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Legacy Asset Redeployment: How to lower costs, avoid stranded assets, and accelerate the clean energy transition

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Abstract

The U.S. is taking a multilateral approach in addressing climate change and is focusing on how to accelerate the journey to “net zero” carbon emissions, especially in hard-to-abate industries. To mitigate the time and cost of decarbonization one option is to re-use already paid-for energy delivery assets and retrofit them to continue to add value within a new pro-climate context – an approach we call Legacy Asset Redeployment. Legacy Asset Redeployment has the potential to become an important technical and economic enabler of climate solutions for hard-to-abate sectors. Legacy Asset Redeployment initiatives can and should be the focus of new, creative alliances of public and private sector stakeholders.

Contents

What Kind of Climate Solutions are Needed to Reach Net Zero?

Human-Centered Climate Actions

While a number of technical challenges is emerging as important to reaching net zero – including replacing coal within the power mix, electrifying the transportation sector, and transitioning from natural gas to hydrogen[1] – the human side remains critical. Indeed, as the International Energy Agency notes in its landmark report, Net Zero by 2050: A Roadmap for the Global Energy Sector, "*A transition of the scale and speed described by the net zero pathway cannot be achieved without sustained support and participation from citizens.*"[2]

Deloitte has consistently argued that it is vital to evaluate the risks and benefits of carbon strategies by accounting for their impacts on specific groups of stakeholders and citizens, concluding that "*the impact of climate change and the related direct costs are unequally spread, with some places and communities being more exposed than others. Disadvantaged people and communities are often the worst hit.*"[3] *The IEA also recognizes this reality, asserting that "clean energy jobs will grow strongly but must be spread widely."* [4]

Risk-Adjusted Carbon Mitigation

Not only are the impacts of climate change unevenly spread, but climate risk is also perceived differently depending on individual points of view. Legacy Asset Redeployment is an approach wherein existing energy assets, existing energy networks, and existing social structures are redeployed and reused to accelerate the decarbonization process. Legacy Asset Redeployment can bring together disparate stakeholders to overcome opposition to change. For example, while nuclear energy has been met with trenchant opposition in many communities, it is likely to be an important component of a decarbonized energy mix. As such, the relative potential risks posed by nuclear facilities should be evaluated against (for example) the known health impacts caused by the burning of fossil fuels in and around urban areas.

