: IEA, World Energy Outlook 2012 and 2016

Developing power infrastructures, from power plants to T&D lines, overseas are certainly growth opportunities for Japan 10-EPCOs, which they may not have embraced enough until now.

Japan 10-EPCOs are not complete strangers with international business. At least 6 of them, as well as J-Power, already have power plants overseas. And they will soon be joined by Chugoku EPCO, which has a 15% stake in a 2GW coal power plant project in Malaysia to be completed by the end of 2019 (Chart 14).[9] And it is important to highlight that aware of growth opportunities overseas Japan EPCOs have also set targets for adding capacity outside Japan.

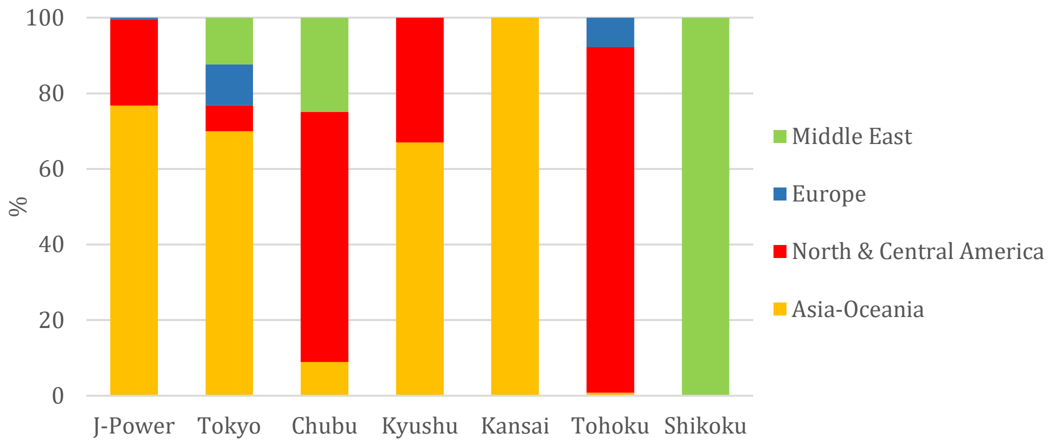
Chart 14: Japan 10-EPCOs & J-Power Overseas Power Capacity by Technology FY2015 and Targets



Notes:
Between brackets are indicated target years
JERA (Tokyo EPCO and Chubu EPCO 50%-50% joint venture) has a target of 20GW by 2030, against 6GW in 2016
Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

So far, these power plant projects have mostly been located in Asia-Oceania and North & Central America, and to a less extent in the Middle East and Europe (Chart 15). That is rather consistent with IEA's expected growth areas.

Chart 15: Japan 10-EPCOs & J-Power Overseas Power Capacity by Geographical Area FY2015

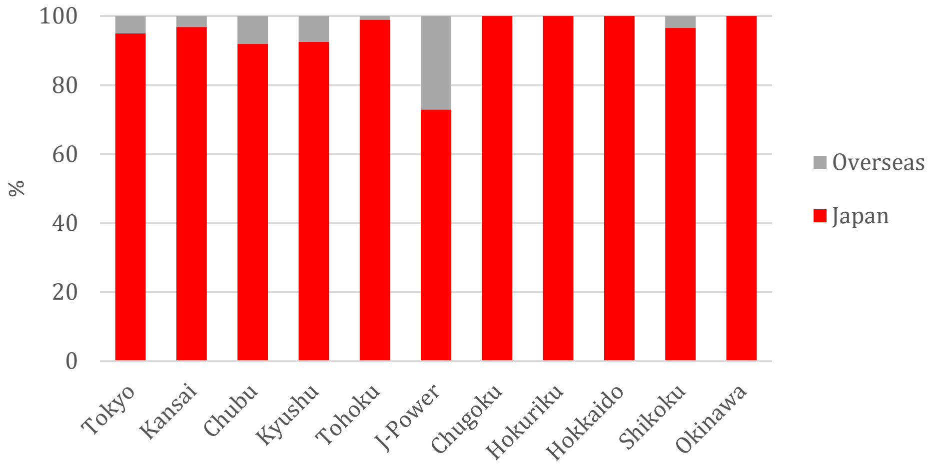


Note: in the case of Tokyo EPCO Uruguay is included in North and Central America

Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

Having made these first observations it is also important to note that these power plants – with the exception of J-Power – only account for a few percents of Japan EPCOs total (domestic+overseas) power capacity (Chart 16 on next page).

Chart 16: Japan 10-EPCOs & J-Power Share of Power Capacity in Japan VS. Abroad FY2015



Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

Compared with European EPCOs such as Italian giant Enel[1] for example, which had two-thirds of its total power capacity located abroad (mostly in Spain & Portugal, Russia, and Latin America) in 2016, international expansion of Japan 10-EPCOs looks quite modest today.[10]

It is clear that Japan EPCOs will add more capacity overseas, both based on their targets, and their construction plans (Table 1). The latter focus again largely on Asia, especially Southeast Asia; Indonesia, Lao, Malaysia, Philippines, and Thailand (ignoring China and India), and America (United States), and disregard opportunities in Africa and Latin America in particular.

Table 1: Japan 10-EPCOs & J-Power Overseas Power Capacity under Construction

EPCO	Country	Technology	Attributable Capacity (MW)	Start of operation/commission
J-Power	Indonesia	Coal	680	2020
JERA	US	Gas	480	2020
Tokyo	Qatar	Gas	240	2017-2018
	Thailand	Gas	12	2017
	Thailand	Gas	26	2017
	Philippines	Coal	27	2019
	Philippines	Coal	18	2019
	Lao	Hydro	19	2019
Chubu	Indonesia	Coal	100	2021
	US	Gas	140	2017
Kyushu	Indonesia	Geothermal	80	2016-2018
Kansai	Indonesia	Coal	500	2020
	Indonesia	Hydro	23	2017
	Lao	Hydro	131	2019
Chugoku	Malaysia	Coal	300	2019

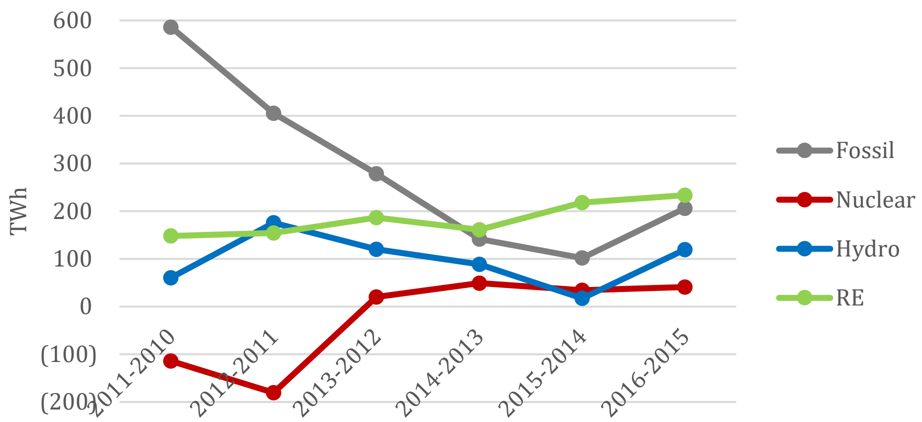
Source: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

An additional observation that can be made on Japan EPCOs international expansion plans is the **almost complete absence of developments for wind and solar power** – with the exceptions

1 Enel had a total of 83GW power capacity in 2016, that is more than 10GW more than Japan largest EPCO (Tokyo EPCO) total power capacity.

of recent announcements that JERA (Tokyo EPCO and Chubu EPCO 50%-50% joint venture (JV)) agreed to acquire an equity stake of 10% in ReNew Power, India's leading solar and wind energy company, that Kansai EPCO agreed to acquire a 24% stake in Evalair which owns and operates 223MW of wind power in Ireland, and that Shikoku EPCO is building a 98MW (share of 30%) solar power plant in Chile with start of commercial operations expected for August 2018.[11] **That is incomprehensible** at a time when in the past two years RE accounted for the majority of new power capacity globally driven by dramatic cost reductions in wind and solar, and when globally for the past three years the increase in RE electricity generation has been higher than the increase in fossil electricity generation (Chart 17).[12]

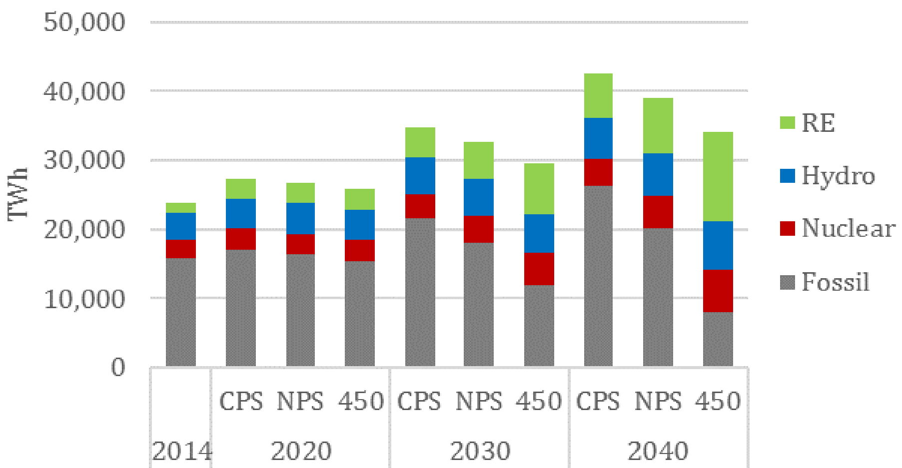
Chart 17: Global Annual Change in Electricity Generation 2010-2016



Source: BP, Statistical Review of World Energy 2017

And these trends are very likely to continue as wind and solar, particularly, economics keep improving and as the world needs more and more clean power. According to IEA's projections between 2014 and 2040, driven by expansion in wind and solar power RE electricity generation will grow by at least +4,800TWh or +325% (CPS) and up to +11,500TWh or +775% (450), and grow more than any other source in both the NPS – "moderate" and 450 (Chart 18). Electricity generation from fossil fuels may increase more than RE in the CPS only, which again is not desirable with regard to climate change. And electricity generation from fossil fuels may even decrease by as much as -7,800TWh or -50% (essentially coal) in the 450, which clearly shows the potential risks to keep investing in dirty technologies.

Chart 18: World Electricity Generation by Energy Source – Projections



Source: IEA, World Energy Outlook 2016

Wind and solar outcompete fossil fuels on a marginal cost basis, but not only; they now also often outcompete fossil fuel based generation on a LCOE basis. Further ignoring these major economic trends may prove a very costly mistake.

Another key aspect of internationalization strategies is competition, something Japan EPCOs have been too little confronted with.

Indeed, whether Japan EPCOs decide to keep sticking to fossil power or invest in RE to expand internationally they will face fierce competition either way from other international experienced and aggressive power companies. European EPCOs have already been mentioned as such competitors, but beyond European EPCOs other companies present such profile.

For instance, among Asian competitors, Korea Electric Power Corporation is currently involved in 17 power plant projects (from fossil to nuclear and RE), in 11 countries in Asia, including solar PV in Japan, Africa, Americas, and the Middle East.[13]

And from Japan, though it is first and foremost a multinational telecommunications and internet corporation, SoftBank through its wholly-owned subsidiary SB Energy Holdings Limited India, is demonstrating strong competitiveness in expanding its solar business in power-hungry India. Indeed, the Japanese Group that started commercial operation of a 350MW solar plant in Andhra Pradesh in March 2017 following a record low winning bid – at that time (December 2015) – of $0.07 per kilowatt-hour (/kWh), made the headlines again in May 2017 by bringing India some of the world's cheapest solar power with aggressive but viable winning bids at about $0.04/kWh for 400MW to be commissioned in Rajasthan.[14]

Opportunities thus certainly exist overseas by participating in competitive auctions notably, but Japan EPCOs will have to show strong competitiveness, as competition is fierce and dynamic. Their success is not impossible, but not granted either.

In addition, another aspect of internationalization may lie in the realization of international interconnection projects such as the Asia Super Grid concept, which based on identified potential economic, technical, environmental and diplomatic benefits envisions connecting the power grids of Japan, China, Korea, Mongolia, and Russia. These would be on the one hand challenges for generating companies, which would have to compete with foreign generators, on the other hand opportunities for grid companies which would have incentives to invest in interconnectors and grid related infrastructures granted these benefit Japanese consumers. In this regard, ESR may provide a decisive change by enabling ITDOs to invest in what is best for Japan industrial, commercial, and residential consumers instead of having to deal with fears from their future former generation segments.

In this first section of the report, we could have identified the three major challenges Japan 10-EPCOs are facing today; energy transition, ESR, and internationalization. Though the picture does not look particularly bright at this point, a number of opportunities have been raised; RE deployment, power grid modernization, and overseas expansion. The next section will concretely demonstrate why Japan EPCOs have to change their business models by introducing the painful European EPCOs experiences.

2) Critical Lessons from the European EPCOs Experiences

In this report, the sample of European EPCOs that will be mainly focused on includes 12 EPCOs particularly active in four geographical areas; Central Western Europe (Germany/Austria, France, and Benelux), South Western Europe (Italy, Spain, and Portugal), Nordic (Denmark, Finland, Norway, and Sweden), and the United Kingdom (UK) & Ireland. Some of them are also very dynamic outside Europe and this will be discussed as well.

These European EPCOs have been selected based on the relevancy – for Japan EPCOs – of their experience in facing the energy transition, ESR, and internationalization. These EPCOs are EDF, Enel, Engie, RWE, Iberdrola, Vatttenfall, EDP, Statkraft, EnBW, Fortum, SSE, and E.ON (Map 1 and Table 2).[m]

Map 2: Selected Major European EPCOs Headquarter Locations

Source: Created by REI

Table 2: Selected Major European EPCOs Introductory Table

Group	Headquarters, Country	Major business area	Service Provision				2016 Financials (€ billion)		
			Generation (GW)	Transmis-sion*	Distri-bution	Supply	Sales or revenue	EBIT**	Net income
EDF	Paris, France	Eur	132	(ITO)			71.2	7.5	2.9
Enel	Rome, Italy	Eur, Latam	83				70.6	8.9	2.6
ENGIE	Paris la Défense, France	Eur, Latam	80				66.6	2.5	-0.4
RWE	Essen, Germany	Eur	46	(ITO)			43.6	-3.6	-5.7
Iberdrola	Bilbao, Spain	Eur, Latam, NA	43	(ISO in UK)			29.2	4.6	2.7
Vattenfall	Stockholm, Sweden	Eur	31				14.6	0.1	-2.8
EDP	Lisbon, Portugal	Eur, Latam, NA	26				14.6	2.3	1.0
Statkraft	Oslo, Norway	Eur	17				5.6	0.3	0.0
EnBW	Karlsruhe, Germany	Eur	14	(ITO)			19.4	-1.7	-1.8
Fortum	Espoo, Finland	Eur	13				3.6	0.6	0.5
SSE	Perth, United Kingdom	Eur	11	(ISO)			34.0	2.3	1.9
E.ON	Essen, Germany	Eur	9				38.2	-0.4	-8.5

*For EPCOs active at the transmission level in Europe the type of TSO is indicated between brackets, as well as the country where it operates if different from the Group's headquarter country.
**Earnings before interest and taxes
Sources: Groups Annual Reports, and in some cases complementary corporate materials available online

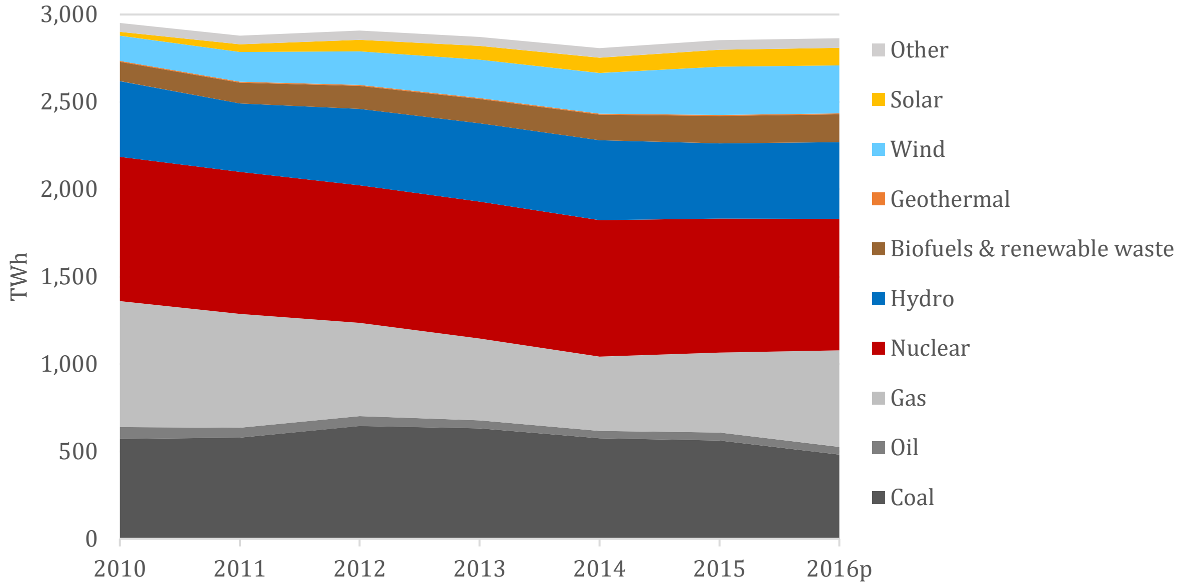
m Other interesting EPCOs such as Verbund (Austrian EPCO leader in hydropower), or DONG Energy (Danish EPCO leader in offshore wind power) will also be mentioned at specific places in the report to illustrate particular points.

A) Similarities and Differences

The key challenges faced by Japan 10-EPCOs today; energy transition, ESR, and internationalization, are the same ones the European EPCOs have been facing for some years now. What differentiates the situation of Japan 10-EPCOs and European EPCOs is the extent to which progresses have been accomplished with regard to each of these challenges.

For instance, when it comes to the energy transition **reduction in electricity consumption has been higher in Japan than in Europe**; -11% VS. -4% since the beginning of the decade**, and increase in RE electricity generation has been lower in Japan than in Europe**, with a much larger deployment of wind power in the later (Chart 19).

Chart 19: Europe Gross Electricity Generation 2010-2016



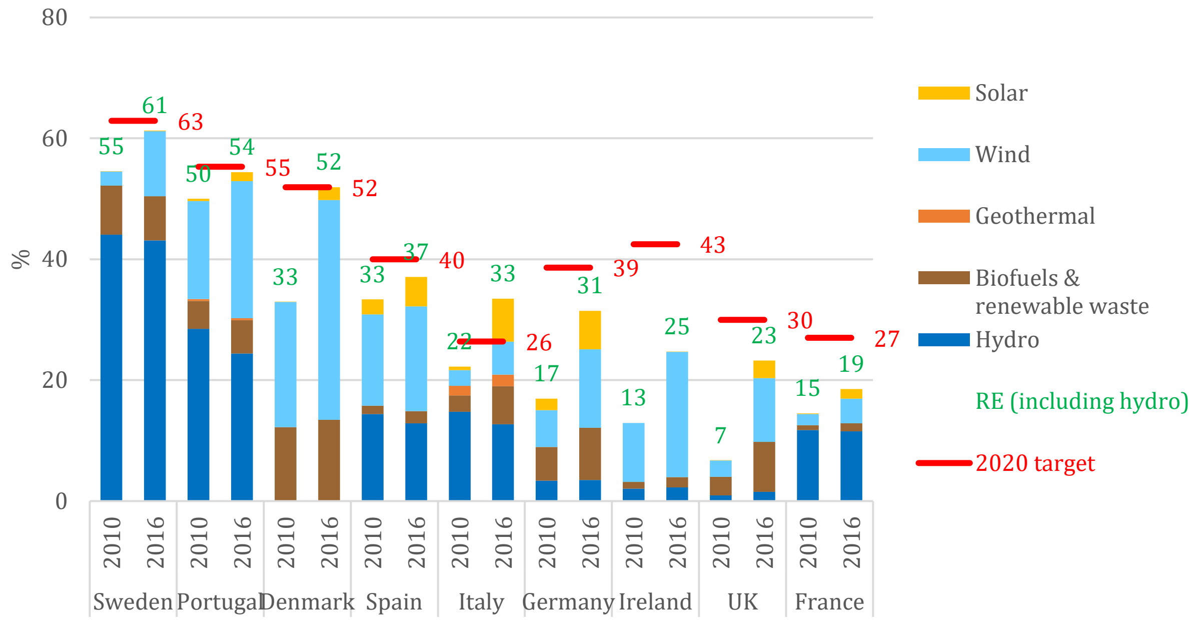
Notes:
Countries included; Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, and UK
"Other" includes pumped storage, non-renewable waste, and other (e.g. fuel cells, electricity from chemical heat).
And "hydro" includes tide, wave, ocean which is negligible

Source: IEA, Electricity Information 2017, Renewables Information 2015-2017, and Statistics (online)

It must be noted that expansion of RE is not advancing at the same pace in all European countries. Indeed, some countries are more progressive than others, and have thus set more ambitious RE deployment targets and implemented more aggressive policies to reach them (Chart 20 on next page).

