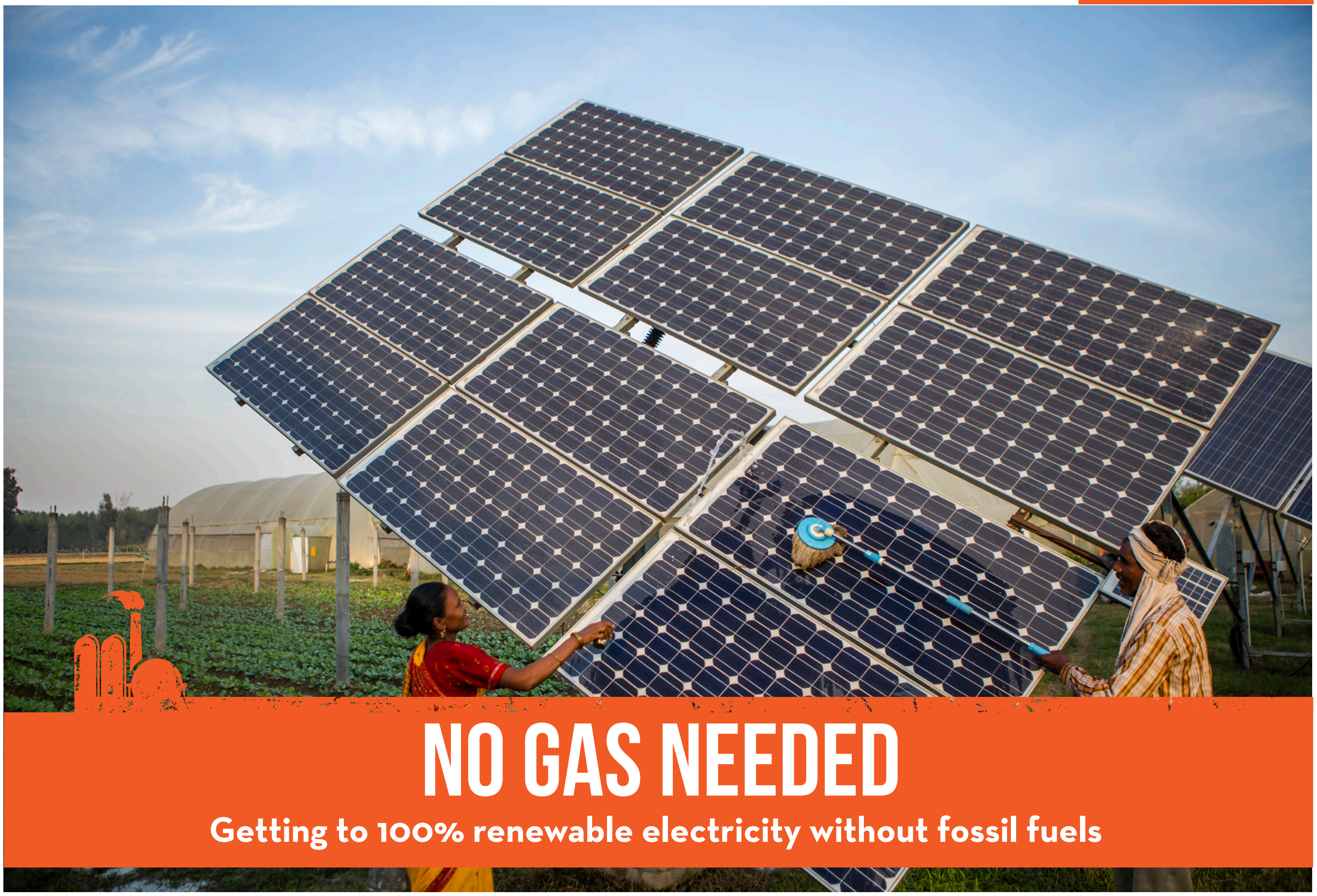


NO GAS NEEDED

Getting to 100% renewable electricity without fossil fuels

Farmers with solar panels in Haryana, India. Source: Prashanth Vishwanathan (IWMI). Flickr.

The fossil gas industry works hard to portray gas as essential to the transition to a clean energy future.[1] However, this ignores the fact that gas is expensive, risky, and dirty.[2] New gas infrastructure locks in decades of new carbon emissions and slows the transition to clean energy. Real-world experience and ongoing research show that transitioning to a clean power system without gas is achievable using a suite of readily available policies, tools, and technologies.