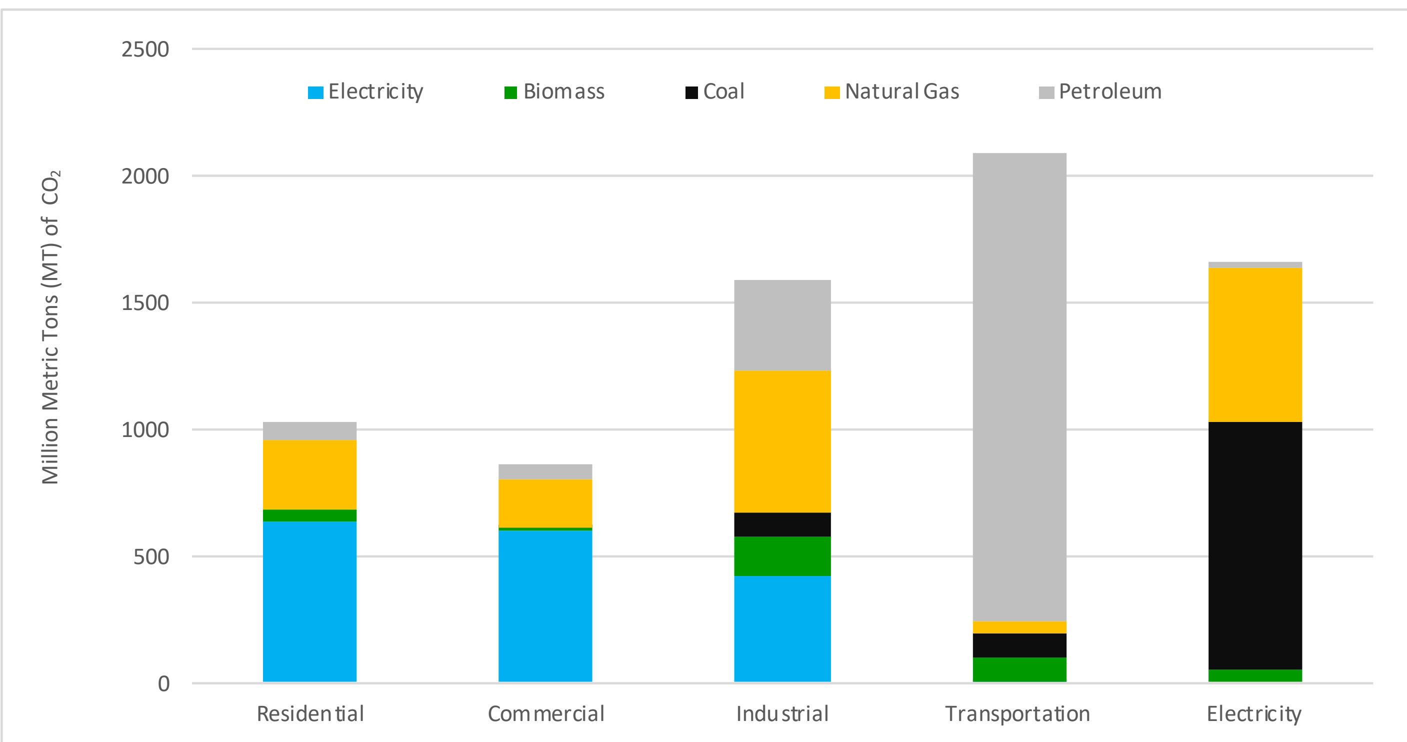
Emissions Strategy

Globally and as exemplified in the U.S., carbon emissions come mainly from electricity, transportation, and industry, residential, and commercial activity.[5] The sectoral breakdown of emissions for the U.S. is shown in Figure 1.[6]

Three facts stand out in Figure 1. First, coal makes up only 20% of electricity generation, but it produces 59% of the CO_2. Second, petroleum use is almost entirely concentrated in transportation. Third, natural gas use is well distributed amongst residential, commercial, industrial, and electricity sectors – a testament to the market dynamics governing gas delivery networks and the technological advances driving down gas prices.

To address the potential for Legacy Asset Redeployment to accelerate the U.S.' decarbonization agenda, Deloitte considered three factors: 1) market scalability and replicability, 2) step-wise bets on new technology, and 3) the potential for reuse of existing networks.

Figure 1: 2019 Estimated U.S. Energy-Related CO_2 Emissions: 5,485 MT



Source: Deloitte Analysis, U.S. Department of Energy, Energy information Administration, DOE/EIA-0035(2020/03)

Scalability and Replicability

Replicability, modularity, volume, and experience were key to achieving cost reductions in wind, solar, batteries, and electric vehicles (EVs). In the case of nuclear, replicability is critical to avoid the custom permitting of first-of-a-kind designs that has typically been responsible for driving up the time and cost of large nuclear generation asset installations.[7] As a possible antidote to this trend, the potential to develop small modular reactors (SMRs) has increasingly found favor over the last decade. In April 2021, the U.S. Department of State announced the Foundational Infrastructure for Responsible Use of Small Modular Reactor Technology (FIRST), concluding that *"SMRs offer significant benefits, including lower costs, scalability, flexibility, and the ability to partner with other clean energy sources, such as wind and solar power.... SMRs can replace coal to power energy-intensive industrial processes and produce hydrogen to help decarbonize transportation and other sectors."* [8]

Other new and emerging technologies with potential for rapid cost reductions include hydrogen electrolyzers – the modular nature of which will help to promote operational flexibility and geographical dispersion.