In Sweden, Portugal, and Denmark RE exceeded 50% of gross electricity consumption in 2016. In Spain, Italy, and Germany 30-40%. Ireland has an ambitious target of meeting 43% of its electricity consumption from RE in 2020 from 13% in 2010 and 25% in 2016. The UK made good progresses from 7% in 2010 to 23% in 2016, and aims for 30% by 2020. France is lagging behind both in terms of achievements; 19% of electricity consumption covered by RE in 2016, and target; 27% by 2020, but has seen improvements in the past few years with the adoption of its Energy Transition Law for the Green Growth, which set a new more ambitious RE target; 40% of electricity generation by 2030, and reinvigorated expansion of wind and solar power in the country.

Chart 20: RE Share in Gross Electricity Consumption in Selected European Countries



Note: "hydro" includes tide, wave, ocean which is negligible

Sources: IEA, Electricity Information 2017 and Renewables Information 2017, and European Commission, National Renewable Energy Action Plans

Still at the generation level, following Fukushima nuclear accident, in both Japan and Europe nuclear power is terribly struggling.

In Japan, it is more complicated to meet more stringent safety standards and difficult to gain social acceptance to restart nuclear reactors.

In Europe, some countries have decided to phase-out nuclear power; Germany, Belgium, and Switzerland.

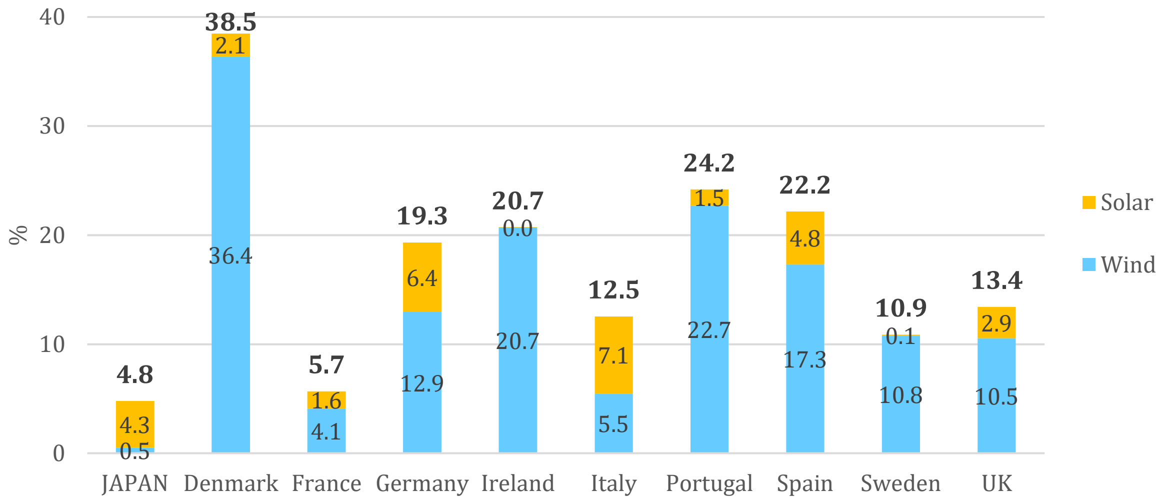
France has decided to reduce its reliance on nuclear power from 75% to 50% of its electricity generation by 2025 for a number of reasons, among which diversification of energy sources, electricity cost reduction, and safety were prominent (other arguments included greater independency, sustainability, and employment). An ambitious goal that, contrarily with Germany, lacks of a clear plant closures roadmap though, and still faces reluctance from the French nuclear industry, which raises the specters of higher electricity prices – which is becoming irrelevant (see II 1) C) “Nuclear Will Soon Belong to the Past, Leave it There”), increasing carbon dioxide (CO_2) emissions, and job losses. Enough to slowdown the denuclearization of France, for now, but not to stop it.

And new-build projects are well over budget and behind schedule, e.g. Flamanville III in France, Olkiluoto III in Finland, Mochovce III and IV in Slovakia, and without subsidies no new project will probably ever be built, e.g. controversial Hinkley Point C in the UK.

For now, fossil fuel power fate has been somewhat different in Japan and in Europe. This is due to differences of cost competitiveness of wind and solar VS. coal and gas in Japan and Europe (this will be presented in II 1) A) “Deploy Wind and Solar”).

When it comes to operating electrical grids with high shares of VRE European grid operators are more advanced than their Japanese peers (Chart 21 on next page). It has become a common daily business in Europe to balance fluctuating output from wind and solar power by using a combination of solutions; flexible operations of conventional power plants – from fossil power to nuclear and hydro (pump hydro storage notably), optimization of interconnection uses, grid reinforcement and expansion, demand side management, battery storage…

Chart 21: VRE Share in Gross Electricity Consumption 2016

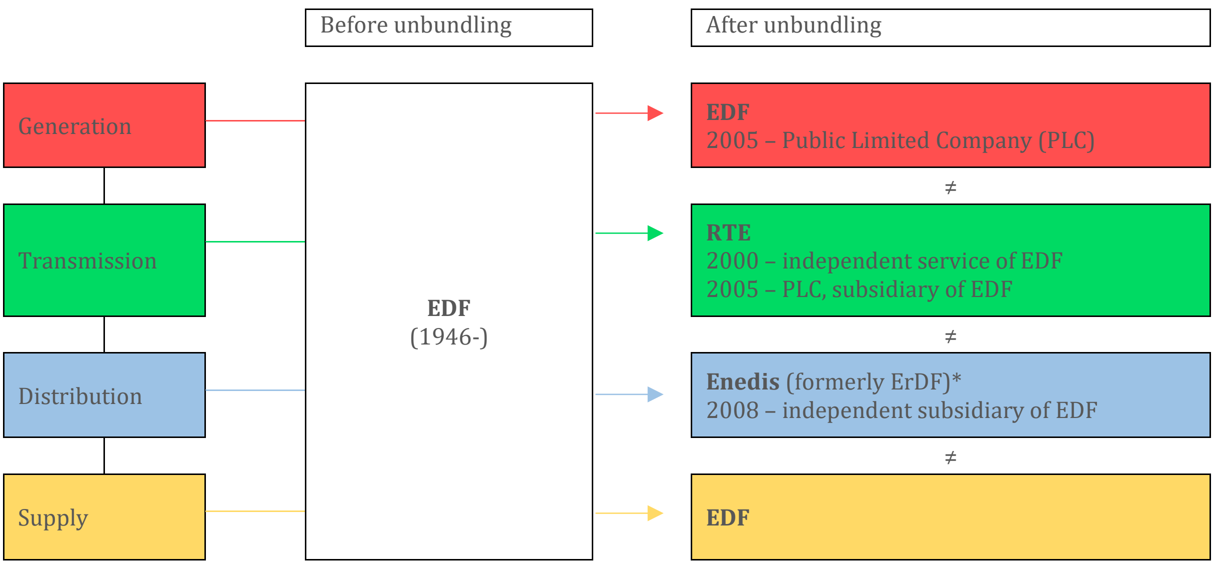


Source: IEA, Electricity Information 2017

The development of this expertise has certainly been helped by the unbundling of grid companies from generating interests that is yet to be realized in Japan in the next few years.

As for the ESR, Europe is clearly more advanced. For instance, the first EU (European Union) electricity market liberalization directive was adopted in 1996 and was to be transposed into Member States legal systems by 1999 (*Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity*).[15] About twenty years and two other *Directives* later, all European EPCOs are now completely unbundled.[16] Among the sample of European EPCOs of this report French EDF, German RWE and EnBW chose the legal unbundling model (Chart 22).

Chart 22: EDF, an Example of Legal Unbundling in Europe



*In 2015/2016, ErDF changed of logo and name (to Enedis) to avoid confusion with EDF among customers
Sources: EDF, RTE, and Enedis

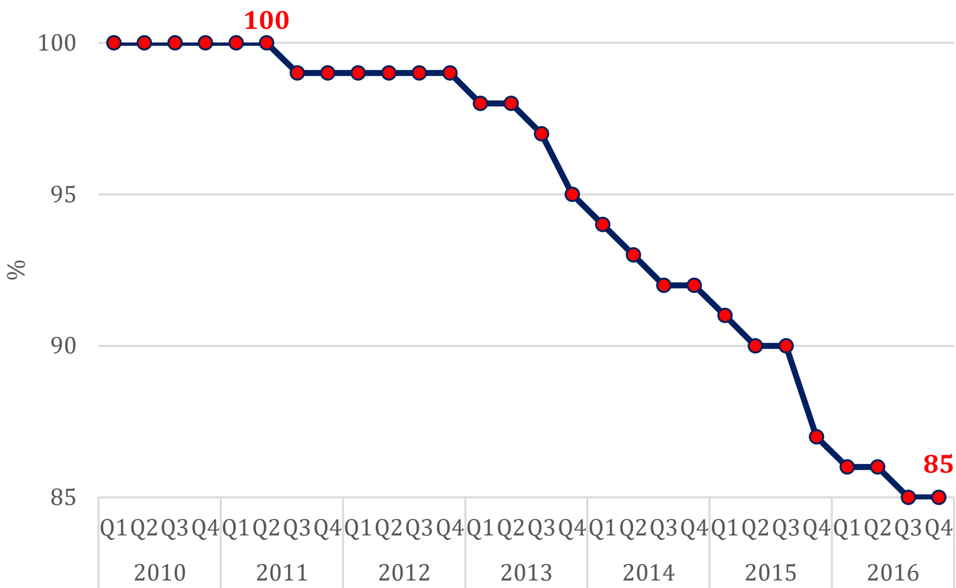
In the legal unbundling model, i.e. independent transmission operator (ITO), a transmission system operator (TSO) owns the grid assets and belongs to a vertically integrated company, with special rules to guarantee its independence. That is the unbundling model chosen in Japan, with the difference that Japan EPCOs transmission and distribution businesses will not be separated.

Two other models are (1) the functional unbundling model, i.e. independent system operator (ISO), a fully unbundled system operator without the grid assets (still belonging to an integrated company), and (2) the ownership unbundling (OU) model implying the appointment of the network owner as the system operator and its independence from any generation and supply interests.

It should also be noted that transmission and distribution networks operations are two different businesses in scale and complexity. Transmission lines carry electricity from large power plants to either substations or large consumers. Distribution lines carry electricity either from substations or distributed power plants to medium and small size consumers. Transmission and distribution businesses have been unbundled in Europe, which will not be the case in Japan and that will have its importance (discussed greater details in II 2) A) “Onwards to the 21st Century Electrical Grids”).

Still regarding ESR, competition at the supply level is also more developed in Europe (once again the time dimension should not be ignored). For instance, in Great Britain (GB) the so-called “Big 6” electricity suppliers; British Gas (or Centrica, a major energy supplier in the UK and a part of former gas monopoly British Gas notably), E.ON UK (E.ON), EDF Energy (EDF), nPower (RWE), ScottishPower (Iberdrola), and SSE still held a 100% electricity supply market share in GB in the first half of 2011. That number went down to 85%, i.e. -15 percentage points, at the end of 2016 due to increased competition on prices particularly (Chart 23).

Chart 23: Aggregated Electricity Supply Market Share of the “Big 6” in GB 2010-2016



Source: OFGEM, Electricity supply market shares by company: Domestic (GB) (December 2016)

Finally, **when it comes to internationalization** (and international competition more broadly speaking including competition through interconnectors) **European EPCOs are also much more advanced than their Japanese peers**. Indeed, while Japan EPCOs are becoming more aggressive in expanding overseas, the large majority of European EPCOs have been for many years major international market players, either at the global and/or European level.

From the end of the 1990s until the beginning of the 2010s a number of historical noteworthy international mergers and acquisitions (M&As) **were led by European EPCOs** (some of which are illustrated in Chart 24 on next page). For instance:

In Germany;

- In the early 2000s, Swedish Vattenfall notably acquired Hamburgische Elektrizitätswerke (HEW), Berliner Städtische Elektrizitätswerke Aktiengesellschaft (BEWAG), and Vereinigte Energiewerke Aktiengesellschaft (VEAG) – three of Germany former vertically integrated utilities.[17]

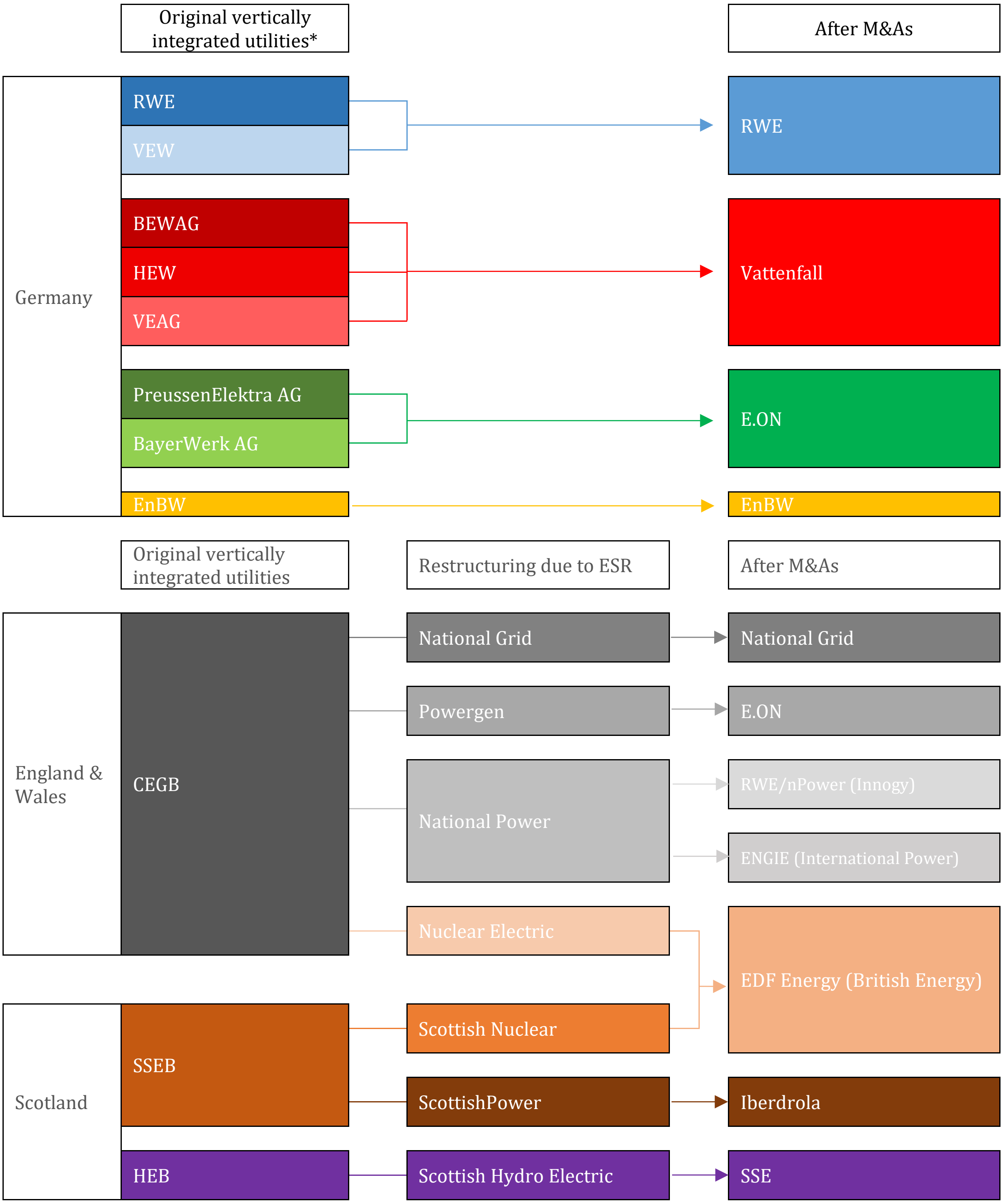
In the UK;

- At the end of the 1990s, French EDF acquired 100% of London Electricity, renamed EDF Energy in 2003 after a series of M&As.[18] In 2009, EDF Energy acquired British Energy; a combination of former Nuclear Electric, which owned the nuclear assets of former England and Wales generation and transmission monopoly Central Electricity Generating Board (CEGB), and of former Scottish Nuclear, which owned the nuclear assets of former vertically integrated utility South Scotland Electricity Board (SSEB).[19]
- In 2002, German RWE acquired Innogy one of the two parts of former National Power (one of the three generating parts of former CEGB, with aforementioned Nuclear Electric and Powergen, the latter one was acquired by German E.ON in the early 2000s).[20]
- ENGIE (originally France former national vertically integrated gas monopoly) expanded internationally by merging with the French Group Suez, full owner of Belgian power company Electrabel notably, in 2008, and by acquiring 70% of International Power, the other part of former National Power in 2011.[21]
- SSE is the result of the merger between Southern Electric and Scottish Hydro Electric (former vertically integrated utility North of Scotland Electricity Board (HEB)) in 1998.[22]
- In 2007, Spanish Iberdrola completed ScottishPower (former SSEB without nuclear assets) takeover.[23]

Other;

- In 2009, Italian Enel took full control of Endesa, Spain largest power company.[24] Endesa also has significant operations in Latin America.[25]

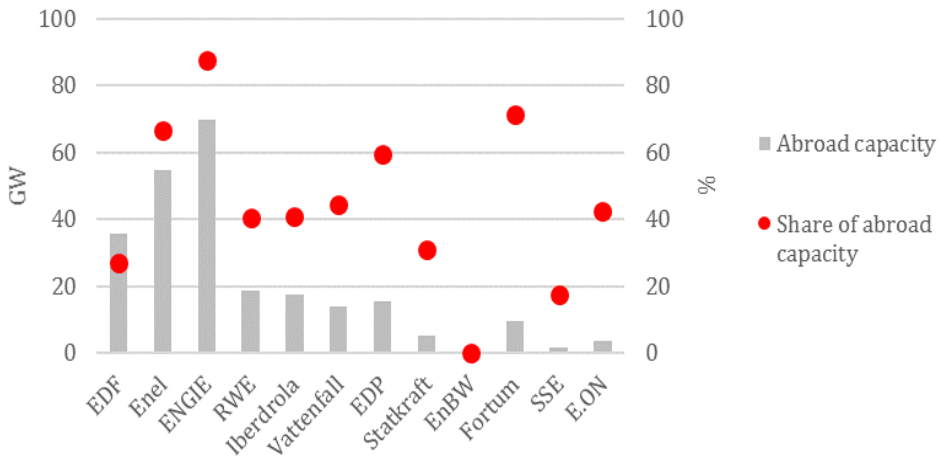
Chart 24: Examples of Historical M&As in Germany and the UK (Simplified)



*"Vertically integrated" here means at least generation and transmission segments integrated. These segments were in all cases unbundled after ESR. An important difference between Germany and the UK is that in England & Wales, particularly, the generation assets of original vertically integrated utilities were split to promote horizontal competition ("restructuring").
Source: Created by REI

As a result of these internationalization strategies European EPCOs significantly expanded their abroad generating capacity portfolios. Indeed, at the end of 2016, with the exception of EnBW which had no international business, all European EPCOs studied in this report had at least 2GW (SSE) of abroad power capacity, and half of them at least 15GW with ENGIE and Enel leading the pack with 70GW and 55GW, respectively (Chart 25). That is without common measure with Japan EPCOs.

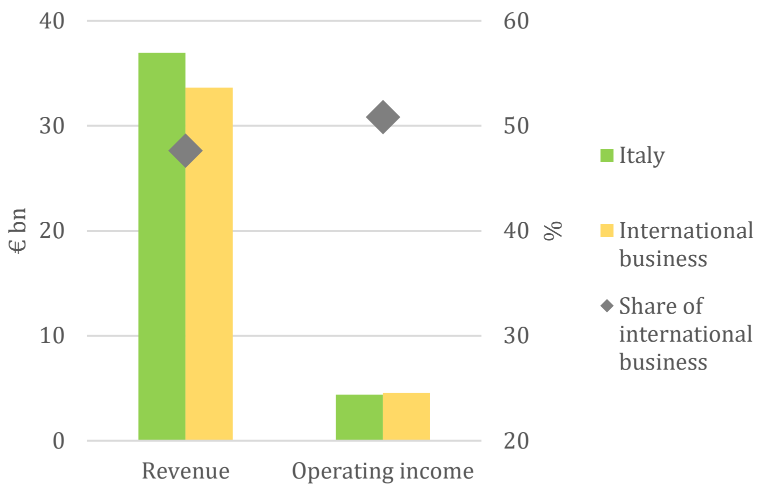
Chart 25: European EPCOs Abroad Power Capacity 2016



Sources: EPCOs Annual Reports, and in some cases complementary corporate materials publicly available online

In the cases of ENGIE and Enel revenues generated abroad represented respectively roughly €42 billion (63% of total revenues) and €34 billion (48% of total revenues) in 2016.[26] And for Enel international businesses accounted for €4.5 billion or 51% of the Italian EPCO operating income (Chart 26).[n27] These are substantial amounts.

Chart 26: Enel International Businesses Financial Indicators 2016



Source: Enel, Annual Report 2016

From all these observations, it is fair to recognize that European EPCOs have gone further on the path Japan EPCOs are now advancing, especially when it comes to RE expansion, ESR, and internationalization.