This fact sheet provides insights into the latest research on achieving fossil-free electricity, outlines solutions for maximizing renewable electricity, and highlights policies to enable this change.

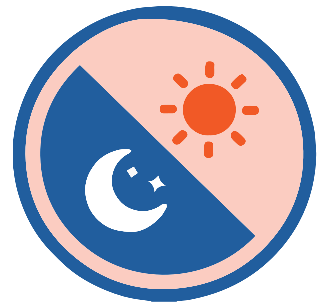
1. 100 PERCENT RENEWABLE ELECTRICITY IS ACHIEVABLE

Wind and solar met 12 percent of global electricity generation in 2022.[3] The contribution of these two generation sources grew 17 percent and 24 percent, respectively, from the year before. According to analysts at Ember, "We are entering the clean power era. The stage is set for wind and solar to achieve a meteoric rise to the top."[4] The intermittent nature of wind and solar means that they cannot provide secure, reliable service at all times. But there is no reason to assume that gas or other fossil fuels are the only way to balance wind and solar variability.

Scientists at the U.S. National Renewable Energy Laboratory (NREL) have found that there are no technical barriers to running electricity grids primarily on wind and solar.[5] Grid operators around the world have learned that many of the perceived barriers to integrating wind and solar have disappeared, enabling the percentage of variable renewable energy (VRE) on some networks to reach levels previously thought impossible. The remaining challenges to achieving 100 percent fossil-free electricity are increasingly solvable. Figure 1 summarizes the stages of renewable energy integration.

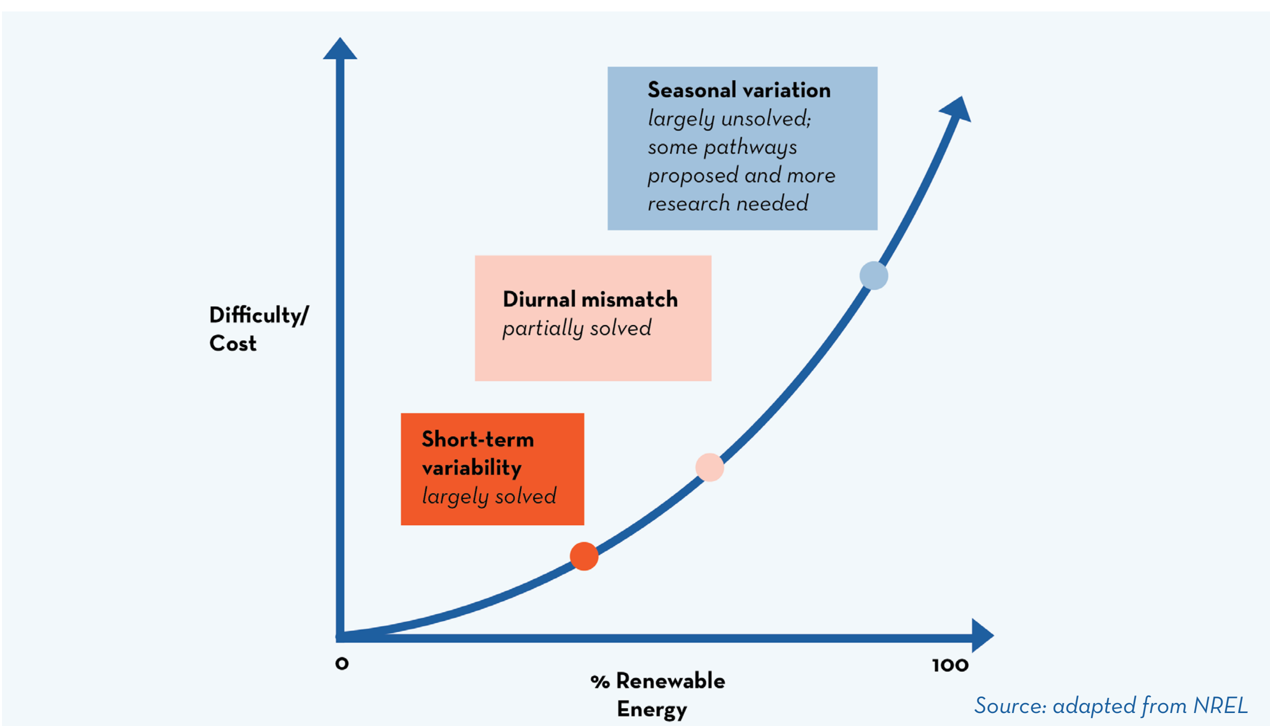
- **Short-term variability** refers to the fluctuations in VRE production over minutes to hours, as the wind and sun's intensity fluctuates in a given location. The challenges around short-term variability are now largely solved using combinations of energy storage and existing power generation assets combined with rapid monitoring and maintenance of grid voltage and frequency. These techniques have already allowed some grids to reach 30-50 percent VRE penetration or more.[6]