Step-wise Bets on New Technologies

Experimenting in clean energy technology is vital but it is challenging to fund brand-new technology on a large scale on a project financing basis. Venture capital is appropriate for high-risk, high-return ventures but scaling at the dimension necessary for widespread decarbonization will require performance warranties that are not available for technologies that lack a proven track record and installed base. Such guarantees will necessarily, therefore, require backing by strong corporate balance sheets. Near-term climate project financing should focus on proven physical and business technologies, such as large-scale wind and solar, and electric vehicles (EVs). Hydrogen, small modular reactors, and carbon capture utilization and storage (CCUS), which may be considered technologies-in-development, can in contrast be rolled out via smaller increments. It should be noted that in the European Union, member states contribute to the joint funding of renewable energy projects under the European Green Deal; a set of policy initiatives by the European Commission targeted with making Europe climate neutral by 2050.

Reusing Existing Networks

Those countries emitting the most greenhouse gases almost by definition tend to have significant existing power networks, gas networks, and road networks. Some 40% of the price of electricity is incurred during the transmission and distribution phases, according to the U.S. Energy Information Administration.[9] Indeed, networks should not be viewed only as collections of physical assets; they also comprise energy supply businesses, customers, and regulators. Reusing existing networks in a cleaner-energy context not only leverages the sunk costs already incurred (such as billing, metering, and customer service systems), but also helps to transition existing operators and stakeholders from a legacy focus (what their traditional business model has been) to a future focus (what that business model could be in the future), thereby broadening the constituency for change.

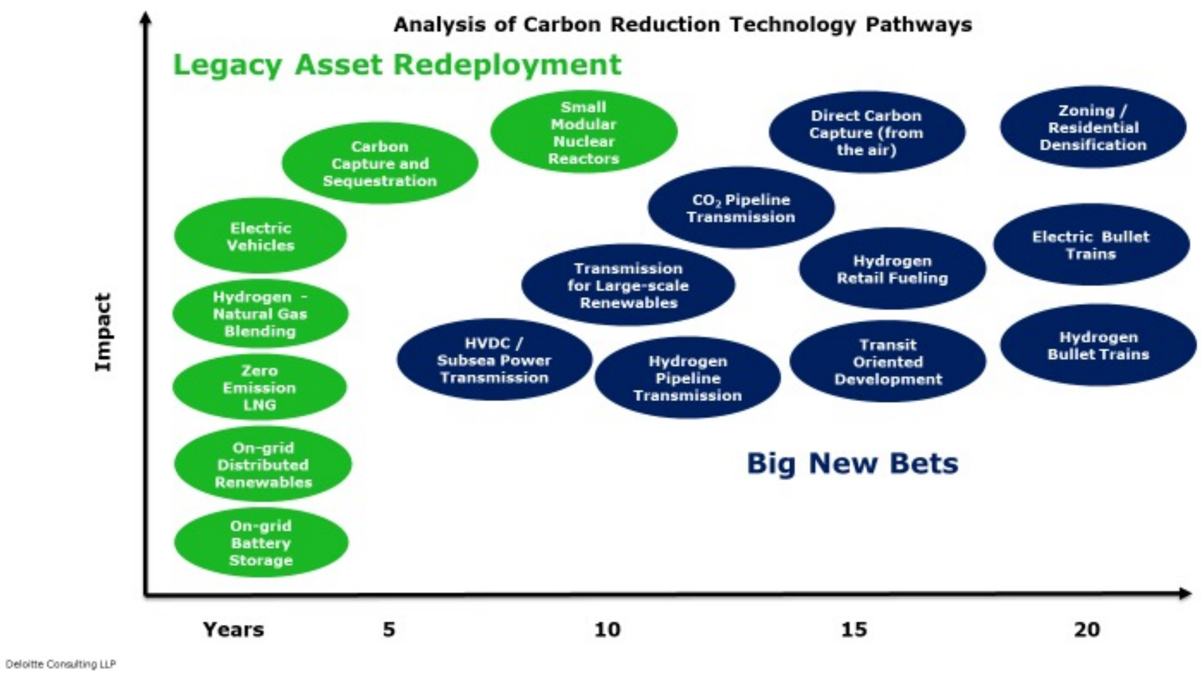
The Legacy Asset Redeployment approach does not forswear or dismiss the need to build new transmission and distribution infrastructure, but rather proposes that existing networks are the logical starting points to cost-effectively deliver low-cost low-carbon electricity. Indeed, 80% of EV charging is already done at home, according to the U.S. Department of Energy.[10] Paralleling the electricity sector, an analysis of natural gas shows that costs on average are comprised of about 60% commodity and 40% transmission and distribution expenses.[11] To the extent that lower carbon hydrogen/gas blends are technically compatible with end user profiles, the possibility to transition existing networks to serve a greener blend of fuel in the future therefore has great potential.[12]