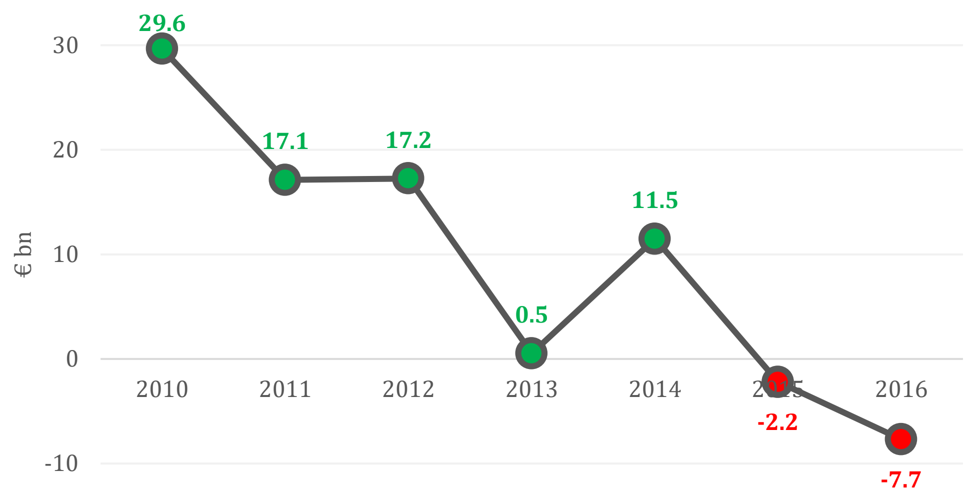
This means two things; (1) Japan EPCOs are lagging behind, and (2) that is in fact not necessarily a bad news as most European EPCOs have until now not really been successful in adapting to the new energy paradigm, and particularly the energy transition. Japan EPCOs thus have the chance to learn from their European peers costly mistakes.

n The reporting of ENGIE does not allow for a similar calculation for the French EPCO.

B) European EPCOs Failed to Adapt Quickly

In recent years, some of the European EPCOs have posted record losses: ENGIE; €(-9.2) billion in 2013 and €(-4.6) billion in 2015, E.ON – the most profitable European EPCO in 2010; €(-7.0) billion in 2015 and €(-8.5) billion in 2016, RWE; €(-2.8) billion in 2013 and €(-5.7) billion in 2016, and Vattenfall did not post a single positive annual profit since 2012. Aggregated the profits of all the European EPCOs studied in this report collectively collapsed from almost €30 billion in 2010 to a record low of about €(-8) billion in 2016 (Chart 27).

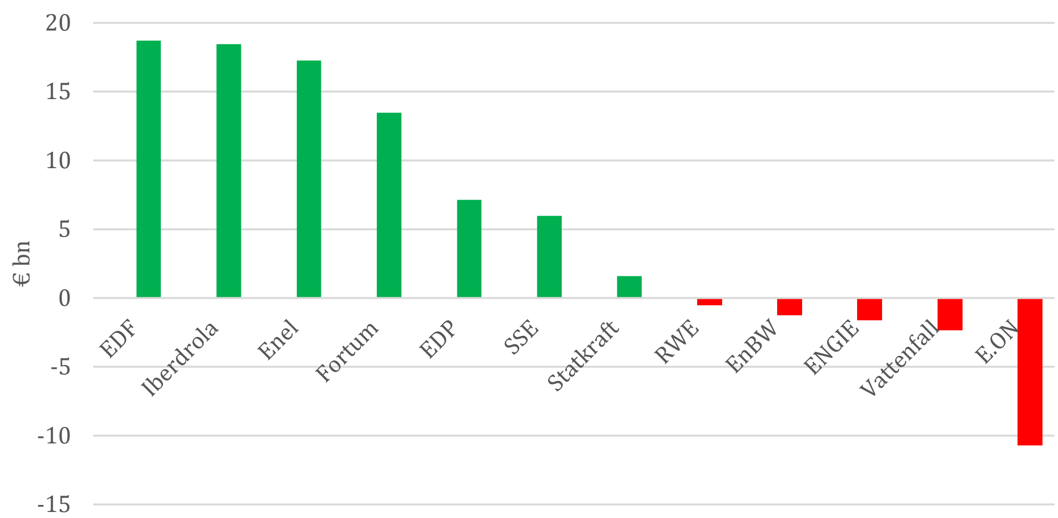
Chart 27: European EPCOs Aggregated Profits 2010-2016



Note: "Profits" means "net incomes attributable to shareholders of Groups (post-tax profits)"
Sources: EPCOs Annual Reports

Looking at each EPCO we can notice that EPCOs with a strong presence in Germany – the country of the *Energiewende* (energy transition) – have been performing particularly poorly (Chart 28). This may be explained by strategic failures in adapting to a new business environment in the country, resulting from national energy policies determined to significantly expand RE generation and consume electricity more efficiently.

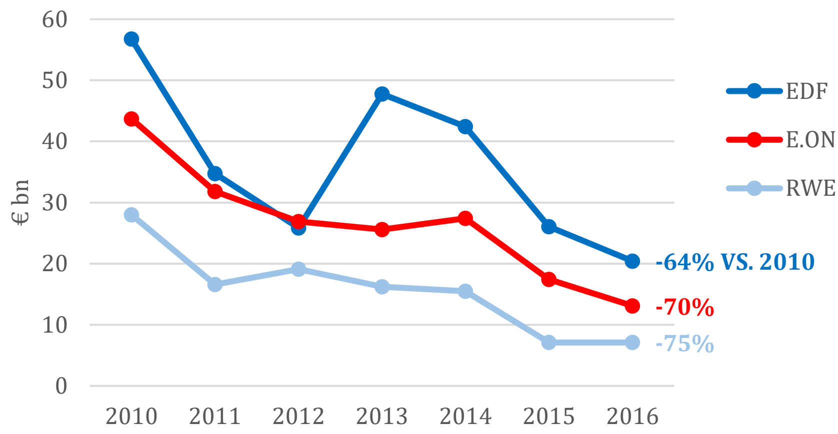
Chart 28: European EPCOs Profits 2010-2016



Notes:
In the period considered, profits of Fortum have been very positively impacted by the sale of the EPCO distribution businesses in Finland, Norway and Sweden 2014-2015
"Profits" means "net incomes attributable to shareholders of Groups (post-tax profits)"
Sources: EPCOs Annual Reports

However, even French EDF the most profitable EPCO in this period has seen its market capitalization collapse, like its German peers E.ON and RWE, because of of its inability to quickly adapt to the challenges of the energy transition taking place in the Central Western Europe region (Chart 29). That is because power grids and electricity markets integration at regional levels in Europe result in national energy policies impacting businesses of EPCOs even beyond national borders in an integrated same region; i.e. energy policies in Germany impact EDF business in France for example.

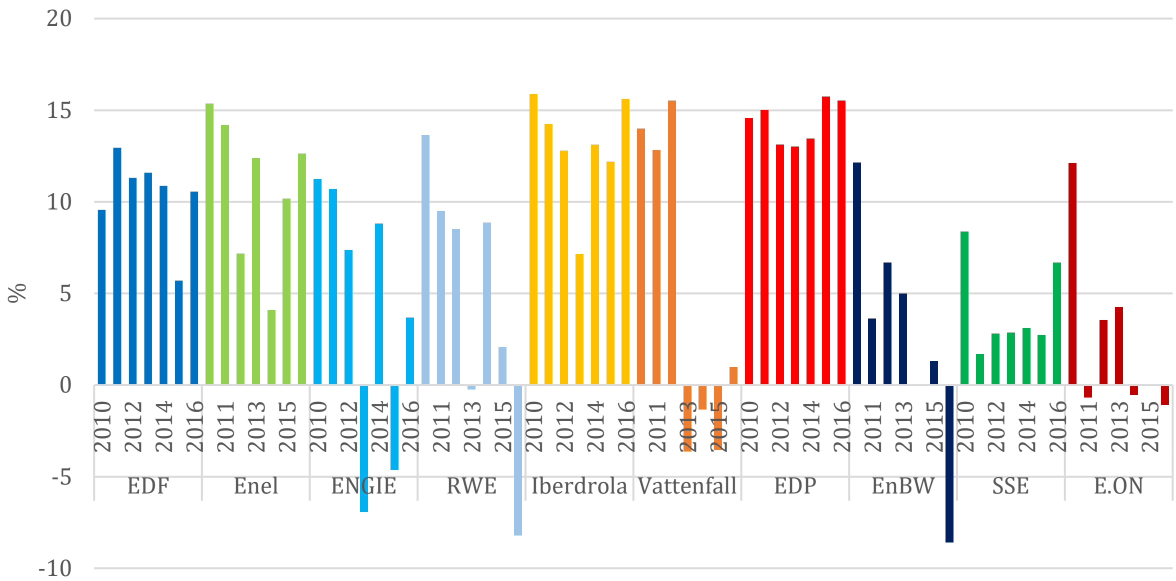
Chart 29: EDF, E.ON, and RWE Market Capitalization 2010-2016



Sources: EDF, E.ON, and RWE Annual Reports

Another indicator of profitability is the operating margin (Chart 30). Again EPCOs with a strong presence in Germany performed quite poorly in the period. Overall, performances have not been really brilliant with the remarkable exceptions of Iberdrola and EDP, two leading EPCOs in wind power with active international strategies in Latin America and North America particularly.

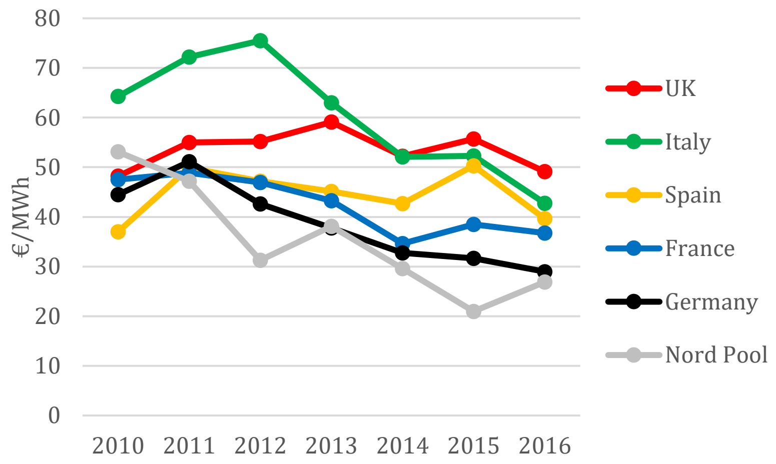
Chart 30: Selected European EPCOs Operating Margin 2010-2016



Sources: EPCOs Annual Reports

These overall negative performances result from the European EPCOs failure to quickly adapt to the energy transition, at the generation level especially. While electricity consumption stagnated, significant expansion of close to zero marginal cost wind and solar power, in which European EPCOs did not sufficiently invest, took place in Europe. The latter helped lowering wholesale electricity prices due to the merit order effect. At the same time, conventional power capacity did not significantly decrease which combined with stagnating electricity consumption and the expansion of RE resulted in overcapacity further reducing wholesale electricity prices (Chart 31). European EPCOs conventional power plants were thus outcompeted due to their higher marginal costs and suffered from low wholesale electricity prices, thus significantly affecting European EPCOs profitabiliy.

Chart 31: Average Spot Prices in Europe 2010-2016

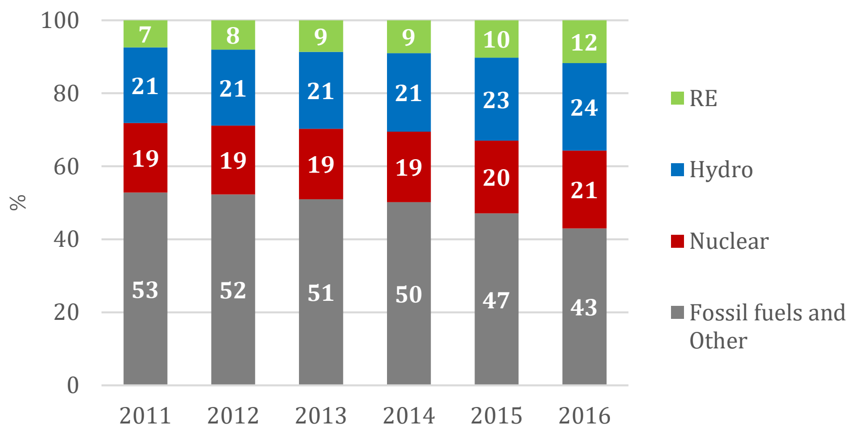


Sources: European Power Exchanges

According to the merit order principle generating capacity are to be economically dispatched based on their marginal cost to meet demand at the lowest cost. Generating capacity with the lowest marginal costs such as wind and solar or hydro and geothermal, which do not necessitate fuels to generate electricity are thus to be dispatched first. Nuclear which has relatively low marginal cost is to be dispatched next. Finally, come thermal generating capacity such as coal, gas, oil, and biomass.

Until recently (2014) fossil fuel-fired power plants accounted for the majority of the European EPCOs aggregated power capacity, and between 2011 and 2016 nuclear plants accounted for roughly 20% (Chart 32).

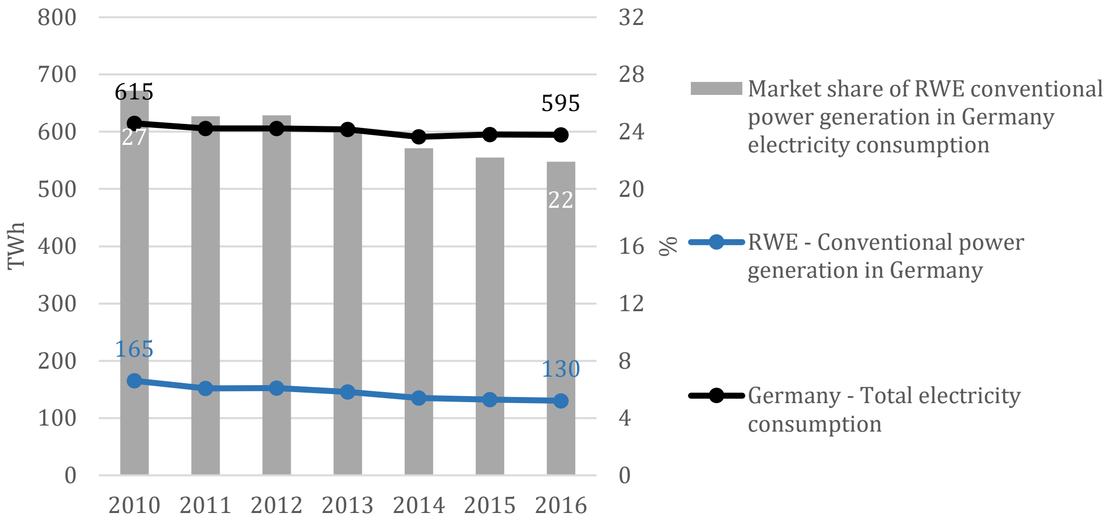
Chart 32: European EPCOs Power Capacity Share by Technology 2011-2016



Sources: EPCOs Annual Reports and other corporate materials publicly available online

This means that a significant portion of their power capacity portfolio was at risk of being penalized by the stagnation of electricity consumption and the expansion of close to zero marginal cost RE, which happened with the energy transition. Because of these developments the conventional power plants, particularly fossil-fired, of European have been operated less, losing market shares, and rewarded less (lower prices) for their service – a double blow (Chart 33).

Chart 33: RWE, an Example of European Conventional Power Generation Losing Market Shares



Sources: RWE, Annual Reports (2011-2016), and AGEB, Stromerzeugung nach Energieträgern 1990 - 2016 (August 2017)

As a result, European EPCOs had to recognize substantial loss of value for their conventional power plants. For instance, for the period 2011-2015 E.ON recognized impairment losses of over €13 billion for the non-current assets of its former "Generation" segment that consisted of all E.ON conventional (defined as fossil, biomass, and nuclear) generation assets in Europe.[o][28] Another striking and more specific example of impairments is the Moorburg coal-fired power plant of Vattenfall in Germany. A little over €3 billion were invested in the realization of this project decided in 2006 and finally commissioned in 2015.[29] It could be identified that in 2014, 2015, and 2016 Vattenfall recognized impairment of respectively €606 million, €437 million, and €488 million – half of the plant investment value.[30]

These trends have raised concerns about a lack of incentives for EPCOs to invest in new electricity generation capacity; "missing money problem." In Europe, several EU Member States including France, Germany, Italy, Spain, and the UK, notably, have introduced rewards for making capacity available, in the form of capacity mechanisms. However, capacity mechanisms are considered problematic because they risk distorting electricity markets. Inappropriate designs of mechanisms may for instance result in existing uneconomic power plants receiving financial support and disturbing the transition to a low-carbon economy – a failure.[31] The UK and Germany offer telling examples of far from perfect capacity mechanisms.

In the UK, National Grid, TSO in GB and Wales, held three main auctions for delivery four years ahead between 2014 and 2016. Existing power plants were allocated £2.4 billion, or 80% of the total capacity payments. Power plants rewarded were mainly; gas[p] over 60%, coal 13%, and nuclear 9%, to the detriment of clean and flexible technologies such as hydro, storage, demand-side response, and interconnection. And in February 2017, the first year-ahead auction, for delivery from October 2017 was concluded. Again, existing capacity were allocated a very large

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o Conventional generation activities are not part of E.ON business anymore following the spin-off of the EPCO in 2016. These activities are now carried on by Uniper.
p Possibly including some oil as well.

part of total capacity payments; 92%. And again, power plants rewarded were mainly; gas[q] 45%, coal 19%, and nuclear 14%.[32]

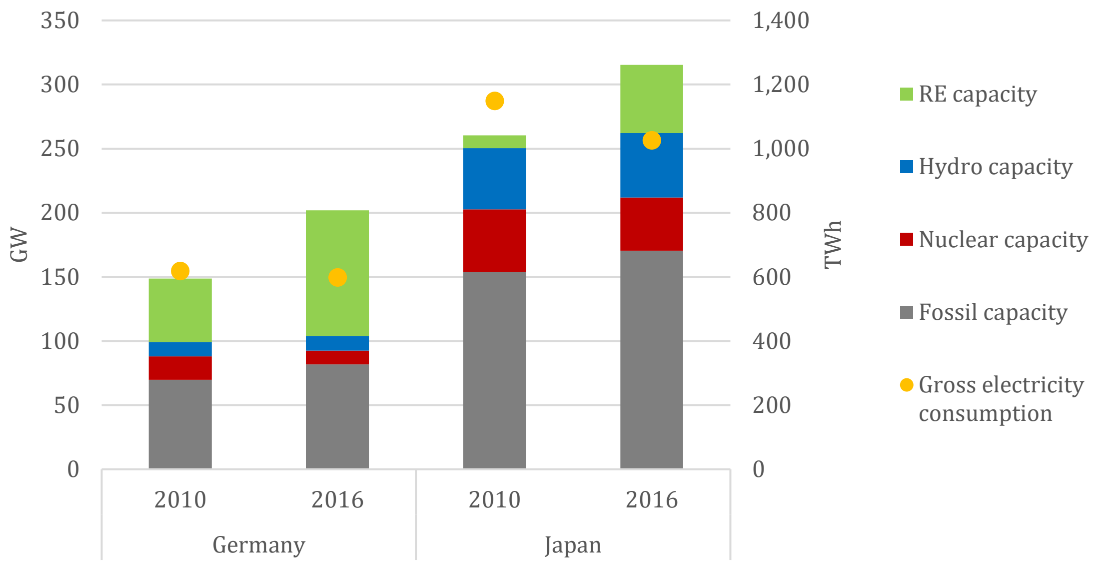
And in Germany, from this year 2.7GW of largely inflexible and high-emitting lignite capacity will be placed into an emergency stand-by reserve, only to be used as back-up when required for a period of four years, after which these plants will be permanently retired.[33] This comes at an estimated cost of €1.6 billion to the German government to compensate for lost revenues from the electricity market during these years of security stand-by.[34]

These flawed designs are unsurprising insofar as it has been found that many of EU Member States did not adequately assess the need or cost-effectiveness before introducing such mechanisms.[35]

In addition, it has also been recognized that capacity mechanisms implementation must be accompanied by appropriate market reforms.[36]

Thus, before adding gigawatts of new conventional power plants and/or pushing for the implementation of a capacity mechanism in Japan, Japan EPCOs should thus be well aware of these painful lessons learnt in Europe, and particularly of the risks related to the merit order effect and to overcapacity which are clearly looming in Japan. In Germany, EPCOs already showed the way not to go (Chart 34).

Chart 34: Merit Order & Overcapacity, Japan EPCOs Do Not Need to Repeat the Same Mistakes made in Germany

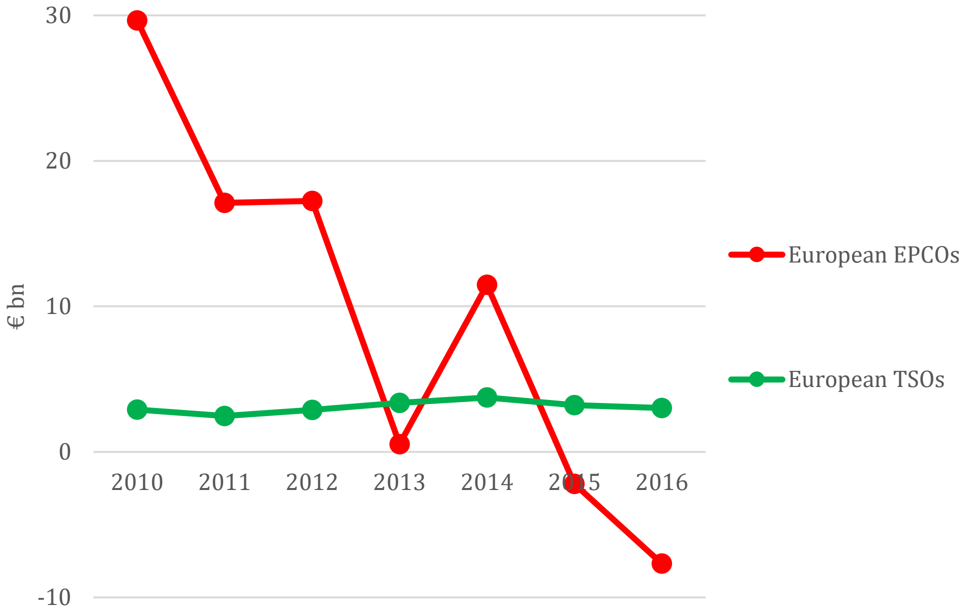


Sources: BNEF, Germany and Japan Country Profiles for power capacity (except; (1) for Japan nuclear capacity from Japan Atomic Industry Forum, Nuclear Power Plants in Japan (6 april 2017), and (2) for Germany and Japan hydro capacity from IRENA, Renewable Capacity Statistics 2017), and IEA, Electricity Information 2017 for gross electricity consumption.