- **Diurnal mismatch** describes periods during the day and night when wind and solar production do not match electricity demand. This can lead to too much VRE or not enough. Fortunately, a combination of existing and near-commercial technologies are solving this (see Section 2), allowing renewable energy to potentially scale up to 80-95 percent penetration of electricity grids.[7]



- The remaining issue is how to provide year-round renewable energy, especially in areas with high **seasonal** wind and solar variations. The challenge is less about finding a technology to bridge this gap without fossil fuels and more about cost. A resource required only to meet the last increment of demand will suffer from infrequent utilization. This means it will require a high price per unit of energy produced. Finding a cost-effective, fossil-free solution is increasingly recognized as the "last 10 percent challenge."[8]

Figure 1: Three Stages of Renewable Energy Integration



Source: adapted from NREL

REAL-WORLD EXAMPLES OF HIGH VRE PENETRATION

Whitelee Windfarm in Scotland is the UK's largest onshore windfarm. Source: Ian Dick, Flickr.

Several examples worldwide demonstrate how wind and solar have reached high levels without scaling up fossil gas generation and, in some cases, displacing it.

- South Australia averaged over 64 percent wind and solar generation in the 12 months to September 2022 and "regularly reaches levels where wind and solar produce more than 100 percent of state demand."[9]
- The U.S. Energy Information Administration expects rising wind and solar generation to displace gas in the next few years in the U.S. power sector as renewable energy operating costs drop even further below those for gas.[10]
- From 2014 to 2020, the share of California's electricity supplied by renewable energy, mainly wind, solar, and geothermal, grew almost 13 percent to 33 percent. Gas's share declined 7.5 percent to 37 percent, and coal fell 3.3 percent.[11]
- Hawai'i achieved 30 percent average annual renewable energy in 2020, with **no gas-based generation**.[12] It closed its last coal plant in September 2022.[13] While petroleum supplied the remaining generation, Hawai'i is working to reduce its use of this expensive, polluting energy source. For example, Maui County achieved 41 percent RE generation by 2019 through the aggressive installation of wind, solar, hydroelectric, and geothermal.[14] This will allow Maui to close a large oil-fired plant in 2024.[15] Further, NREL modeling has shown that Maui can reach 100 percent RE generation in the next few years.[16]
- Ireland hit 42 percent average annual RE generation in 2020 by replacing coal over the last few years and keeping gas use unchanged.[17]
- Scotland generated 62 percent from RE in 2020, mostly from wind.[18] The United Kingdom replaced coal with gas, wind, and solar, with gas declining in 2020. This is due to significant investment in offshore wind and a program that provides renewable energy developers with a steady, 15-year indexed rate for their electricity.[19]
- Modeling from NREL shows California could reach 94 percent renewable energy by incorporating existing battery storage technology. Texas could reach 90 percent. Florida could hit 91 percent, and New York could achieve 73 percent.[20]
- World Bank models show Pakistan's least-cost option for increasing power capacity is scaling up to 30 percent VRE by 2030. The move would save at least US$5 billion over the next 20 years. Given the rising cost of fossil fuels due to the Russian invasion of Ukraine, this figure would likely increase. The study found domestic and imported coal and gas were not cost-competitive with wind and solar over the next decade.[21]

These real-world examples show that very high levels of renewable energy penetration are achievable today and in the near future without increasing the use of gas or other fossil fuels.

2. THE ELECTRICITY DECARBONIZATION TOOLBOX

Despite the gas industry's claims that gas "has a pivotal role to play in the renewable transition,"[22] a wide range of existing and emerging technologies can complement wind and solar and achieve 100 percent clean energy systems without gas. The infographic on page 6 outlines the many existing and emerging technologies and strategies for supporting wind and solar on the path to decarbonization. It details three categories of tools and indicates their current market readiness. Additionally, 'Energy Efficiency' is a crucial strategy that we elaborate upon below as it is fundamental to any safe, secure and affordable energy strategy.