Legacy Asset Redeployment

Legacy Asset Redeployment complements, but does not substitute, the critical steps needed to reduce emissions – such as increasing renewable generation, deploying electric vehicles, and improving efficiency. Legacy Asset Redeployment focuses on using new, innovative clean energy solutions and integrating these into existing networks. For example, battery storage can be co-located at existing power stations, or pumped storage can be sited at former mine sites, with these new technologies connected to the gird via existing transmission assets.

Sample "quick win" Legacy Asset Redeployment approaches are shown in Figure 2 as green ovals; other Legacy Asset Redeployment options (blue ovals) also have potential over the longer-term, and should be prioritized appropriately.

Figure 2: Survey of Carbon Mitigation Approaches, U.S. and International



Source: Deloitte Analysis

Three Legacy Asset Redeployment Examples

Select Legacy Asset Redeployment options:

1. Retrofit legacy coal and gas assets with replacement low-emission technologies
2. Blend hydrogen into natural gas networks
3. Sequester carbon with in-situ carbon capture

1. Retrofit Legacy Coal and Gas Assets with Replacement Low-Emission Technologies

Pumped hydro, large-scale battery storage, and small modular nuclear reactors (SMRs), are among the list of high-potential lower-emission technologies that could be located to take advantage of preexisting transmission and other infrastructure at legacy thermal generation sites. While SMRs may take another 5-10 years until they are ready for broad adoption, using retired coal plant infrastructure for other alternative energy ventures, such as large-scale battery storage, can provide an operational bridge in the medium term to maintain on-site employment and community engagement. Australia appears to be a leader in this type of asset transition: the 1,450 MW Yallourn coal-fired power plant is being retired early, in 2028, and will be replaced with a 350 MW battery storage facility.[13] In the U.S., Talen Energy is already constructing a 20 MW battery fleet at a retiring coal plant in Maryland.[14] Origin Energy's 2,880 MW coal-fired Eraring Power Station will retire in 2032, and will be replaced with 700 MW of battery storage[15] – allowing continued use of the coal plant's network infrastructure long after it has stopped thermal operations.

Besides innovative repowering of power stations, other assets in the fossil fuel supply chain can be redeployed. For example, coal mines that have enough vertical drop can be used for pumped hydro storage: Idemitsu Australia Resources has conducted a pre-feasibility study to convert an open cut mine at Muswellbrook into a 250 MW pumped-storage facility, scheduled for completion in 2027.[16] Centennial Coal in Australia is also performing a feasibility study to convert its underground coal mine into 600 MW of pumped storage. This agile approach to repurposing legacy assets addresses one of the key problems facing the widespread adoption of pumped storage – finding low-cost, community-supported sites with adequate reservoir volumes and grid access.

A variety of venture capital-funded

developers are backing different versions of SMR technology, including: NuScale Power, GE Hitachi, Westinghouse, and X-energy. The U.S. Nuclear Regulatory Commission issued its final safety evaluation report on NuScale Power's design in 2020, and full certification is expected in 2021.[17] The U.K. government has an SMR-focused public-private partnership with Rolls Royce, which is aiming for the technology to achieve Generic Design Assessment in 2024, and first unit deliveries in 2030.[18] Other SMR developers include Toshiba, ARC Nuclear, Terrestrial Energy, Holtec International, U-Battery and TerraPower. The benefits of SMRs include a (relatively) lower initial capital investment, greater scalability, and siting flexibility for locations unable to accommodate more traditional larger reactors. SMRs require limited on-site preparation, can be expanded modularly, and substantially reduce the lengthy construction times and financial undertakings that typify larger nuclear plants.