European EPCOs generation segments have particularly suffered from the energy transition. That has, however, not been the case of their former transmission segments, which without necessarily striving accumulate reasonable and relatively stable positive profits year after year (Chart 35 on next page).

[q] Possibly including some oil as well.

Chart 35: European EPCOs VS. European TSOs Profits 2010-2016



Notes:
European EPCOs; EDF, Enel, ENGIE, RWE, Iberdrola, Vattenfall, EDP, Statkraft, EnBW, Fortum, SSE, and E.ON
European TSOs; RTE (France), Amprion (Germany), Elia (Belgium - including 50Hertz (Germany)), TenneT (Netherlands & Germany), Terna (Italy), Statnett (Norway), Red Electrica (Spain), Svenska Kraftnat (Sweden), and National Grid (United Kingdom)
"Profits" means "net incomes attributable to shareholders of Groups (post-tax profits)"

Sources: European EPCOs and TSOs Annual Reports

This demonstrates that processes such as the energy transition and ESR do not only deliver losers. Gone through very hard times in the past few yars, European EPCOs are now advancing new business models better suited for the new energy paradigm. Japan EPCOs now have the chance to learn the critical lessons from the European EPCOs, and they would better have to do so as the threat is real.

C) The Multiple Opportunities of the New Energy Paradigm

European EPCOs have now recognized that business as usual is not an option when confronting a new energy paradigm and stopped fighting an irreversible shift. In recognition of this new realtity, they have recently announced new strategies and started to implement them (Timeline on next page).

Timeline: Important Strategic Decisions Made by European EPCOs 2013-2016

Source: Created by REI

Chronologically:

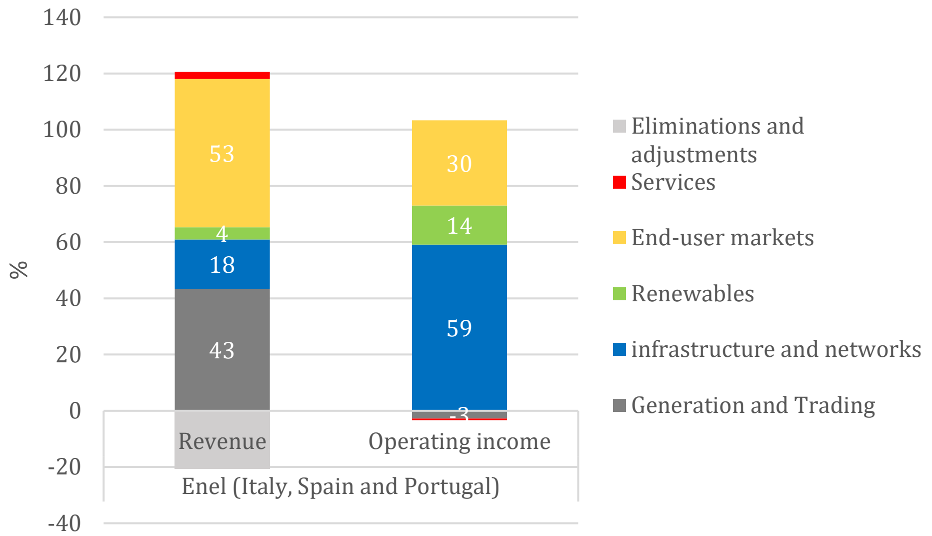
- June 2013, EnBW launches its "EnBW 2020 Strategy" notably targeting more than 40% of power capacity from RE (including hydropower) against only 19% in 2012, and 23% in 2016.[37]
- November 2014, E.ON announces spin-off (effective from 1 January 2016). E.ON now focuses on RE, energy networks, and customer solutions. New company Uniper focuses on conventional generation and energy trading.[38]
- April 2015, GDF-Suez becomes ENGIE, a new name to embrace the energy transition and targets four key sectors; RE, energy efficiency, LNG, and digital technology.[39]
- September 2015, EDF announces its strategic plan "CAP2030" notably targeting 50GW of RE (including hydropower) against 28GW in 2014, and 29GW in 2016.[40]
- November 2015, Enel buys back Enel Green Power, the RE developer it sold to the public in 2010, to spur growth.[41]
- December 2015, RWE announces carve-out. Taking a different approach than E.ON – instead of carving out the older assets RWE splits off the more attractive ones; RE, grid and retail operations into a new subsidiary "Innogy," which initial public offering took place in 2016.[42]
- February 2016, Finnish Fortum launches new strategy targeting increasing investments in solar and wind power.[43]

- April 2016, Vattenfall sells German coal (lignite) operations that included about 8GW of power capacity or 20% of Vattenfall total power capacity at the end of 2015.[44] This is part of the Group strategy to phase-out coal and fight against climate change.[45]

From these new strategies three key areas of growth emerge; RE, energy networks, and consumer solutions (end-user markets), and one area with negative expectations is more or less left behind; conventional generation.

This may be explained by the fact that while conventional generation is still an important source of revenues for European EPCOs, it is not really a profitable business area though, particularly when compared with RE, energy networks, and consumers solutions (Chart 36). This is due to overcapacity and merit order effect.

Chart 36: Enel, an Example of European EPCO Revenue VS. Operating Income Streams 2016



Source: Enel, Annual Report 2016

In addition, it is also important to note that all these new strategies were decided roughly within five years after Fukushima nuclear accident, a turning point in accelerating the energy transition. **In the power sector five years is a relatively short period of time, this demonstrates how quickly and strongly the effects of the new energy paradigm hit the European EPCOs.** In Japan, as these challenges are looming and gaining in intensity, Japan EPCOs would be wise to get themselves ready rapidly. There is no curse, but again the threat is real.

Based on all these observations, Part II of this report will now invite Japan EPCOs to learn more from the three key areas of growth designated by European EPCOs; (1) RE for electricity generation, (2) networks and integration, and (3) innovative solutions for customers.

II NEW BUSINESS MODELS

1) Electricity Generation; Turn Green

A) Deploy Wind and Solar

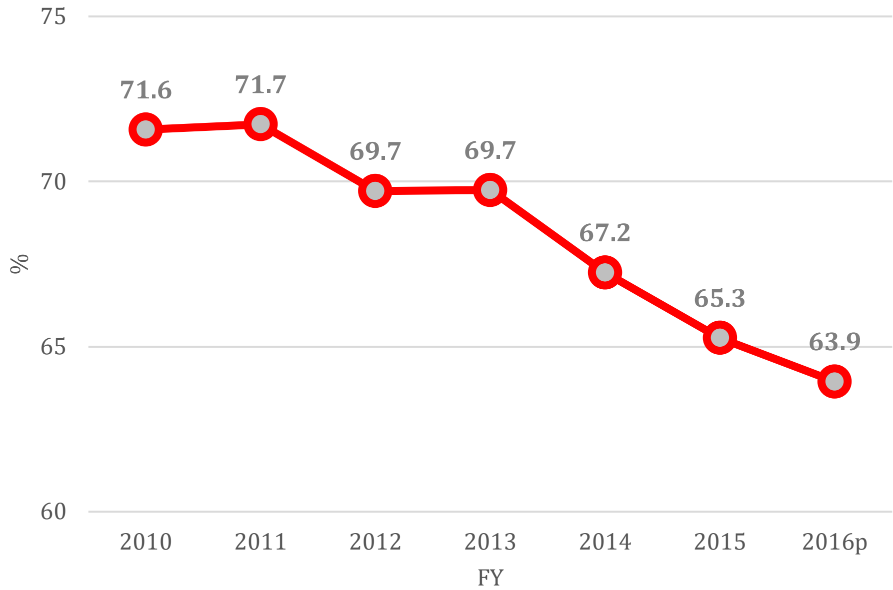
Analyzing key challenges faced by Japan EPCOs today, as well as the critical lessons to be learnt from their European peers experiences in facing these challenges to a greater extent, three areas for Japan EPCOs to focus on clearly appeared; RE, energy networks & integration, and customers solutions.

There are several reasons why Japan EPCOs should invest more in RE, and especially solar and wind power, both domestically and internationally.

Domestically;

- **If Japan EPCOs do not participate in the domestic expansion of solar and wind power others will and they will lose market shares.** This has already been demonstrated in recent years (Chart 37). Such investments may of course affect the profitability of Japan EPCOs existing power plants, especially if the close to zero marginal cost RE capacity they invest in are directly displacing their own power plants. This is, however, probably the less damaging approach to take.

Chart 37: Japan 10-EPCOs Market Share of Electricity Generation in Japan FY2010-FY2016

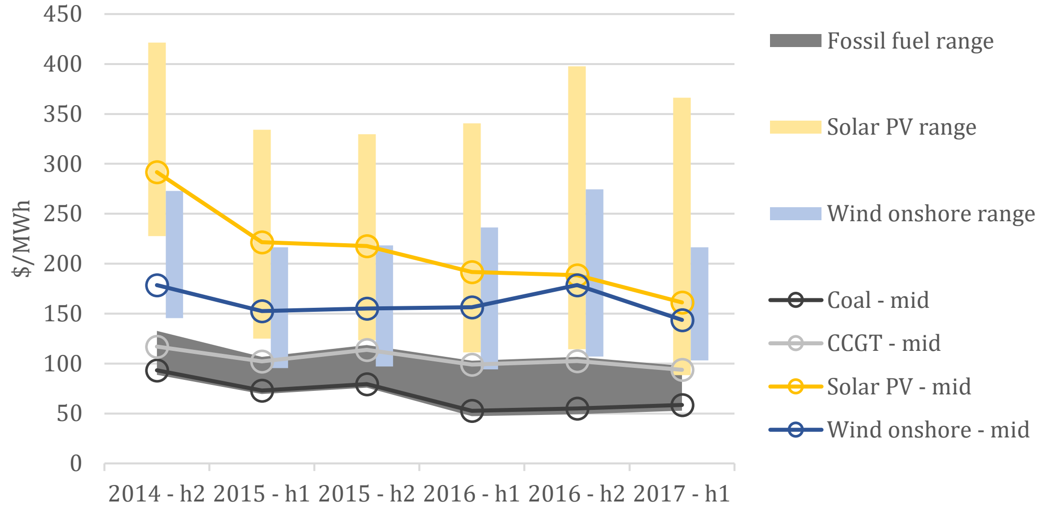


Sources: IEA, Electricity Statistics Information 2017 and Statistics (online), and METI, Electric Power Statistics

- On a more positive note, it may also be considered that **investing in close to zero marginal cost RE is a safe bet insofar as this capacity should always be dispatched first from an economic optimization perspective, that is a theoretical hedge**. There may of course be risks of curtailment in case generation from wind and solar exceed demand, but it is likely that following unbundling more favorable regulations (e.g. grid operations) regarding this particular matter will be implemented as grid operators will not have to consider the interest of their future former generation segments anymore, thus reducing curtailment risks for these close to zero marginal cost RE.

- Another decisive reason to invest in solar and wind power is their increasing cost competitiveness on a LCOE basis, especially for solar PV. **New best solar PV is now cheaper than new LNG power in Japan, even with low LNG prices**; ~$8-9 per million British thermal unit (/MBtu), range observed in the first half of 2017 and expected for the next few years (Chart 38).

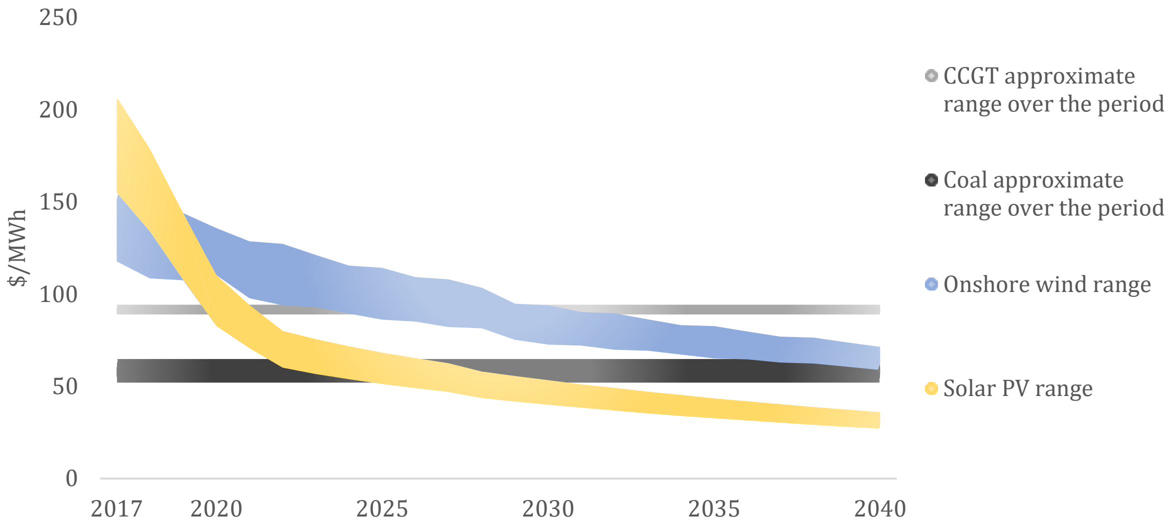
Chart 38: LCOE – New Best Solar PV Now Competitive with New CCGT Power in Japan



Notes:
Fossil fuel range does not include oil
Operational durations; Solar PV 25 years, wind onshore 20 years, CCGT 25 years, and coal 35 years
Source: BNEF, Levelized Cost of Electricity

And as further cost reductions are expected, new solar PV will be cheaper than new coal within 15 years from today according to BNEF (Bloomberg New Energy Finance) (Chart 39). **Cost reductions in wind power are also very achievable in Japan where wind potential is good**, particularly in the regions of Hokkaido and Tohoku. Improving time-consuming and costly procedures related to stringent land use regulations and environmental impact assessment is primordial to unlock this potential.[46] **Economics are thus clearly favoring RE over fossil fuels.**

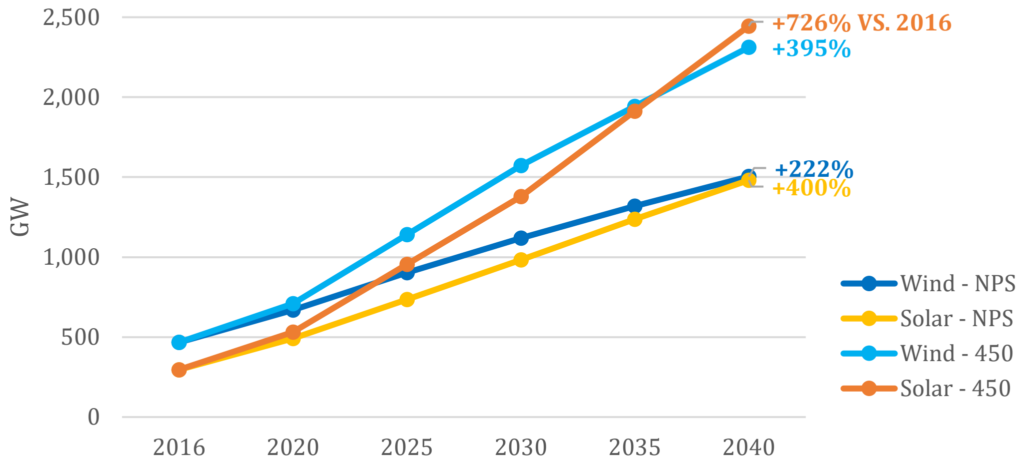
Chart 39: LCOE – New Solar PV to Be Cost Competitive with New Coal Power in 5-10 Years, and Cheaper from 2030 in Japan



Note: Operational durations; Solar PV 25 years, wind onshore 20 years, CCGT 25 years, and coal 35 years
Source: BNEF, Japan range of LCOE forecasts by technology (April 2017)

Overseas growth opportunities exist for Japan EPCOs, particularly in solar and wind power. IEA's moderate and decarbonization scenarios forecast significant growth for both technologies (Chart 40).

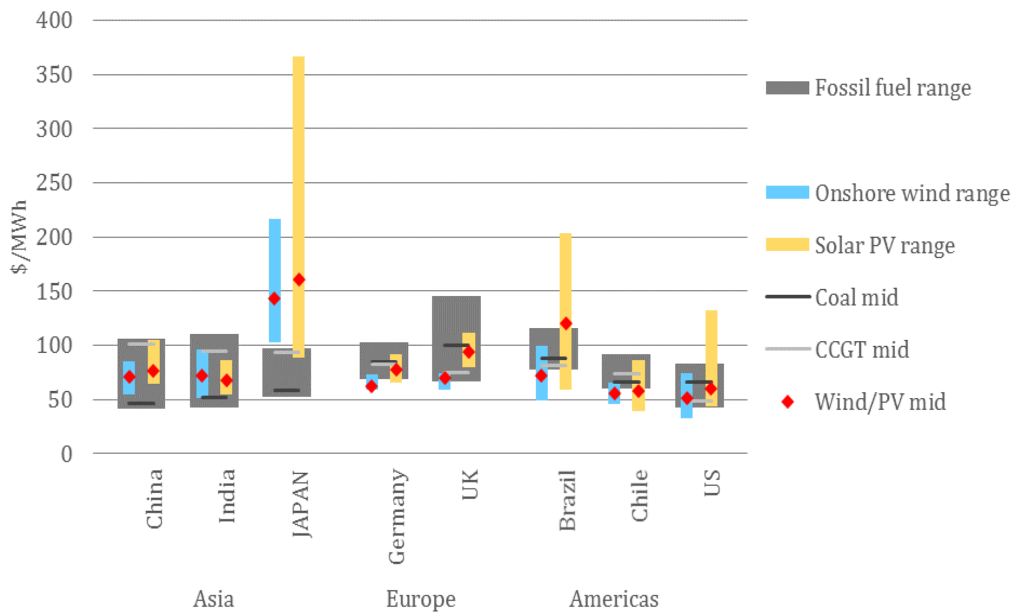
Chart 40: World Wind and Solar Power Capacity Projections to 2040



Sources: IRENA, Renewable Capacity Statistics 2017 for 2016, and IEA, World Energy outlook 2016 for projections

One of the key reasons behind these expectations is once again the economics. **Whereas solar and wind power are not completely cost competitive in Japan yet, these two technologies have already demonstrated in many countries around the world that they can be as cheap as fossil fuel power or even cheaper** (Chart 41).

Chart 41: LCOE H1 2017 – Solar PV and Onshore Wind Cost Competitive in many Countries around the World



Note: Fossil fuel range does not include oil

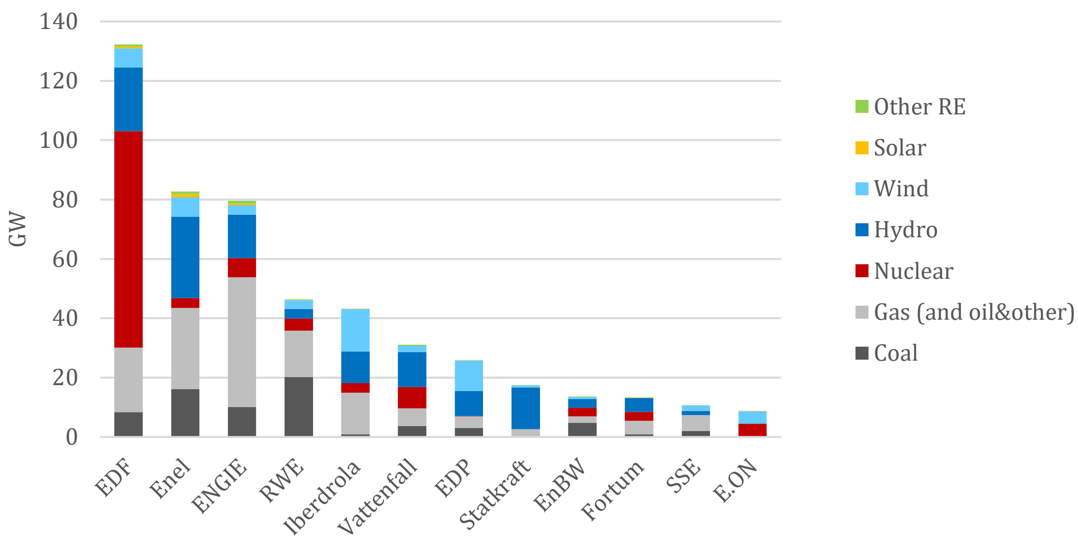
Source: BNEF, Levelized Cost of Electricity (April 2017)

These remarkable developments have been made possible thanks to dramatic cost reductions in key equipments between 2008 and 2015. In the case of solar PV, modules; -80%. In the case of wind, turbines; -30-40%.[47]

As for how Japan EPCOs may increase their RE portfolio several possibilities exist. For instance, by either (1) building new projects or (2) merging and/or acquiring RE companies. The latter solution presents the advantage of fast expansion. It may be favored by Japan EPCOs on the ground that they do not necessarily have a stronger expertise in deploying solar and wind power that specialized RE companies have. Such deals may also be in the interest of RE companies which financing may be more limited than Japan EPCOs to accelerate their growth and to benefit from the experience of established retailers when it comes to sell their production.

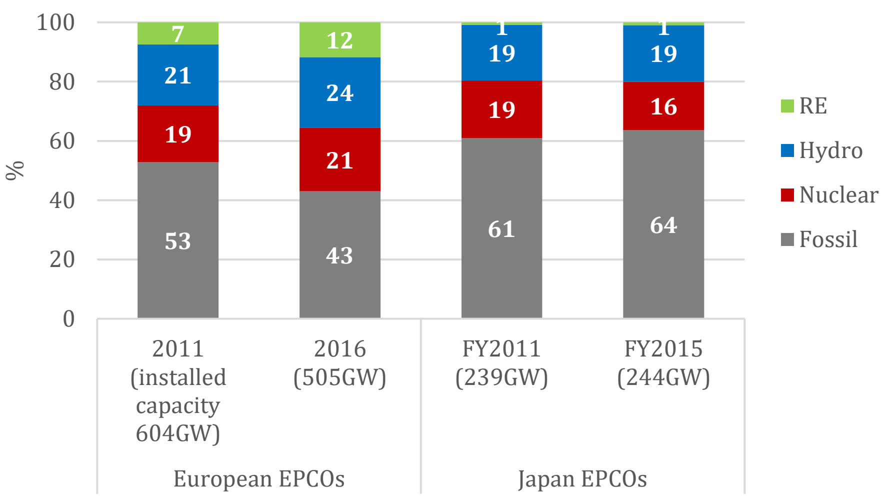
Having recognized these key trends European EPCOs have deployed RE more aggressively than Japan EPCOs in the past few years (Chart 42 and Chart 43).

Chart 42: European EPCOs Power Capacity 2016



Sources: EPCOs Annual Reports, and in some cases complementary corporate materials publicly available online

Chart 43: European EPCOs Deploying RE More Aggressively than Japan EPCOs



Note: Including capacity located abroad
Sources: EPCOs Annual Reports, and in some cases complementary corporate materials publicly available online

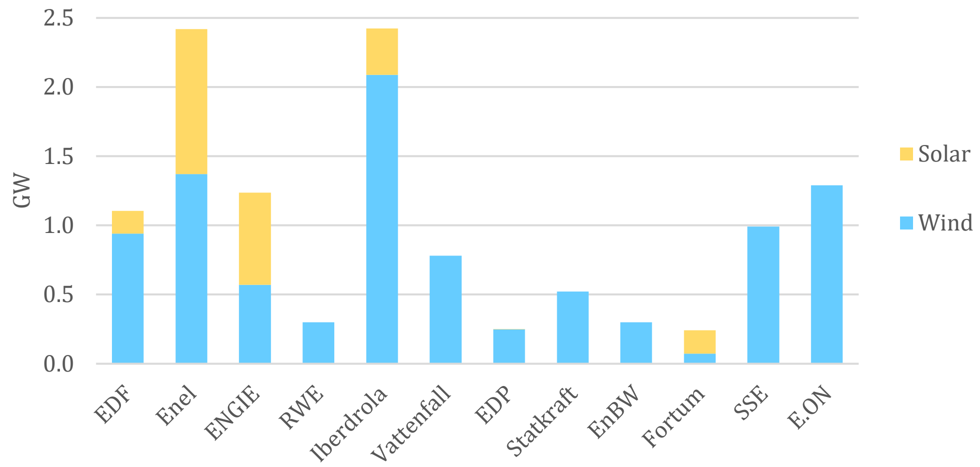
Being a more mature technology onshore wind power has been most deployed until now. However, it is also important to highlight that solar and offshore wind power are increasingly being deployed based again on dramatic cost reduction.

For instance, Enel added about 1GW of solar power to its power capacity portfolio in the past four years, including 0.7GW in 2016 alone. Enel is deploying solar power aggressively in Chile and South Africa particularly. ENGIE added hundreds of megawatts of solar power to its power capacity portfolio by acquiring a 95% take in Solairedirect, a global leader of competitive solar, in July 2015.[48] It is also worth noting that European EPCOs such as ENGIE, again, or Fortum recently won competitve auctions to build solar power in India for example.[49]

As for offshore wind, Vattenfall won a tender to build two offshore wind farms, total of 0.35GW, in the North Sea thanks to a roughly €65 per megawatt-hour (/MWh) bid in September 2016.[50] Two months later, Vattenfall again won a tender to build a 0.6GW wind farm in the Baltic Sea thanks to a bid just below €50/MWh.[51] Even more impressive, in April 2017, EnBW (0.9GW) and DONG Energy, a former Danish oil and natural gas state utility that has now become the global leader in developing and building offshore wind farms, (0.48GW) won bids to build German offshore wind farms at market price.[52] And in the UK in September 2017, (1) DONG Energy (1.39GW), (2) EDP Renovaveis (EDP RE subsidiary) and ENGIE (0.95GW), and (3) Innogy and Statkraft (0.86GW) were awarded to build three offshore wind projects with a total combined capacity of 3.2GW at strike prices of £57.50/MWh for the first two projects and £74.75/MWh for the third one – much less than the £92.50/MWh of EDF UK nuclear project Hinkley Point C.[53]

This is thus without surprise that European EPCOs added over 14GW of RE power capacity to their power plant portfolio in the past five years, and had about 12GW of wind and solar power capacity under construction at the end of 2016 (Chart 44).

Chart 44: European EPCOs Power Capacity Under Construction 2016



Sources: EPCOS Annual Reports, and other corporate materials publicly available online

Finally, **it should be mentioned that if European EPCOs are deploying wind and solar, and have set targets for RE expansion the reason is because as reasonable businesses they expect returns on their investments**.[r] In this regard, it may be worth to introduce here a couple of examples of European EPCOs with financial targets for their respective RE business; Enel and EnBW.

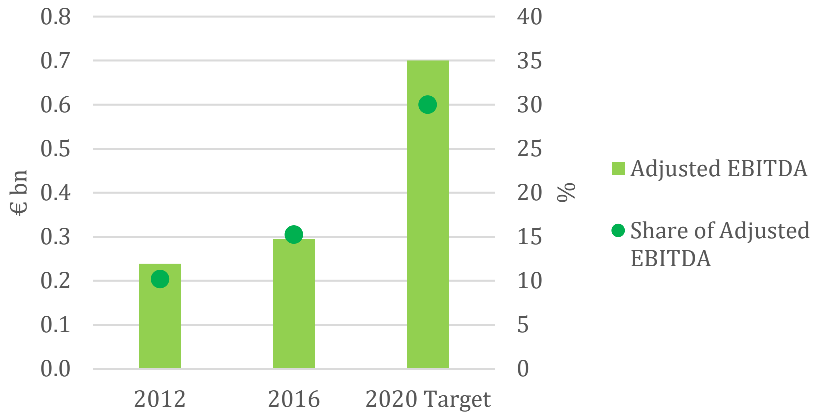
Enel expects its "Global Renewables Energies" business EBITDA (Earnings Before Interest, Tax, Depreciation and Amortization) to grow from €4.0 billion to €4.6 billion from 2016 to 2019 (+15%) and account for about 27% of its total EBITDA in 2019.[54] Accordingly, Enel plans a growth capital expenditure (CAPEX) of €5.2 billion for its renewables business for the period

r In addition, among others, Enel has a target of 39.2GW of RE (including hydropower) capacity by 2019 against 35.9GW in 2016. ENGIE targets 25% of RE (including hydropower) capacity by 2020 against 19.5% in 2016. And Vattenfall targets to commission more than 2.3GW of new renewables capacity between 2016-2020 (0.3GW in 2016).

2017-2019.[55] With these investments Enel will add over 3GW of RE (including hydro) power capacity; essentially wind and solar in the Americas, Africa, and Asia.[56]

And EnBW targets its "Renewable Energies" business adjusted EBITDA to grow from about €0.2 billion to €0.7 billion between 2012 and 2020 (€0.3 billion in 2016), and reach 30% of its total adjusted EBITDA in 2020 against about 10% and 15% in 2012 and 2016, respectively (Chart 45).

Chart 45: EnBW Adjusted EBITDA for RE Business Achievements VS. Targets



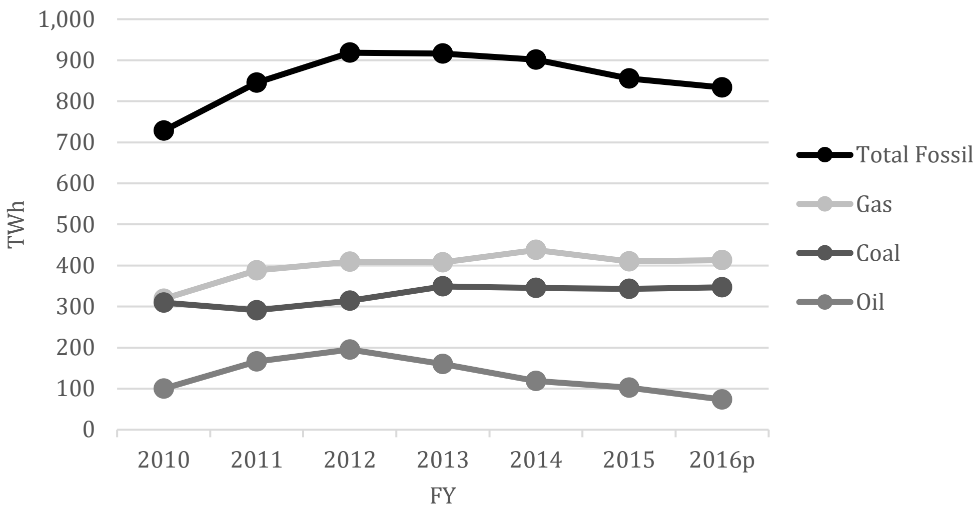
Source: EnBW Annual Reports 2013 and 2016

European EPCOs are thus pursuing RE expansion, especially in wind and solar, on economic grounds. And that is in the same strategic mindset that they are now turning their back on fossil power.

B) Fossil Power, Heavy Pressures to Come

In Japan, if electricity consumption further decreases, RE keeps expanding, and some nuclear reactors are restarted the need for fossil fuel power will significantly decrease because fossil power will be – in all cases – outcompeted from an economic dispatch point of view due to higher marginal costs. This has actually already started to happen in the last four FYs (Chart 46).

Chart 46: Japan Gross Electricity Generation from Fossil Fuels FY2010-FY2016



Source: IEA, Electricity Information 2017, and Statistics (online)

It is likely that as these trends continue Japan EPCOs fossil-fired power plants will sell less and less volumes, and at increasingly higher costs notably because they will be more and more operated at sub-optimal capacity factors.

Fossil power stations may also suffer from increasing wear and tear due to more frequent and faster ramping up and down in order to help integrate VRE into grids. This may also contribute to raise the operating costs of fossil power stations, to different extents though. Indeed, fossil power plants have different technical characteristics; gas-fired power plants are usually more flexible than coal-fired plants for example.[57]

It is possible to improve the flexibility of existing coal-fired power plants by investing several tens of millions of euros (€60-70 million per unit) in upgrade of control system in combination with plant engineering upgrades, notably, as demonstrated by RWE at a number of lignite-fired power plants (e.g. Weisweiler and Neurath) in Germany.[58] Repowering, that involves placing a gas turbine upstream of the water-steam circuit in coal-fired plants, is another option, but costlier.[59]

Gas power plants are admittedly more flexible than coal plants, but have higher LCOE and marginal costs due to higher fuel costs. In Japan, once oil plants will have been reduced to extreme peak capacity, gas plants will be the next victims of RE expansion. Their capacity factors will significantly decrease and their cost competitiveness be quite hindered.

This is not necessarily a very welcome development with regard to Japan decarbonization effort; 80% reduction of greenhouse gas by 2050. Indeed, gas power plants emit less CO_2 than coal power plants, and are better suited to help integrating VRE. In this regard, ambitious carbon pricing implementation is critical to not let Japan lag behind in the fight against climate change.

The UK which industrial revolution was fueled by coal, and that has decided to phase-out the world's dirtiest fuel by 2025 may provide a good example of efficient carbon pricing for Japan. Indeed, the doubling of the carbon price floor from £9 per ton of CO_2 to £18 in April 2015 has been a major factor in driving coal out of the UK electricity mix.[60] While from April 2014 to March 2015 electricity generation from coal still stood at over 95TWh, accounting for 27% of the UK electricity supply, it fell to 61TWh from April 2015 to March 2016, and below 27TWh, accounting for only 8% of electricity supply, from April 2016 to March 2017. In total, coal generation decreased by about -69TWh or - 72% in just two years, and became almost marginal in the UK electricity mix.[61] Among the victims, Iberdrola Longannet 2.3GW coal-fired power plant closed in 2016, three years before its estimated closure date because of poor economic prospects due to carbon taxes notably.[62]

In addition, France, which only had about 3GW of coal power capacity remaining at the end of 2016 (against 8GW in 2010) is planning to phase-out coal power by 2022, and seeks to establish a common carbon price floor of €30 per ton of CO_2 with Germany.[63]

Selling less electricity at higher cost for lower prices (merit order) from their fossil power plants should horrify Japan EPCOs, which are not only already heavily reliant on these technologies, but are also planning to be even more so by adding more than 22GW of new fossil power capacity, eclipsing the expected decommissioning of 11GW of fossil power capacity nationwide by FY2026 (Table 3 on next page).**[64] "Overcapacity" and "merit order effect" have been the key reasons why European EPCOs failed so badly to adapt to the energy transition, this has been made very clear in this report. There will be absolutely no excuse for Japan EPCOs to not take necessary corrective strategic measures rapidly. Thousands of billions of yens in impairment charges and stranded assets are just around the corner.[65]**

Table 3: Japan 10-EPCOs & J-Power Fossil Power Plants Construction Plans

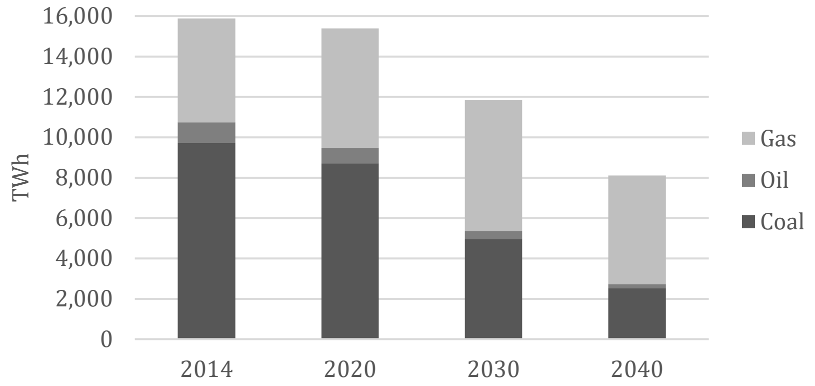
	Coal		Gas		TOTAL FOSSIL	
	Project	Capacity (MW)	Project	Capacity (MW)	Project	Capacity (MW)
Tokyo	No	0	No	0	0	0
Kansai	Kobe Steel (FY2021-22)*	1,221	Wakayama (FY 2027)	3,700	2	4,921
Chubu	Taketoyo (FY2021)	1,070	Nishi-Nagoya (FY2017)	2,376	2	3,446
Kyushu	Matsuura (FY2019)	1,000	No	0	1	1,000
Tohoku	Noshiro (FY2020)	600	Joetsu (FY2023)	572	2	1,172
J-Power	Takehara (FY2020) Takasago (FY2021-27) Kashima (FY2020) Nishiokinoyama (2023-25)	600 1,200 323 (share of J-Power) 540 (share of J-Power)	No	0	4	2,663
Chugoku	Misumi (FY2022) Soga (2024)	1,000 1,070	No	0	2	2,070
Hokuriku	No	0	Toyama Shinko (FY2018)	425	1	425
Hokkaido	No	0	Ishikariwan Shinko (FY2018-28)	1,708	1	1,708
Shikoku	Sendaiko-Takamatsu (FY2021) Saijo (FY2022)	112 500	No	0	2	612
Okinawa	No	0	No	0	0	0
JERA	Hitachinaka (FY2020) Yokosuka (2023-24)	650 1,300	Goi (2023-2024)	2,340	3	4,290
TOTAL EPCOs	14	11,186	6	11,121	20	22,307

*Procurement program

Sources: EPCOs and J-Power Annual Reports and other corporate materials publicly available online

Temptations to invest in fossil fuel power overseas should also be refrained as the economic and climate needs are clearly for new RE power capacity not fossil. Indeed, RE are now as cheap or even cheaper than fossil fuel electricity generation in many countries around the world. And with regard to climate change, if humanity is to embrace the path of decarbonization, which it will need to survive then we will not need more electricity from fossil fuels, but much less – in particular coal (Chart 47 on next page).

Chart 47: World Electricity Generation from Fossil Fuels in IEA 450



Source: IEA, World Energy Outlook 2016

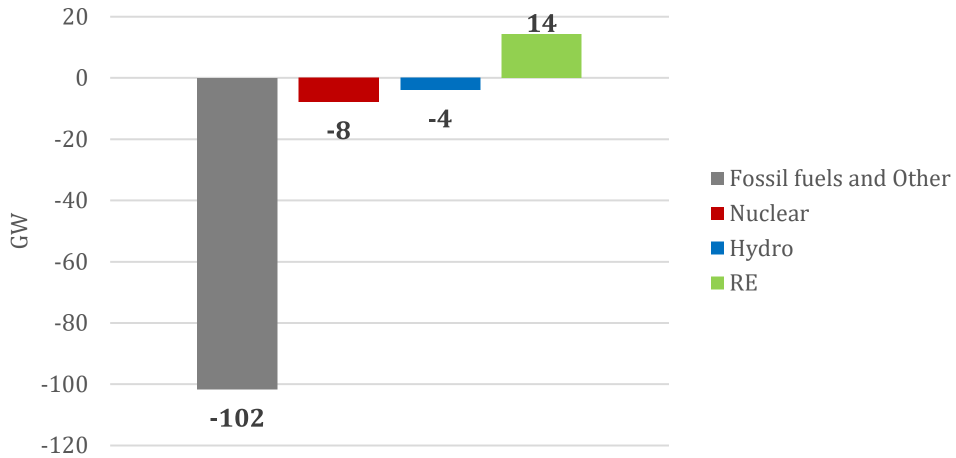
In Europe, electricity generation from coal decreased by -90TWh or -16% between 2010 and 2016. An effort led by; the UK -77TWh, France -15TWh, Finland -11TWh, and Denmark -8TWh.

And electricity generation from gas decreased by -168TWh or -23% between 2010 and 2016. That is a bigger reduction than coal due to relative fuel cost competitiveness over that period. However, when comparing 2015 and 2016 only, electricity generation from coal decreased by -80TWh and electricity generation from gas increased by +95TWh. This coal-to-gas switching was made possible thanks to coal power plants closures, lower gas prices, and higher carbon price in the UK.

Though it is difficult to predict which combustible will win this fossil fuel internal duel in the next few years, in the medium-term it may well be gas. Indeed, while coal power capacity decreased by -19GW in Europe between 2010 and 2016, and not a lot of new coal-fired power plants are expected to come online anymore, gas capacity increased by +7GW in the same period and may be further supported as the fight against climate change intensifies. However, and this is more important, both are ultimately to lose as the energy transition moves forward in Europe over the course of this century.[66]

European EPCOs have now well integrate these fundamental changes and have started to implement drastic strategies to reduce their fossil power exposure. Thus between 2011 and 2016 they decreased their global fossil fuel power portfolio by over 100GW either by closing or selling plants (Chart 48).

Chart 48: European EPCOs Power Capacity Change 2016-2011



Sources: European EPCOs Annual Reports and other corporate materials publicly available online

This effort has so far been led by several EPCOs. At the forefront, E.ON, of course, which had over 52GW of fossil power capacity in 2011, and has now exited the fossil power business (E.ON has a 46.65% stake in the Uniper Group, which was deconsolidated from E.ON from 31 December 2016 and had about 33GW of fossil power capacity at the end of 2016).[67] Enel which has reduced its fossil power capacity by roughly 14GW in the past five years (with a focus on oil&gas), and is targeting to further reduce its fossil power capacity by another 7-10GW by 2019.[68] ENGIE which has reduced its fossil power capacity by about 11GW (with a focus on gas). Vattenfall which has reduced its fossil power capacity by approximately 8GW (with a focus on coal). And EDF and RWE which have reduced their fossil power capacity by about 4GW each.

In this regard, it may be highlighted that in October 2015 ENGIE announced its decision not to build anymore new coal-fired power plants.[69] And in April 2017, EURELECTRIC, the union of the electricity industry in Europe, stated that it does not intend to invest in new-build coal-fired power plants after 2020.[70]

In light of these developments Japan EPCOs would be well inspired to deeply reconsider their position towards fossil power. And not only towards fossil power. Nuclear power, which they are desperately trying to promote again also shows signs of severe stress.