A flexible, distributed SMR fleet is compatible with, and complementary to, increased use of renewables and storage, particularly to stabilize the electric grid. As such, there is a strong opportunity to implement Legacy Asset Redeployment via SMR colocation at existing brownfield and on-grid sites – such as TerraPower's 345 MW sodium fast reactor, which is being built at the site of a retiring coal plant in Wyoming.[19]

Though utility-scale battery plants and SMRs have high projected costs relative to those of fossil-fueled power plants and wind and solar, fossil-fueled plants are carbon-intensive, and on-shore wind and solar cannot be considered baseload resources. Once these operational and environmental factors are taken into consideration, the commercial viability of such new technologies becomes much more attractive. The projected cost basis of battery storage and SMRs (included in the definition of Advanced Nuclear along with advanced light water reactors according to the U.S. Department of Energy) is shown in Table 1.[20]

By retrofitting retiring coal and gas generation sites, Legacy Asset Redeployment can leverage the existing site footprint, established transmission

Table 1: Average Levelized Cost of Energy for different plant types

Dispatchable Technologies	
Ultra-supercritical coal	$72.78
Combined cycle	$37.11
Combustion turbine	$106.62
Advanced nuclear	$69.39
Geothermal	$36.40
Biomass	$89.21
Battery storage	$119.84
Non-dispatchable technologies	
Wind, onshore	$36.93
Wind, offshore	$120.52
Solar, standalone [4]	$32.78
Solar, hybrid [4,5]	$47.67
Hydroelectric [5]	$55.26

Source: U.S. Department of Energy Annual Energy Outlook 2021

infrastructure, proven local labor skills, and stakeholder political influence. Such an approach therefore has the potential to preserve communities, accelerate the adoption of new technologies, and streamline the decarbonization process.

2. Blend Hydrogen into Natural Gas

Hydrogen can be a significant low-carbon alternative for gas in transport, industry, and residential applications. Hydrogen can also be blended with natural gas at low concentrations within existing transmission and distribution infrastructure, and used in existing appliances at such concentrations with minimal need for retrofits. The process of producing green hydrogen by electrolysis can also absorb surplus low-cost intermittent electricity from hydro, wind, or solar, thereby providing grid balancing on an as-needed basis. Green hydrogen production, in particular, has strong potential to act as a demand center for seasonal renewables (when hydro or wind availability increases dramatically for months at a time because of annual regional weather patterns), thereby complementing the hourly renewables balancing capability of battery storage installations.[21]

Using relatively low percentage blends of hydrogen within existing natural gas networks appears to be technically feasible. For example, according to the U.S. National Renewable Energy Lab, *"If implemented with relatively low concentrations, less than 5%–15% hydrogen by volume, this strategy of storing and delivering renewable energy to markets appears to be viable without significantly increasing risks."*[22] Regulators globally are also reviewing how much hydrogen can safely be blended into natural gas. The California Public Utilities Commission started hearings in 2020 on this issue.[23] The European Union Agency for the Cooperation of Energy Regulators reported that "23 national regulatory authorities (NRAs) have looked into the current possibilities for admixing hydrogen and injecting biomethane or transporting pure hydrogen via existing gas networks."[24]

Hydrogen blending feasibility studies are ongoing globally and demonstration projects are showing positive results. In 2020 a U.K. gas company successfully tested a 20% hydrogen blend on 100 homes and 30 university buildings.[25] The EU tested a vehicle on 30% hydrogen blend with compressed natural gas and found a 35% drop in CO_2 emissions and even higher reductions in damaging emissions from particulates and NOx.[26] In Oregon in the U.S., NW Natural Gas is developing a 2 MW power-to-gas hydrogen project with the Eugene Water and Electric Board.[27] The gas company hopes to use its gas storage capacity, equivalent to 4.7 million MWh, for seasonal gas-power rebalancing.[28] In Utah, the Intermountain Power Plant Project will replace its 1,800 MW coal-fired plant with turbines using a blend of natural gas and green hydrogen.[29]