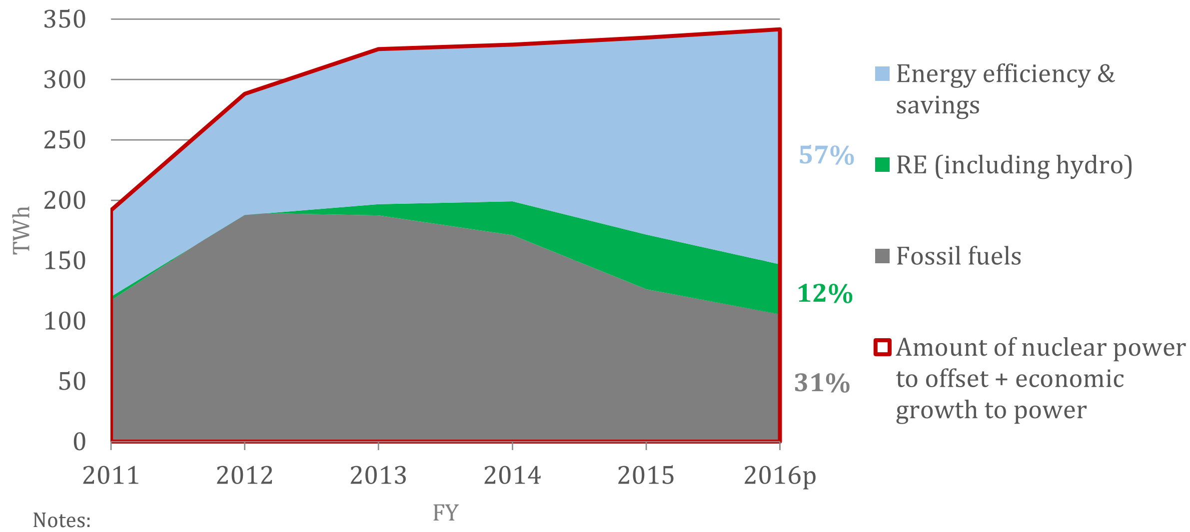
C) Nuclear Will Soon Belong to the Past, Leave it There

Back in FY2010, with 54 reactors nuclear power accounted for over a quarter of Japan gross electricity generation, and was considered as cheap, clean, and safe. Then Fukushima nuclear accident happened in March 2011, a man-made disaster for which Tokyo EPCO and regulators at the Nuclear and Industrial Safety Agency have been recognized responsible. **Fukushima nuclear accident is a major event in Japan power sector history, but not only. Indeed, it had implications worldwide. Whereas in Japan, it triggered the country energy transition, and gave new impetus to the ESR, at the global scale, it accelerated the deployment of RE and casted a shadow on the whole nuclear industry.**

In the months and years following the accident Japan has impressively demonstrated that it could meet its power demand on its own (i.e. without having the possibility to import electricity from another country) by making important efforts in reducing its electricity consumption thanks to energy efficiency & savings, ramping up fossil power generation, and massively deploying RE, particularly solar PV. And **in FY2016, as a result of the efforts made in the field of energy transition, Japan could replace roughly 60-70% of the substantial decrease in electricity generation from nuclear power with energy efficiency & savings and RE (including hydro)** (Chart 49 on next page).[s]

s In FY2016, energy efficiency & savings and RE replaced 61% (not assuming constant electricity intensity) or 69% (assuming constant electricity intensity) of the decrease in nuclear power generation; -270TWh – FY2010 VS. FY2016.

Chart 49: How Japan Replaced Nuclear Power



Notes:
Assuming constant electricity intensity
"Other" is included in fossil fuels and is negligible

Sources: IEA, Electricity Information 2017, Renewables Information 2015-2017, and Statistics (online), and Government of Japan, Cabinet Office, Economic and Social Research Institute, National Accounts of Japan

From a power capacity perspective only (notwithstanding economic or environmental dimensions), this major achievement demonstrates that **Japan does not need its remaining 42 nuclear reactors** (12 of which are planned for decommissioning, including the 6 of the troubled Fukushima Daiichi plant) **to meet its electricity consumption**. In other words, there is no critical need to restart Japan EPCOs nuclear power plants, which Japan EPCOs are strongly pushing for – with a quite limited success until now (only 5 reactors were online as of the beginning of October 2017) – despite lack of social acceptance.[71]

It is understandable that Japan EPCOs want to maximize the profits they can realize from their existing assets. It is also fair to consider that in the very short-term restarting nuclear reactors in Japan could help decreasing imports of costly fossil fuels, strengthening the country energy security, reducing electricity generation cost (since nuclear power has lower marginal cost than fossil power that would be displaced in the merit order), and improving air quality. However, this may just be a short relief for nuclear power in Japan, which is not only facing social acceptance issues, but also existential medium- and long-term economic and technical challenges.

Economics of nuclear in Japan are quite doubtful today. Historically, nuclear power has been considered as one of the lowest cost options to generate electricity. This may have held true for decades by jeopardizing the security of people (lack of implementation measures to meet insufficient safety standards), not holding EPCOs financially responsible in case of nuclear disaster (Tokyo EPCO would have gone bankrupt without Japanese government intervention), and not seriously considering decommissioning and radioactive waste management & storage issues. Taking all these critical aspects into account the bill may probably end up not being so cheap anymore.

In this regard, more transparency in the cost of nuclear power in Japan would be very timely and very much welcome for many stakeholders, particularly at a time when Japan EPCOs are investing to upgrade the safety of their plants to meet stricter safety standards, considering lifetime extensions as about half the country nuclear fleet has been grid connected for over 30 years, and are expected to start providing concrete realistic plans describing their dismantling and radioactive waste management & storage financial and technical viable solutions.[72]

Once again, it is likely that the outcome of this process will result in a strong degradation of nuclear power cost competitiveness.

Finally, based on present situation in Japan for social and economic reasons it is hard to imagine new build projects, i.e. there may be no growth opportunity at all for nuclear power business in the country.

These observations are supported by recent developments in the nuclear power business of European EPCOs. Indeed, **as the energy transition proceeds with low wholesale electricity prices and higher nuclear costs due to the implementation of higher safety standards following Fukushima nuclear accident, a number of uncertainties regarding nuclear power economics have now been removed in Europe. And these findings are absolutely not playing in favor of nuclear power**:

As for existing plants;

- In April 2015, Vattenfall announced the permanent shutdown of Ringhals I and II in Sweden years ahead of schedule due to declining profitability and increased costs.[73] Schedule to end operation were confirmed and specified in October 2015; Ringhals I to be shutdown in 2020 and II in 2019.[74]
- In October 2015, E.ON decided that it would permanently shutdown Oskarshamn I and II in Sweden years ahead of schedule due to deteriorated economics; low wholesale electricity prices and additional requirements on extensive investments.[75] On 17 June 2017, unit I has been permanently shutdown after suffering a last operational disturbance.[76] Unit II has already been offline for a few years now and will not be restarted.[77]
- In February 2016, the French Cour des comptes, the supreme body for auditing the use of public funds in France, estimated the production cost of electricity from nuclear power in France by French nuclear giant EDF at roughly €63/MWh, against €50/MWh in 2010 – an increase of 26% due to a strong increase in maintenance investment.[78] That is not competitive anymore with solar PV as demonstrated by the results of a recent auction in France which showed average price of solar PV for awarded large scale ground mounted projects (5-17MW) at €56/MWh.[79]

As for new plants;

- EDF Flamanville European pressurized reactor (EPR) in France which construction started in 2007 with commercial operation expected in 2012 is now scheduled to be connected to the grid in 2019.[80] Cost was initially estimated at €3.3 billion, last official figure available from September 2015 indicated a cost of €10.5 billion.[81] Generation cost of the plant is estimated to be €120/MWh – roughly double the price of solar PV.[82] That is not cheap, neither is the strike price that EDF will get for building Hinkley Point C in the UK; £92.50/MWh (2012 prices, fully indexed to the consumer price index for 35 years) – roughly €117/MWh as of early October 2017.[83]
- Construction of Olkiluoto EPR, in which Fortum as a 25% share, started in 2005 with commercial operation expected in 2009 is now scheduled to begin commercial operation at the end of 2018, another considerable delay.[84] This project also suffered substantial cost overruns; cost was initially estimated at €3.2 billion, latest estimate in 2012 indicated a price tag of €8.5 billion.[85]

- Another project plagued by delay and cost overrun is Mochovce III & IV in which Enel is involved. Construction started in 2009 with expected completion in 2013 at a cost of €2.8 billion.[86] These reactors will not provide power before late 2018 and late 2019, respectively.[87] In October 2016, the estimated cost had grown to €5.4 billion.[88]

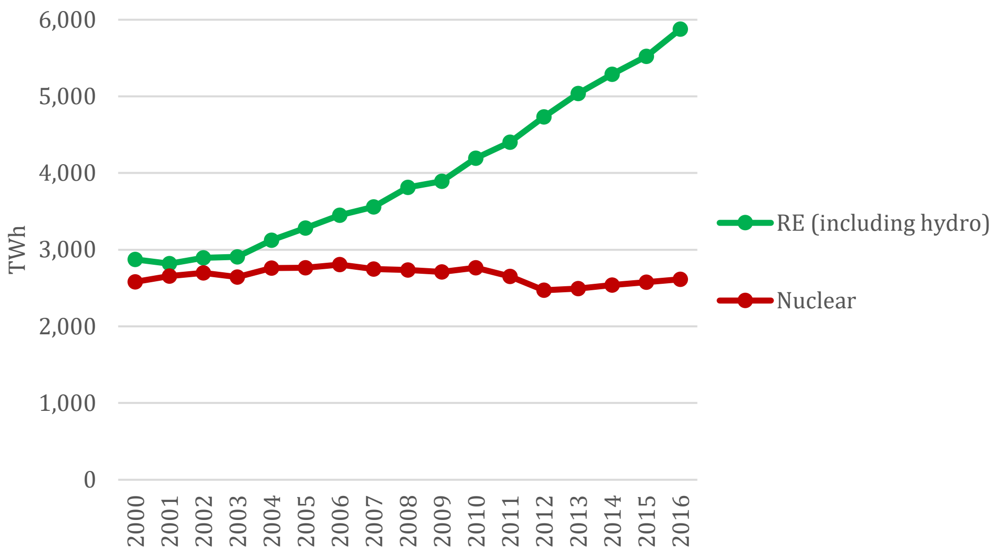
In light of these developments ENGIE may be considered as fortunate to have had the possibility to sell its stake in NuGen, a UK based nuclear energy company, to financially struggling partner Toshiba for £109 million in July 2017, thus avoiding to get involved in the construction of a nuclear project at Moorside in the UK.[89]

As for the costs of radioactive waste storage;

- In January 2016, the French Ministry for the Environment, Energy and the Sea issued a decision setting the cost associated with implementation of long-term management solutions for long-lived medium and high-level radioactive waste under the Cigéo storage project at €25 billion for 140 years.[90]
- In October 2016, European EPCOs with nuclear power operations in Germany; RWE, Vattenfall, EnBW, and E.ON, could reach a landmark deal with the German government.[91] The four EPCOs agreed to pay about €24 billion into a public fund to dispose of radioactive waste.[92] This shift of liability to the government gave investors greater clarity over the EPCOs future finances.[93]

And nuclear power struggles are not limited to Japan and Europe, in June 2017 analysis by BNEF showed that more than half of America nuclear reactors are losing money notably because of RE.[94] **Overall, at the global scale nuclear power is being completely outpaced by growth in RE (including hydropower)** (Chart 50).

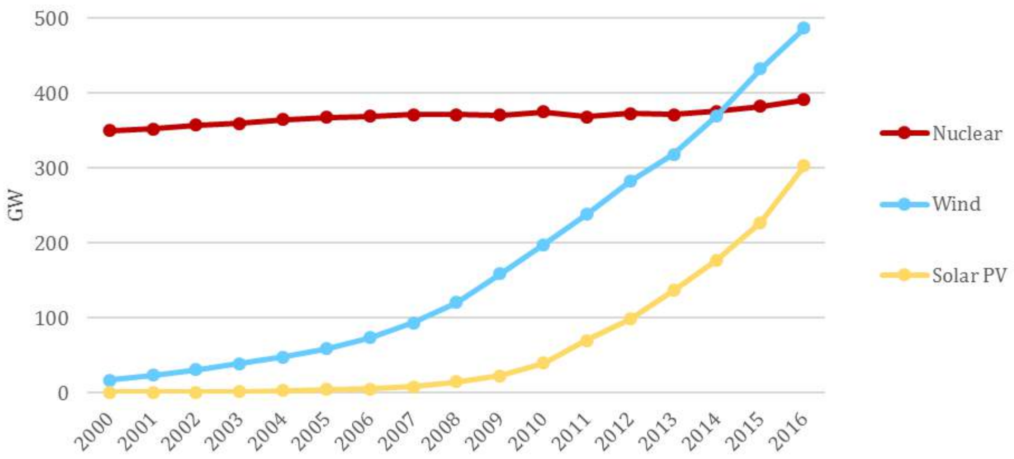
Chart 50: World Nuclear VS. RE Electricity Generation 2000-2016



Source: BP, Statistical Review of World Energy 2017

That is because of significant growth in wind and solar power. Wind power capacity exceeds nuclear power capacity since 2015, and solar PV capacity will certainly have overtaken nuclear power in 2018 (Chart 51 on next page).

Chart 51: World Nuclear, Wind, and Solar PV Power Capacity 2000-2016



Sources: IAEA PRIS, Nuclear Power Capacity Trend, GWEC, Global Wind Report 2015 and 2016, and IEA-PVPS, Trends in Photovoltaic Appliactions 2016 and Snapshot of Global Photovoltaic Markets 2016

The last two arguments to defend nuclear power today are that (1) it can help mitigate climate change and (2) it can provide baseload power.

As for the first argument, it holds true only when nuclear power replaces fossil power, which RE can do faster and at lower costs without negative uncertainties in terms of long-term cost, safety, and sustainability. Or a decrease in nuclear power production is not completely offset by an increase in RE electricity generation in combination with energy efficiency & savings, which has so far been the case in Japan after Fukushima nuclear disaster, but may not be anymore in a few years.[t]

As for the second argument, with increasing penetration of cost effective VRE into grids **there is a common understanding that what is needed now is flexibility not baseload, making this concept outdated**. As already discussed European EPCOs have already been working for some years on improving the flexibility of their fossil power plants. They have also increased the flexibility of their hydro power plants (e.g. EDF, Vattenfall, Statkraft), further developed pumped hydro storage (e.g. Iberdrola, EDP, Verbund), advanced combined heat and power (CHP) plants (e.g. EnBW, Fortum), and started to invest in battery storage (e.g. Enel, ENGIE, RWE).

Nuclear power economics are worsening, and from a technical point of view the technology is not well suited for tomorrow challenges. Nuclear power will soon belong to the past and it may thus be better for Japan EPCOs to leave it there and rather start to focus, in addition of RE, on energy networks and integration.

t Contrary to Japan, in Germany the increase in RE electricity generation has more than offset the decrease in nuclear power generation.

2) Energy Networks and Integration; Embrace the Change

A) Onwards to the 21st Century Electrical Grids

As VRE are increasingly being deployed in Japan challenges related to their good grid integration will have to be dealt with. The companies which makes it possible to always maintain the balance between electricity supply and demand are the power grid companies. In the case of Japan, after the completion of ESR the ITDOs will be in charge of this very specific responsibility.

In Europe, a very clear distinction between transmission and distribution grids have been made, based on the recognition that these segments differ in scale and complexity.

Following unbundling in Europe, less than half of European EPCOs are still active at the transmission level, and when they are it is only through independent subsidiaries.

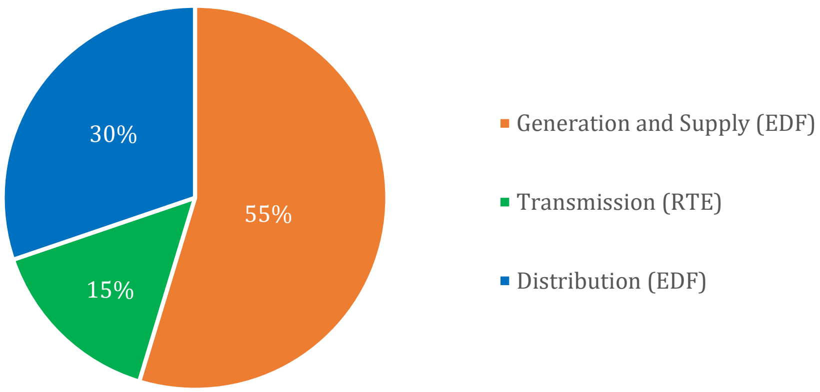
With the exception of Fortum, all European EPCOs are active at the distribution level (once again through independent subsidiaries). This may be the case for two reasons; (1) ESR in Europe rather focused on unbundling at the transmission level and (2) economic reason.[95]

Examples of European EPCOs distribution companies include; Enedis (EDF), e.distribubuzione (Enel), Innogy (RWE), Iberdrola Distribucion Electrica (Iberdrola), EDP Distribuicao (EDP), Netze BW (EnBW),…

Though power grid businesses are usually not making the headlines, perhaps because transmission and distribution are non-competitive regulated businesses, they remain important and profitable sources of incomes for EPCOs.

For instance, Chart 36 (on page 32) showed that infrastructure and networks accounted for 18% and 59% of ENEL revenue and operating income, respectively, in Italy, Spain and Portugal in 2016. Combined EDF T&D activities in France generated almost €6 billion in EBITDA in 2015, 45% of EDF+RTE EBITDA in mainland France in that year (Chart 52).[96] And for RWE the Grid & Infrastructure business of Innogy in Germany and Eastern Europe accounted for the majority (55%) of RWE adjusted EBIT in 2016.[u][97]

Chart 52: Electricity Network Businesses, a Major Source of EBITDA for EDF+RTE in France – 2015



Note: Excluding activities in the island energy systems
Sources: EDF and RTE Annual Reports 2015

u Enel and Innogy infrastructure businesses include gas networks as well.

Chart 53: Selected Major European TSOs and their Origins

COUNTRY	TSO	**PART** OR *FORMER PART*
France	RTE	**EDF (ITO)**
Germany	50Hertz	**Elia (Belgium TSO)** – *Vattenfall* (OU)
	Amprion	**RWE (ITO)**
	TenneT	**TenneT (Netherlands TSO)** – *E.ON (Transpower)* (OU)
	TransnetBW	**EnBW (ITO)**
Great Britain	National Grid	*CEGB* (OU)
	Scottish Hydro Electric Transmission	**SSE (ISO)**
	ScottishPower Transmission	**Iberdrola (ISO)**
Italy	Terna	*Enel* (OU)
Norway	Statnett	*Statkraft* (OU)
Spain	Red Electrica	*Including Endesa* (OU)
Sweden	Svenska Kraftnat	*Vattenfall* (OU)

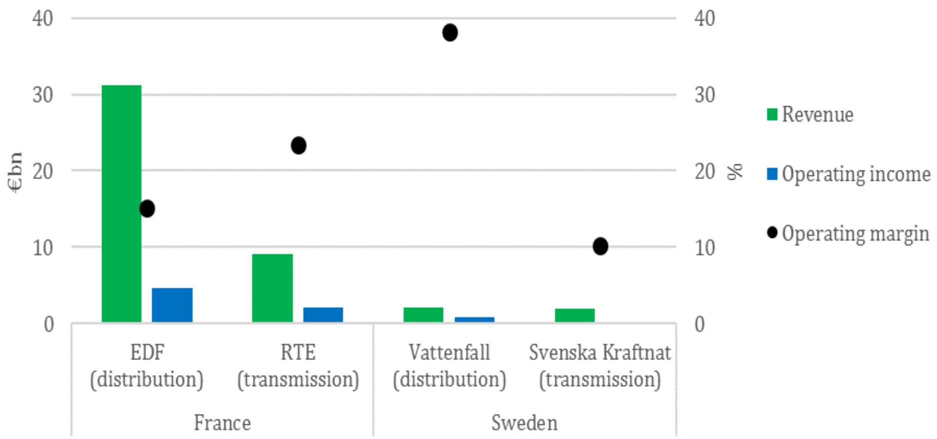
Source: Created by REI

Properly comparing the profitability of the transmission business with the profitability of the distribution business is a particularly complex exercise as few data are reported satisfyingly for this purpose. Thanks to examples of French EDF/RTE and Swedish Vattenfall/Svenska Kraftnat it is possible to provide a beginning of answer (only) though (Chart 54 on next page).

As for the French example; in 2015 and 2016, respectively, EDF reported revenues of 15.4 billion and €15.7 billion, and operating incomes of €2.3 billion and €2.4 billion for its electricity distribution business in France that is an operating margin of 15% for the 2015-2016 period.[98] And RTE reported revenues of €4.6 billion and €4.4 billion, and operating incomes of €1.2 billion and €0.9 billion, that is an operating margin of 23%.[99]

As for the Swedish example; in 2015 and 2016, respectively, Vattenfall reported revenues of €1.1 billion and €1.1 billion, and operating incomes of €0.4 billion and €0.5 billion, for its electricity distribution business in Sweden, that is an operating margin of 38% for the period 2015-2016. And Svenska Kraftnat reported revenues of €1.0 billion and €1.0 billion, and operating incomes of €0.1 billion and €0.1 billion, that is an operating margin of 10%.

Chart 54: Transmission or Distribution, Both Profitable, and Hard to Say Which is Most



Note: period 2015-2016
Sources, EDF, RTE, Vattenfall, and Svenska Kraftnat Annual Reports 2016

In light of these results, **it is possible to conclude that in absolute amount the distribution business usually provides more income than the transmission business**, probably because there are more customers[v] connected to the grid at the distribution level than at the transmission level. Limited and contradictory information about profitability (in terms of operating margin) does not allow for further conclusions at this point.

An additional remark that can be made through these French and Swedish examples is the confirmation of the **stability and predictability of grid businesses incomes**. This had already been mentioned and illustrated for the transmission business earlier in the report (see I 2) B) European EPCOs Failed to Adapt Quickly and Chart 35 on page 30 specifically).

Revenue streams for grid operators mainly come from (1) grid usage fees and (2) grid connection charges.

As for grid usage fees, the two main drivers of revenues are the amount of power flowing through the lines and the applicable tariff for each unit of electrical energy that is transmitted/distributed. With regard to the energy transition in Japan, it may be that not only (1) less electricity will be flowing on power lines (as overall electricity consumption should tend to decrease), but also that (2) as necessary grid developments take place to connect more distributed RE some lines will see their capacity utilization rate decrease. These are two potential economic threats to the timely developments of grid infrastructures. In order to prevent this from happening, grid tariff will need to be revised to provide the right incentives to stimulate investments.

As for grid connection charges, it is likely that the energy transition will benefit to power grid companies, particularly distribution companies since most of small-scale distributed RE are connected at the distribution level. For instance, in France at the end of 2016, 92% and 94% of solar and wind power capacity, respectively, were connected at the distribution level.[100] Similarly, these ratios stood at 100% for solar PV and 66% for onshore wind in the UK at the end of 2016.[101]

And it is also at the distribution level that the rollout of smart meters, which enable monitoring and communication of electricity consumption – information that are necessary to incentive flexibility, takes place. In France, distribution company Enedis will invest €4.5 billion between

v To be understood here as power producers and electricity consumers, both categories using power grids – for different purposes.

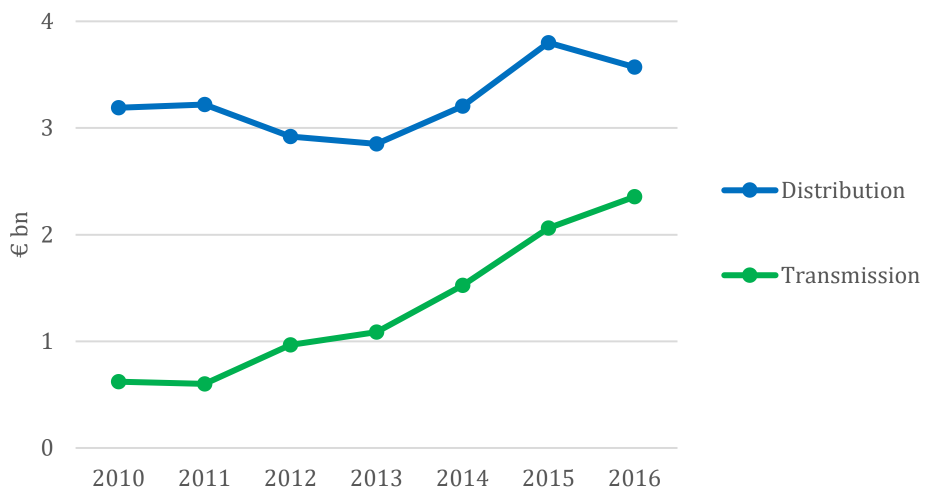
2014 and 2021 to install 34 million smart meters by 2021.[102] As Japan 10-EPCOs are also proceeding with the installation of smart meters throughout the country (rollout should be completed by FY2024 nationwide) they should theoretically be able to benefit from the same advantages as European distribution companies deploying smart meters.[103]

Transmission companies may rather strive when it comes to build long distance transmission lines to connect areas with high solar or wind potential. For instance, TSOs in Germany are now developing major projects such as the SuedOstLink, SuedLink, and Ultranet to bring wind power generated in the north to consumption centers in the south of the country.[104]

All power grid companies should benefit from reinforcing the grids both at the transmission and distribution levels to help integrating higher shares of VRE.

It is understood that to stimulate necessary grid investments to advance a successful energy transition in Japan power grid companies should be rewarded with a fair rate of return for their investments. If tariffs are set in an efficient manner, necessary important investments will be enabled. This has notably been the case in Germany where network costs moderately increased between 2010 and 2016; from about €0.057/kWh to €0.066/kWh for households, and from about €0.024/kWh to €0.036/kWh for industry, encouraging investments in grid infrastructures (Chart 55).[105]

Chart 55: Germany Investments in Power Grids 2010-2016



Source: Bundesnetzagentur, Monitoring Report 2016

If transmission and distribution businesses offer stable and predictable profits, these may be lower than in the competitive segments of generation and supply. Lower risks businesses are logically rewarded less. That may be the reason why some European EPCOs either opted for the ownership unbundling model and sold their transmission assets (e.g. in Germany, E.ON to Dutch TSO TenneT, and Vattenfall to Belgian TSO Elia) **or sold stakes in their TSO after opting for the legal unbundling model** (e.g. in France, EDF/RTE, and in Germany RWE/Amprion). Doing so enabled them **to cut their debt, reduce grid investment burden, and finance new potentially more profitable projects** (Table 4 on next page).[106]

Table 4: Divestment Cases in Transmission Business from Unbundled European EPCOs

Country	Unbundling Model	Unbundled EPCO/TSO	Buyer	Purchase price	Date
France	Legal	EDF/ RTE	Caisse des Dépôts (public financial institution) and CNP Assurances (insurance company)	€4 billion (for 49.9% stake)	March 2017
Germany	Ownership unbundling	E.ON/ Transpower	Tennet (Netherlands TSO)	€1.1 billion (for 100% stake)	February 2010
Germany	Ownership unbundling	Vattenfall/ 50Hertz	Elia (Belgium TSO) and Industry Funds Management (global infrastructure investment manager)	€0.5 billion (for 100% stake)	August 2010
Germany	Legal	RWE/ Amprion	Consortium of mainly German institutional financial investors (insurance companies and special pension funds) managed by Commerz Real AG	€0.7 billion (for 74.9% stake)	July 2011

Sources: EDF, E.ON, Elia, and RWE-Commerz Real

In this regard, it may also be mentioned that Fortum sold its distribution businesses in Finland, Norway (including heat business), and Sweden in 2013-2015 for €2.6 billion, €0.3 billion, and €6.6 billion, respectively.[107] A decision based on Fortum strategy, which targets emission-free generation, efficient CHP production, and supply businesses as growth areas.[108]

As a result, based on the European EPCOs experiences in the transmission and distribution businesses, Japan ITDOs should benefit from the energy transition as this new energy paradigm requires massive cost-efficient investments to develop the 21st century electrical grids by modernizing, reinforcing, and expanding infrastructures.

Japan EPCOs may consider whether they prefer to retain their power grid assets, accumulating reasonable profits year after year, or sell them for big one-time gains. That is a very strategic decision to be wisely made.

In addition, to realize successful integration of VRE in Japan, interconnectors will probably play an increasingly important role. In the development of these particular grid assets may thus also lie new business opportunities for Japan power grid companies.

B) Interconnections

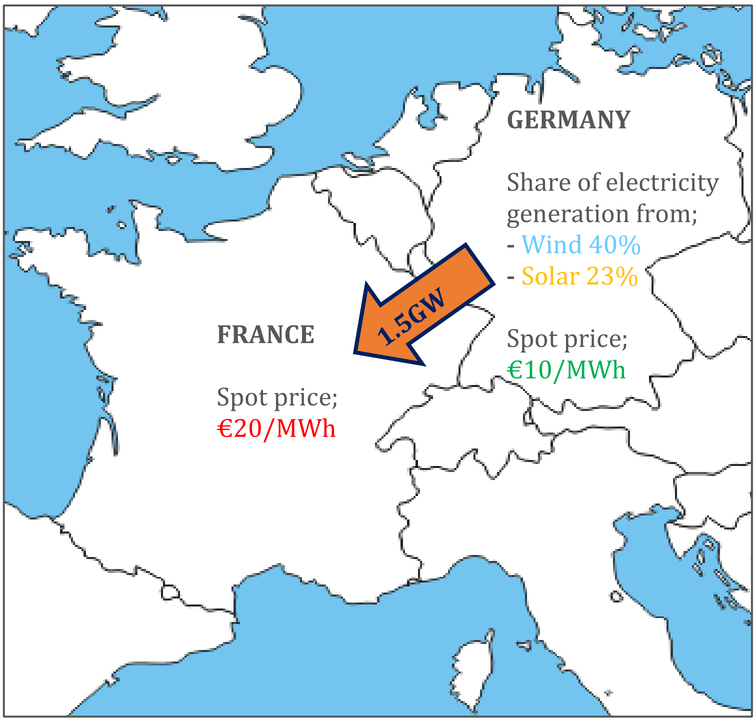
Electricity interconnectors are the physical links which allow the transfer of electricity across regional or national borders. Interconnectors provide substantial economic, technical, and environmental benefits, especially with the expansion of VRE.

From an economic point of view, interconnectors enlarge the electricity generation competition field, i.e. from both sides of a border generating units are vying to sell as much power as possible. With interconnectors market becomes thus larger and more competitive. And on an economic dispatch basis wind and solar, with their close to zero marginal costs, are among the most competitive power sources with hydro and geothermal.

From a technical perspective, thanks to interconnectors it becomes possible for a region or a country with high renewable potential to export its surplus of cheap and clean power to a region or a country that is less blessed, thus reducing curtailment risks because domestic generation exceeds local consumption. In this regard, interconnectors help making the integration of VRE more smoothly.

For instance, in Europe, France has been benefitting from importing cheap clean solar and wind power from Germany for some years now (Chart 56).

Chart 56: France Importing Cheap Clean Power from Germany thanks to Interconnections (7 June 2017, 13:00-14:00)



Sources: ENTSO-E, Transparency Platform, and EPEX, Market Data

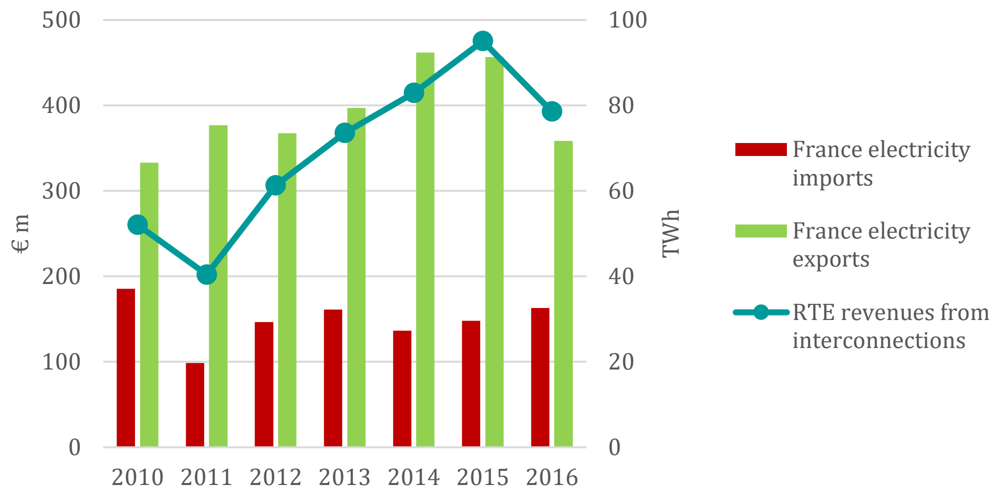
Based on these observations it is understood that in the superior interest of Japan consumers, Japan ITDOs should make best use of existing domestic interconnectors, and potentially develop new ones when needed, which may increasingly be the case as the RE expansion moves forward in Japan. In the medium-term, international interconnections with neighboring countries such as China, Korea, and Russia as described in the Asia Super Grid concept may also be worth being developed.[109]

Interconnectors derive their revenues from congestion revenues, which are dependent on the existence of price differentials between markets at either end of the interconnector.[110]

In the case of France, a country well interconnected with its neighbors; in average 13.5GW of export and 9.8GW of import capacity at the end of 2015[w], and exporting and importing roughly 80TWh and 30TWh in average annually since the beginning of the decade, **French TSO RTE revenues from interconnections amount to several hundreds of millions of euros each year, and accounted for roughly 8% of the TSO revenues in the period 2010-2016** (Chart 57 on next page).[111] Revenues are fluctuating depending on price differentials between national electricity markets (see Chart 31 on page 27).

w Respective interconnection rates are about 10% and 8%.

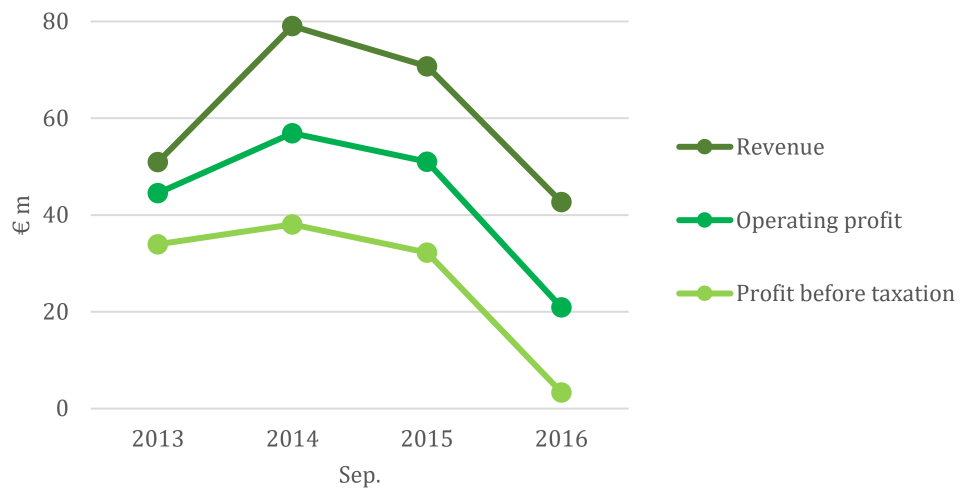
Chart 57: French TSO RTE Revenues from Interconnections 2010-2016



Source: RTE, Rapport de Gestion Comptes Consolides and Bilan Electrique (2010-2016)

The East West Interconnector (EWIC), managed by Irish TSO EirGrid, offers a specific example of interconnector profitability. The EWIC is 264 kilometers (km) long, of which 187km are beneath the Irish Sea, and links the electricity transmission grids of Ireland and Great Britain using high voltage direct current (HVDC) cables.[112] Capacity available on EWIC in both import and export directions is 500MW.[113] EWIC started (partial) commercial operation in December 2012[x] with an expected lifetime of 40 years.[114] Investment cost stood at €562 million.[115] **From the beginning of EWIC commercial operation until the end of September 2016 it already generated €243 million in revenues. And €108 million in profit before taxation – roughly 20% of the project investment cost in just 10% of its expected lifetime, accounting for more than 70% of EirGrid profit before taxation in the period 2013-2016** (Chart 58).

Chart 58: EWIC Business Financial Results 2013-2016



Note: In 2016, the lower revenue reflects a return to transmission use of system (a regulated tariff) customers of higher than anticipated revenues earned in prior years from EWIC capacity auctions. There was also a decline in actual interconnector receipts earned during the year due to carbon price floor reforms in GB.

Source: EirGrid Annual Reports (2013-2016)

x Full operation from May 2013.

In light of these observations, it appears that **developing interconnections** and thereby actively participating in the establishment of the 21st century electrical grids, which the energy transition would also benefit from, **may be a profitable business option for Japan ITDOs**. In that regard, it may be mentioned that interconnection works are in progress between Hokkaido and Tohoku, and Tokyo and Chubu, and that a start of further collaboration is taking place between Kansai, Chubu, and Hokuriku EPCOs power transmission and distribution segments.[116]

It may, however, also be acknowledged here that increasing competition among generating units resulting from the construction of interconnectors may deteriorate the profitability of some Japan EPCOs, particularly the ones who will fail to invest in cost efficient close to zero marginal cost RE.

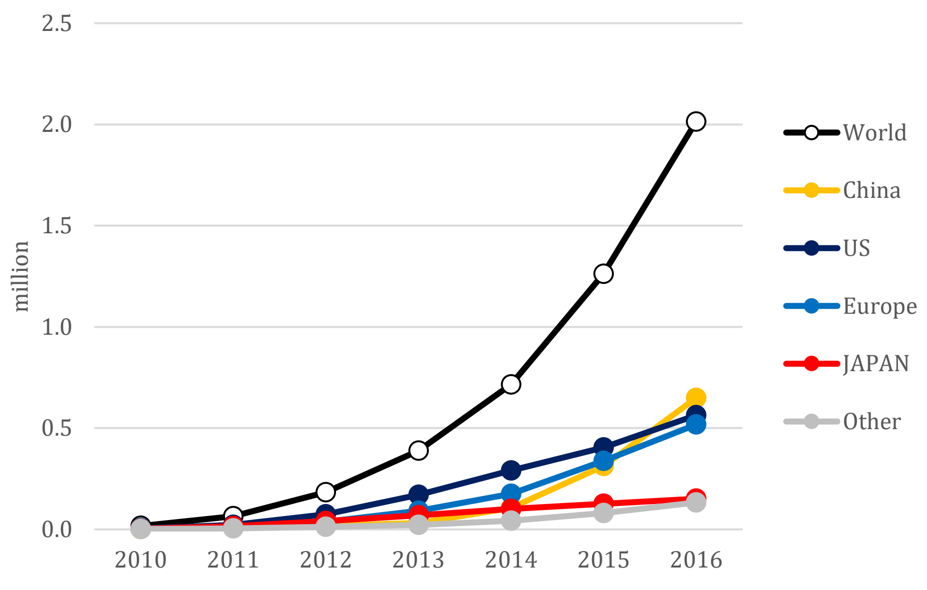
With the energy transition advancing in Japan, electrical grids modernization, reinforcement, and expansion – including further developments of interconnections (possibly international ones) – will take place. It is likely that these integration efforts, will probably not be limited to the electrical networks and go well beyond. Indeed, other networks such as transportation and heating & cooling (H&C) also present technical and business opportunities to build tomorrow integrated energy systems in which Japan EPCOs could play important roles.

C) Integrated Energy Systems

The energy transition not only requires more integrated electrical systems, but also more integrated energy systems; electricity – transportation – H&C, especially since decarbonization of economies is expected to be realized at lowest cost through electrification.

Enabled by **dramatic battery cost reductions** from very roughly $1,000/kWh in 2010 to $200-300/kWh in 2016, **rapid expansion of electric vehicles** (EVs) **has started since the beginning of the decade**; world EVs stock increased from about 17,000 to 2 million from 2010 to 2016 (Chart 59).[117]

Chart 59: Electric Car Stock 2010-2016



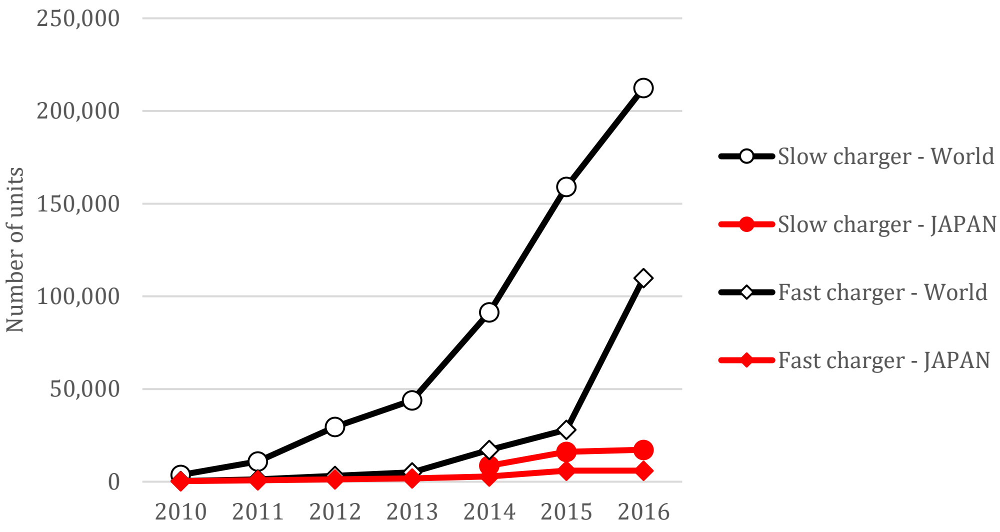
Source: IEA, Global EV Outlook 2017

And that is probably just the beginning; according to IEA NPS projections, global stock of EVs could exceed 150 million by 2040.[118]

This significant growth will contribute to increase electricity consumption. In this regard, BNEF forecasts that EVs will add over 1,700TWh of electricity demand globally by 2040, equivalent to 5% of 2040 demand.[119] Still according to BNEF, in Japan, EVs are expected to consume 36TWh or 4% of the country total electricity demand.[120]

The electrification of the transportation sector thus offers EPCOs the possibility to increase their sales of electricity of course, but not only. **It also presents the opportunity to develop new networks; EVs charging infrastructure networks.** Worldwide growth of publicly accessible chargers has seen remarkable growth in recent years, to which Japan has not really contributed (Chart 60).

Chart 60: Publicly Accessible Charger Stock 2010-2016



Source: IEA, Global EV Outlook 2017

In this field, EPCOs can provide solutions such as consulting services on the positioning and scale of the charging infrastructure, their installation (for all customers segments), and their operation and maintenance. European EPCOs have become quite active in this area, sometimes through partnerships with car manufacturers.