Blending hydrogen into gas can absorb wind and solar produced at inconvenient times. The amount of natural gas throughput (31 trillion cubic feet in 2019[30]) in the U.S. is very large relative to even the most optimistic build-up of variable renewable energy. Some regulators allow up to 10% hydrogen (higher in several jurisdictions) blended within natural gas systems. The amount of renewable energy needed to create 3.1 trillion cubic feet of hydrogen-equivalent is on the order of 500,000 MW – or five times all U.S. solar and wind installed capacity in 2020, per Deloitte Analysis.

Besides decarbonization in the natural gas sector, the benefits of using a hydrogen blend within natural gas supplies includes:

- potential for enhanced electric grid balancing on a seasonal basis,
- ability to run rotating power generation assets closer to maximum efficiency,
- improved security of supply of both electricity and natural gas,
- more flexibility and seasonal adaptability on hydroelectric production, and
- increased ability to absorb forced hydro-electricity generation resulting from mandatory irrigation releases (an issue that is anticipated to become increasingly acute as climate change disrupts traditional agricultural practices).

Looking ahead, hydrogen production using electrolyzers at nuclear power plants is not yet cost-competitive, although the nuclear industry is engaging in research to find ways to improve the economics, according to Tim O'Connor, Chief Generation Officer and Executive Vice President at Xcel Energy.[31] Exelon Senior Vice President Scot Greenlee said one of its electrolyzers could begin operation as early as 2023.[32] Energy Harbor, Exelon, Xcel Energy, and Arizona Public Service are considering building hydrogen electrolyzers under the U.S. Department of Energy's H2@Scale initiative – a program that explores the potential for utilities to use nuclear energy to accelerate wide-scale hydrogen production and utilization across the U.S.[33]

3. Sequester Carbon with In-Situ Carbon Capture

Carbon capture utilization and storage (CCUS) is emerging as an important component in meeting the 1.5° Intergovernmental Panel on Climate Change (IPCC) goal. In-situ CCUS may enable new and existing gas fields to power emerging markets without significant emissions impact, albeit at the incremental cost of the capture and storage process. Many producing or near-depleted oil and gas fields have geological formations that can be used to accommodate carbon capture, potentially repurposing existing gas supply pipelines towards CO_2 disposal.

An example of in-situ carbon capture is the development of the Gundih Gas field in Central Java, Indonesia. The Government of Japan and PT Pertamina plan to extract CO_2 from Gundih's field-adjacent gas processing plant and transport it back to the wellhead for permanent injection into the underlying strata.[34] In another example, Equinor Energy AS, along with Royal Dutch Shell and Total, will invest $680 million in a full-scale CCUS project called Northern Lights in Norway. It will transport liquefied CO_2 by pipeline to permanent offshore subsea storage. The project will have an initial storage capacity of 1.5 million tons of CO_2.[35] In the U.S., in 2019 the California Air Resources Board added CCUS projects as a pathway to obtain credits under the Low Carbon Fuel Standard.

These positive developments notwithstanding, the long-term efficacy of CCUS projects will require the adoption of comprehensive evaluation norms and rigorous standards to ensure that in-situ leakage does not occur[36]. It is therefore worth noting that one of the largest and oldest examples of CCUS is Sleipner West field in Norway, operated by Equinor since 1996, which has sequestered 11 million tons of CO_2. Monitored by the Norwegian government, plus one of Europe's largest independent research organizations SINTEF (Stiftelsen for Industriell og Teknisk Forskning), and the British Geological Survey, Sleipner West was reviewed by the Organization for Economic Co-operation and Development, which concluded, "There is no evidence of CO_2 leakage and the CO_2 remains in-situ.[37]

The cost of extracting and sequestering carbon at the point of natural gas development is relatively low because in-situ natural gas often contains water, sulfur, CO_2, and other impurities, which are removed during processing. Usually the CO_2 from natural gas formations is vented, but, because of its high purity, the cost of capture and sequester only tends to be in the range of $19-$26 per ton[38], as opposed to $94-$232 per ton[39] or even $250-$600 per ton[40] for in-air capture.


CO_2

Getting Stakeholders on Board

Communities

Many blue-collar communities in the U.S. are centered, both geographically and socially, around legacy gas and coal energy systems. Reusing existing infrastructure can help to marshal such communities to support Legacy Asset Redeployment approaches. Indeed, as outlined earlier, such an approach has been fundamental to TerraPower's building of a sodium fast reactor at the site of a retiring coal plant in Wyoming, Talen Energy constructing a battery fleet to replace a retiring coal plant in Maryland, and the Utah Intermountain Power Plant project planning to replace its coal plants with natural gas and green hydrogen plant.

Municipalities

Many cities are leading the way in climate action. Because Legacy Asset Redeployment can enable swift investment and action, it can promote a rapid positive impact on air quality for urban residents – a pressing environmental justice issue.[41] Most cities are already looking to electrify public and private vehicle fleets; by teaming this trend with Legacy Asset Redeployment municipalities can accelerate access to additional carbon-free generation and thereby reduce particulate matter and NOx emissions at multiple points in the energy supply chain simultaneously.

Corporations

According to Deloitte's 2020 Energy Transitions Survey, *"55% of manufacturing leaders confirmed that sustainability efforts have high-level support from their board of directors."*[42] Large corporations such as Apple are greening their supply chains; using 100% renewable generation; targeting zero waste to landfill; and reusing, recycling, composting, or converting manufacturing waste into energy.[43] Likewise, large corporations including Amazon, Apple, Facebook, Google, Microsoft, and Wal-Mart are signing power purchase agreements (PPAs) to enable the construction of new renewable energy projects and support carbon-free electricity generation *"PPAs have grown in popularity as an effective means for large multi-national corporations to diversify their energy supply, secure long-term cost-effective power, and meet sustainability commitments and demands of shareholders,"* according to Deloitte Analysis.[44] For example, in Vietnam approximately 40 multinational companies have committed to achieving 100% renewable energy consumption by purchasing and/or owning renewable energy generation assets.

Many energy-intensive corporations have recognized hydrogen as an important pathway to decarbonization, demonstrated by various hydrogen alliances organized in Europe, the UK, Northwest U.S., and Hawaii. Legacy Asset Redeployment is an important opportunity for companies to go beyond climate commitments and marry those to their environmental, social, and governance (ESG) and community commitments. Indeed, Deloitte's 2021 Chief Procurement Officers Survey, revealed that nearly 68% of the over 400 respondents listed corporate social responsibility (CSR) as a top priority across their entire supply chain.[45]

NGOs

Legacy Asset Redeployment is already being championed by several NGOs, who recognize its potential to transform the economic and social impact of climate-related investments on different social groups. For example, Good Energy Collective is a women-led professional collective of researchers, lawyers, and analysts who support small modular nuclear energy as a key component not only of carbon reduction but also environmental justice.[46] Breakthrough Institute is a Berkeley, California-based think tank that has commented that "scaling up nuclear energy is a promising path to creating a global energy system that supports high universal living standards and yields meaningful reductions in greenhouse gas emissions."[47] According to Thomas Cochran of the Environmental Defense Fund, "If we are serious about solving the largest issue in the world, we have to be willing to look at nontraditional options like nuclear. It's not that we don't see risks. But we have to keep an open mind."[48] The Union of Concerned Scientists took a revolutionary turn in 2020 when it fully supported nuclear power. Ken Kimmell, President of the Union of Concerned Scientists, said groups should "abandon a tribalistic attachment to particular solutions" to achieve 100% clean energy.[49]

Summary

Legacy Asset Redeployment means using integrating new and innovative low-carbon technologies into already-existing energy supply chains, businesses, and physical infrastructure and communities. The reasons to pursue and implement Legacy Asset Redeployment approaches are not only economic, but also social and political. Climate initiatives will be spurred and carbon-free targets will be accelerated if and when they can be achieved while addressing social and political concerns.

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