Among most significant recent developments:

- In September 2016, ENGIE, which had already installed over 5,000 charging points in Europe, won a tender to install 4,000 new charging points in the Netherlands.[121] And in March 2017, ENGIE acquired EVBox the world's largest EV charging player with over 50,000 charging points installed (as of September 2017).[122]
- In February 2017, E.ON and Denmark based e-mobility service provider CLEVER established a partnership with the ambition to roll out ultra-fast charging stations for EVs along main European motorway corridors (sites will be placed every 120-180km along motorways).[123] In Denmark, E.ON operates 1,200 public charging points and 39 fast chargers.[124]
- Innogy (RWE), which had over 5,400 charging points in 2016, intends to have finished up approximately 150 fast charging stations for a motorway service operator in Germany by the end of 2017.[125]

- Since 2015, in the framework of a consortium that notably brings together EDF, Renault, Nissan, BMW, and Volkswagen, Sodetrel (a company which is wholly owned by EDF) has deployed a network of 200 rapid-charging stations.[126]
- Enel has been awarded funding for the EVA+ (Electric Vehicle Arteries) project, which envisages 180 fast charging stations in Italy, and 20 in Austria.[127]
- Fortum and Vattenfall are now both operating over 1,000 charging units, in the Nordic countries, and in Sweden, the Netherlands, and Germany, respectively.[128]

In addition, more integrated energy systems also require better integration of the H&C sector. Though these activities are not particularly central to the strategies of European EPCOs, some are developing CHP plants or district heating sometimes based on RE.

Among most significant recent developments:

- Fortum, through Fortum Varme its JV with the City of Stockholm, commissioned a large new biomass-fired CHP plant (capacity: 130MW electricity and 280MW heat) in Stockholm, Sweden in 2016.[129] The Finnish Group now expects to start supply from its Zabrze CHP plant (capacity: 75MW electricity and 145MW heat) in Poland in 2018.[130] The new plant will primarily be fueled by refuse derived fuel (up to 50% in fuel energy) and coal, but can also use biomass and a mixture of fuels.[131]
- In 2016, Vattenfall converted its Moorburg coal-fired condensing power plant into a CHP plant.[132] In 2017, the Swedish Group aims at completing its €370 million Lichterfelde gas CHP plant (capacity: 300MW electricity and 222MW heat) in Germany.[133] And by 2020, it expects to commission a €325 million CHP plant (capacity: 260MW electricity and 230MW heat) in Berlin, Germany.[134]
- In March 2017, E.ON announced that it intends to build a €250 million thermal waste incineration plant (capacity: 25MW) for the production of electricity, heat and biogas together with a biogas and a CHP facility in Stockholm, Sweden.[135] Full completion of the project is expected for 2019.[136]
- Regarding district heating in 2016, EnBW commissioned a district heating supply system in Dusseldorf, Germany.[137] And Statkraft opened a district heating plant in Arvollskogen, Norway.[138]

It must be noted that Japan EPCOs were not communicating about recent significant activities in the field of energy system integration in their Annual Reports 2016.

In the framework of energy transition and ESR, wind and solar power, electrical grids (including interconnectors), electrification of the transport sector, CHP and district heating, have been identified as potential business opportunities which should encourage Japan EPCOs to embrace the change either from their power generator or network operator perspectives. The last part of the report will focus on the new opportunities that exist at the supply level.

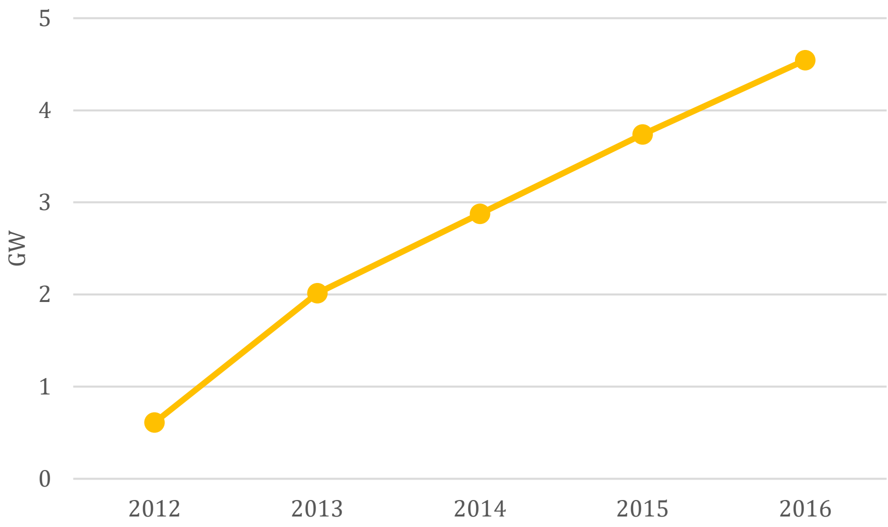
3) Customers; Provide Much More than Just a Commodity

A) Distributed Energy Generation Services

Traditional supply business consists in the sale of electricity to end-users. In recent years, supportive policies, such has FITs, have enabled a significant number of customers to install distributed solar PV at their facilities (factories, office building, farms…) or homes. **These policies have also driven substantial cost reductions. to the extent that in a number of countries around the world, including Japan, solar PV has now reached "socket parity," i.e. when rooftop solar is the same price as electricity that a consumer buys from a supplier.**[139] **It is thus more profitable for Japanese customers to generate their own electricity instead of purchasing it from a supplier. As a result, beyond sustainability and/or independency reasons more and more are seeking to install their own distributed solar PV panels, possibly with batteries, for economic reasons today**.

In Japan from 2012 to 2016, small-scale distributed solar PV (<10kW) capacity registered under FIT significantly increased from less than 1GW to almost 5GW (Chart 61).

Chart 61: Cumulative Operational Solar PV <10kW Capacity under FIT 2012-2016

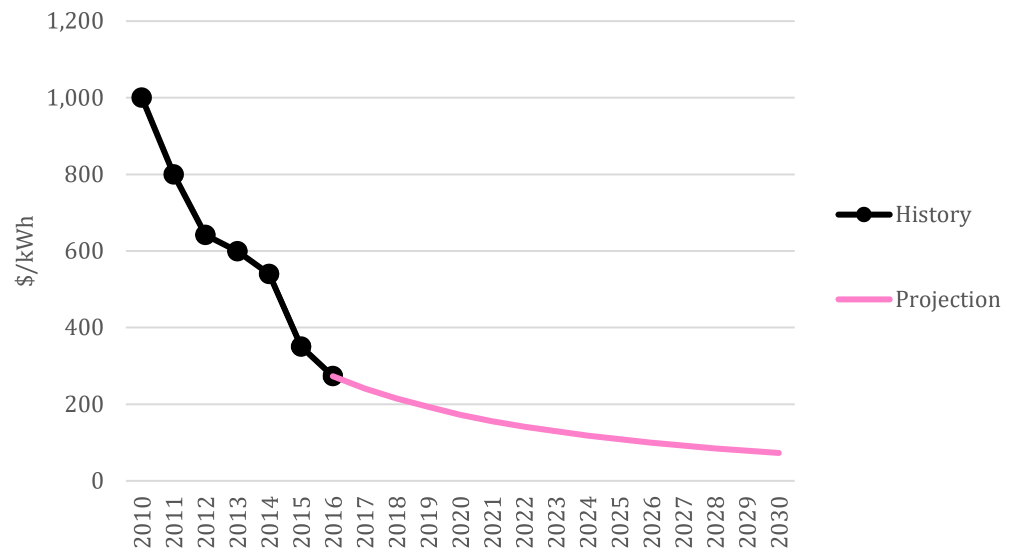


Source: ANRE/METI, Renewable Power Plant Certification Status

This has of course had a negative impact on Japan EPCOs volume sales to end customers and prices at which they can sell on the wholesale market (merit order effect).

Prospects of battery costs further falling down dramatically in the years to come may be another hit to Japan EPCOs, unless they start offering these services (Chart 62 on next page).

Chart 62: Lithium-ion Battery Prices, Historical and Forecast



Source: BNEF, Long-Term Electric Vehicle Outlook 2017

European EPCOs have acknowledged that and entered the distributed solar PV business for some years now, and more recently the distributed solar PV + battery business:

- EDF, through its wholly owned subsidiary EDF ENR Solaire, markets and installs solar PV power solutions in France. At the end of 2016, it had more than 14,000 residential customers and delivered over 900 projects to business customers and local authorities, against over 8,000 and over 200, respectively in 2010.[140]
- In May 2016, ENGIE acquired an 80% stake in Green Charge Networks, a battery storage company based in California that notably offers solar + battery solutions at commercial & industrial and public sector customers sites.[141] In 2016 also, ENGIE, through its retail subsidiary Simply Energy, started offering an innovative package for its residential customers that bundled rooftop solar panels with Tesla Powerwall batteries in Australia.[142] And in May 2017, ENGIE acquired Sungevity International, a company specialized in servicing and installing solar solutions for residential and small commercial customers active in Belgium, Germany, the Netherlands, and the UK.[143]
- In 2016, Vattenfall launched Nuon energy roof, an integrated solution of an energy efficient roof including solar panels and insulation.[144]
- In 2016 as well, EnBW launched sales of EnBW solar+, a solution that offers private customers in Baden-Wurttemberg a rooftop solar PV system, a stationary storage system, an intelligent management and measurement system and an application, as well as service, performance and savings guarantees.[145] All customers are networked in the "Energy Community" – an internet based online marketplace that can be accessed via the application – where individuals can trade surplus electricity amongst themselves.[146]
- In May 2017, E.ON, in partnership with Google, started to offer the Sunroof platform in Germany covering seven million buildings and enabling millions of homeowners to easily and precisely determine their home potential solar capacity and generate plans for installing a solar system, as well as directly order products such as PV modules and a battery storage unit from E.ON.[147] Moreover, with the "Sunshine Guarantee," E.ON

promises that a system will actually deliver the returns calculated, i.e. financial compensation will be provided for any shortfall.[148]

While the sale of simple solar PV rooftops systems is nothing really revolutionary, optimization of systems output either via batteries or internet based online marketplace is relatively new.

At the supply level, beyond optimizing use of solar PV systems output, another growth area for EPCOs may lie in optimizing all energy usages of their customers either by implementing energy efficiency measures and/or offering energy consumption optimization tools.

B) Energy Usages Optimization Solutions

Whereas optimizing energy usages of their customers may not appear particularly appealing at first sight for EPCOs, insofar as the less their customers consume the less EPCOs will supply, it is clear that as the energy transition proceeds **there are strong economic and environmental factors driving end-users to better use energy**, and electricity especially. And where there is a demand, supply opportunities usually emerge.

In order to optimize energy consumption of their different types of customers (residential, commercial and industrial businesses, local authorities…) **EPCOs can provide various services in energy efficiency and consumption; from energy advisory, to implementation of equipment optimizing energy demand**, e.g. more efficient machines and demand side management tools, **and financing services**.[y]

European EPCOs are, in general, already quite active in this field. For instance:

- EDF, through its wholly owned subsidiary Perfesco, identifies high-energy consumption items at major industrial players and offers to install more economical equipment, making profit based on the savings generated.[149] And through, its 45% subsidiary Domofinance, meets the financing needs of EDF residential customers and building management companies who wish to integrate energy efficient solutions into their renovation projects (over 45,000 loans granted in 2016).[150]
- In June 2017, Enel acquired for $250 million leading US based provider of smart energy management services EnerNOC.[151] Through the acquisition Enel incorporates over 8,000 commercial and industrial customers, 14,000 sites under management and a total of 6GW of demand response capacity.[152]
- ENGIE is very active in Western Europe through it specialized subsidiaries Cofely, Axima, and Fabricom which provide customers with multi-technical services such as electrical and mechanical engineering, and industrial maintenance to extend the working life and improve the reliability and energy efficiency of facilities.[153] In France, ENGIE also holds positions across the home energy efficiency value chain, offering energy audits, advice, financing of works, design, and equipment installation and maintenance.[154] In particular, ENGIE is the market leader in individual boiler maintenance.[155]
- RWE (Innogy) successfully introduced SmartHome home automation solution in 2011.[156] SmartHome offers the possibility to network a large number of electronic devices such as intelligent radiator thermostats, door locks and lights in one's home, and control them

y For discussions on smart meters see II 2) A) "Onwards to the 21st Century Electrical Grids." For discussions on battery storage see II 3) A) "Distributed Energy Generation Services."

centrally using a smartphone or tablet – either when at home or on the road.[157] Based on this success RWE (Innogy) plans to expand its SmartHome offering.[158]

- And Fortum has introduced energy efficiency services for private customers in Finland and Sweden. For example, customers can control and optimize the heating of their homes based on electricity price and demand or they can monitor energy consumption with an in-home display.[159]

Among Japan EPCOs, Kansai, Tohoku, Hokkaido, Shikoku, and Okinawa EPCOs reported relatively meaningful activities in the field of customers energy usages optimization in their annual reports 2016 – nothing comparable with the degree of involvement of European EPCOs though. Learning from their European peers Japan EPCOs may thus more aggressively pursue potential opportunities in that field.

C) Choice of Electricity Supply Mix

Increasingly aware of the necessity to consume electricity in a sustainable manner either in their business operations or in their daily home life on the one hand, and that this can be done at low costs thanks to dramatic cost reductions in solar and wind power on the other hand, there is a growing global trend of industrial, commercial and residential customers who seek to buy green power to meet their electricity demand.

Among these customers notably stand a group of 111 international companies (as of 2 October 2017) who have committed to go 100% RE power.[160] Table 5 indicates examples of such companies:

Table 5: Examples of International Companies Committed to go 100% RE Power

Company Name	Country	Business
Apple	United States	Technology
AXA	France	Insurance
Bank of America	United States	Finance
BMW	Germany	Automobile
Burberry	Great Britain	Luxury fashion
Carlsberg	Denmark	Brewer
eBay	United States	e-trading
Facebook	United Sates	Online social media
General Motors	United States	Automobile
Goldman Sachs	United States	Finance
Google	United States	Technology
Ikea	Sweden	Home furnishing
Lego	Denmark	Play materials
Microsoft	United States	Technology
Nestle	Switzerland	Food & Drink
Ricoh	**JAPAN**	**Electronics**
Starbucks	United States	Coffee
Tata Motors	India	Automobile
UBS	Switzerland	Finance
Walmart	United States	Retail

Source: RE 100, Companies (2 October 2017)

In Japan, this trend may be best illustrated by announcement in April 2017 of Japanese multinational electronics company Ricoh, providing document services, consulting, software and hardware to businesses around the world, **to source 100% renewable electricity by 2050** (interim goal of at least 30% by 2030).[161] And others may follow, which could result in significant business opportunities for suppliers who will target these customers.

Customers may not want or be able to invest directly in power capacity to consume RE electricity, but they may well be willing to pay for it either by subscribing green tariff offers or signing power purchase agreements (PPAs) ensuring they consume electricity generated from RE sources.

In this regard, **a number of European EPCOs initiatives proposing various green electricity to their customers are worth to be introduced**:

- EDF allows all corporate and business customers to choose electricity from renewable sources to cover their consumption.[162] For small and medium sized enterprises and professionals, it involves a specific offer the RE contract, which guarantees that 100% of their consumption will come from electricity generated from RE sources in France.[163] For larger customers, it involves an option that allows them to decide themselves what proportion of their consumption will come from guaranteed sources, between 20% and 100%.[164] And in March 2017, EDF Energy, subsidiary of EDF in the UK, signed a PPA to supply the UK facilities of Britain biggest car maker Jaguar Land Rover with 100% RE up to March 2020.[165]

- In Italy, Enel launched the Speciale Luce offering featuring the exclusive use of energy certified to be from renewable sources, and reached an agreement with the City of Madrid, Spain which will be served exclusively with RE for 2017.[166]

- In France in 2016, ENGIE launched the (1) Electricite Verte Pour Tous and (2) Elec'car offerings.[167] (1) Electricite Verte Pour Tous offers no-surcharge green electricity for all new residential and small business customers.[168] And (2) Elec'car is a green electricity offer that is 50% cheaper during off-peak hours that is reserved for owners of rechargeable electric or hybrid vehicles.[169]

- In the US, Iberdrola signed a PPA with American electronic commerce and cloud computing company Amazon for 208MW of wind power (construction of the project started in July 2015 and was almost completed at the end of 2016).[170]

- In 2016, Vattenfall launched Powerpeers, a peer-to-peer digital energy sharing platform in the Netherlands.[171] This web-based platform makes it possible to buy and sell small-scale, locally generated RE electricity between private parties, such as between neighbors in a residential area.[172] Subscribers, who may be generators as well as consumers of electricity, pay a modest monthly fee to both supply the energy they generate to others and choose whose energy they want to receive.[173]

As for Japan EPCOs, while Tokyo EPCO realized a €3 million investment in Conjoule, an Innogy Innovation Hub venture, to accelerate the development of a peer-to-peer energy trading platform for producers and consumers of RE, as well as owners of batteries and other sources of flexibility in July 2017, **almost everything remains to be done when it comes to offer green power contracts to their customers**.[174]

The implementation of these customer-oriented strategies will certainly contribute to build stronger customer relations, which is undeniably critical as ESR takes place.

CONCLUSION

Japan EPCOS may find the ways forward in the new energy paradigm in solar and wind power, energy networks and integration, and customers solutions. Confronted with relatively similar challenges these strategies are now being implemented by European EPCOs.

While it is too early to accurately assess the success of these new business models, they seem quite sound with regard to the economics, especially when compared with business as usual options which clearly have no future.

Based on these observations, this report strongly recommends Japan EPCOs to take action now to redirect their strategies towards identified most likely profitable and sustainable business areas. Once again, there is nothing less at stake than their survival.

APPENDICES

LIST OF ANNUAL REPORTS 2016

Japan	European	
EPCOs	EPCOs	TSOs
Chubu, Annual Report 2016 (Nagoya, Japan: Chubu EPCO, 2016), 122 pp	Electricite de France, Reference Document Annual Financial Report 2016 (Paris, France: EDF, 2017), 538 pp	Amprion, Geshaftbericht 2016 (Dortmund, Germany: Amprion, 2017), 135 pp (in German)
Chugoku, Annual Report 2016 (Hiroshima, Japan: Chugoku EPCO, 2016), 63 pp	Enel, Annual Report 2016 (Rome, Italy: Enel, 2017), 457 pp	Elia, Annual Report 2016 (Brussels, Belgium: Elia, 2017), 111 pp
Hokkaido, Annual Report 2016 (Sapporo, Japan: Hokkaido EPCO, 2016), 50 pp	Energias de Portugal, Annual Report 2016 (Lisbon, Portugal: EDP, 2017), 472 pp	National Grid Electricity Transmission, Annual Report and Accounts 2016/17 (Warwick, United Kingdom: NGET, 2017), 97 pp
Hokuriku, Annual Report 2016 (Toyama, Japan: Hokuriku EPCO, 2016), 23 pp	Energie Baden-Wurttemberg, Integrated Annual Report 2016 (Karlsruhe, Germany: EnBW, 2017), 146 pp	Red Electrica de Espana, Consolidated Annual Accounts 2016 (Madrid, Spain: REE, 2017), 126 pp
J-Power, Annual Report 2016 (Tokyo, Japan: J-Power, 2016), 80 pp	ENGIE, Registration Document 2016 (Paris la Defense, France: ENGIE, 2017), 408 pp	Reseau de Transport d'Electricite, Rapport de Gestion Comptes Consolides 2016 (Paris la Defense, France: RTE, 2017), 122 pp (in French)
Kansai, Group Report 2016 (Osaka, Japan: Kansai EPCO, 2016), 120 pp	E.ON, Annual Report 2016 (Essen, Germany: E.ON, 2017), 240 pp	Statnett, Annual Report 2016 (Oslo, Norway: Statnett, 2017), 155 pp
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Tokyo, Annual Report 2016 (Tokyo, Japan: Tokyo EPCO, 2016), 70 pp	Statkraft, Annual Report 2016 (Oslo, Norway: Statkraft 2017), 138 pp	
	Vattenfall, Annual and Sustainability Report 2016 (Stockholm, Sweden: Vattenfall, 2017), 186 pp	

LIST OF ABBREVIATIONS

BNEF: Bloomberg New Energy Finance
CAPEX: Capital expenditure
CHP: Combined Heat and Power
CO_2: Carbon dioxide
CPS: Current Policies Scenario
EBIT: Earnings Before Interest, Tax
EBITDA: Earnings Before Interest and Taxes
EPCOs: Electric Power Companies
EPR: European Pressurized Reactor
ESR: Electricity System Reform
EU: European Union
EVs: Electric Vehicles
EWIC: East West Interconnector
FIT: Feed-in Tariff
FY: Fiscal Year
GB: Great Britain
GW: Gigawatt
HVDC: High Voltage Direct Current
H&C: Heating & Cooling
IEA: International Energy Agency
ISO: Independent System Operator
ITDO: Independent Transmission & Distribution Operator
ITO: Independent Transmission Operator
JV: Joint Venture
kW: Kilowatt
kWh: Kilowatt-hour
LCOE: Levelized Cost of Electricity
LNG: Liquefied Natural Gas
MBtu: Million British Thermal Unit
METI: Ministry of Economy, Trade and Industry
MW: Megawatt
MWh: Megawatt-hour
M&A: Merger and Acquisition
NPS: New Policies Scenario
OECD: Organization for Economic Co-operation and Development
OU: Ownership Unbundling
PPA: Power Purchase Agreement
PV: Photovoltaic
RE: Renewable Energy
TSO: Transmission System Operator
TWh: Terawatt-hour
T&D: Transmission & Distribution
UK: United Kingdom
VRE: Variable Renewable Energies

ENDNOTES

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