- **Market & Grid Design & Infrastructure:** Achieving the first 30-50 percent of renewable energy penetration requires redesigning electricity markets and their operating rules. These measures support greater renewable energy adoption and increased flexibility and interaction between power generation resources. These power market and grid design shifts are the fundamental basis of the transition to clean energy.[23]

  This includes setting policies and goals to incentivize renewable energy development and implementing supportive pricing and regulatory regimes. Investment in transmission, smart grids that support load and demand shifting, and tools for advanced planning and forecasting for weather and energy demand are also key. These tools are available and affordable today and are common in countries or regions with high wind and solar generation.

- **Energy Storage:** Storing energy is fundamental to a wind and solar-based grid. Short-duration (1-4 hour) lithium-ion battery technology has become highly affordable and is also proving to be very effective at supporting grid stability, providing instant response, and frequency regulation.[24] Pairing batteries with wind and solar allows excess energy to be stored when these sources produce more than is needed. Batteries then provide energy to balance supply and demand as wind speeds and sunlight falling on solar panels fluctuate throughout the day. Energy storage paired with the market reforms discussed above can achieve renewable energy penetration levels of 50 percent or more.

  Many long-duration energy storage technologies are under development today. Some are already entering the market. Some can store and deliver energy for twelve hours or more. This can easily address diurnal variability. Several emerging battery technologies do not rely on lithium, rare earth minerals, or other expensive and destructive materials.[25]

The Crimson Energy Storage Project, a 350 MW battery storage system for Crimson Solar in eastern Riverside County, California. Source: Bureau of Land Management, Flickr.

Hydrogen: Hydrogen produced with renewable energy ("green hydrogen") is often touted as a long-duration energy storage solution. Yet, there are issues around safety[26] and efficiency, particularly with hydrogen storage and transportation.[27] Converting electricity to hydrogen and back again is inherently inefficient, and adding long-distance transportation to the process greatly increases inefficiencies.[28] Hydrogen should be manufactured, stored, and converted back to electricity, all at the same location, to limit inefficiencies and leakage risks. Storage facilities must be closely monitored to prevent hydrogen from escaping into the atmosphere, as it is a potent greenhouse gas.[29]

Several efficient and affordable long-duration energy storage solutions will likely emerge within this decade rather than a single solution. Countries currently in the early stages of the energy transition will be able to take advantage of these technologies in the coming years.

- **Non-variable Renewable Energy (NVRE):** New forms of NVRE are emerging that could provide renewable energy around the clock and throughout the year. Innovation is also raising the potential for existing sources.

One of the main frontiers for NVRE is **ocean-based (marine)** technologies that use the constant movement of ocean currents, waves, and tides to generate reliable energy. While current global deployment is less than one gigawatt (GW), the International Renewable Energy Agency (IRENA) estimates that capacity could reach 10GW by 2030.[30] Ocean Energy Systems, an intergovernmental collaboration established by the International Energy Agency (IEA), targets 300GW of ocean energy globally by 2050.[31]

Today's global **geothermal** power generation capacity represents only 0.2 percent of total global electricity generation capacity, about 16GW. Conventional geothermal is generally limited to seismically active sites with abundant shallow hydrothermal resources. Nonetheless, global potential is estimated to be ten times the current capacity.

Emerging techniques for drilling deeper underground to tap more heat have the potential to unlock geothermal energy in many more locations worldwide. Enhanced Geothermal Systems are emerging as a potential new reliable renewable energy source.[32] Further, into the future, ultradeep geothermal wells could provide a heat source to run power generation turbines worldwide.[33]

Hydropower: Large hydropower dams have harmed communities and caused environmental destruction worldwide. There should not be any new dams built.

Existing hydropower provided 15 percent of global power generation in 2022, which is fossil-free power that can be used to support wind and solar.[34] Hydropower is well-suited to support VRE because turbines can quickly start or stop in response to demand. However, climate change threatens the reliability of hydropower as prolonged drought reduces water availability for power generation. Small-hydro or micro-hydro has a much lower impact on communities and the environment and can be used to support microgrids running on VRE.

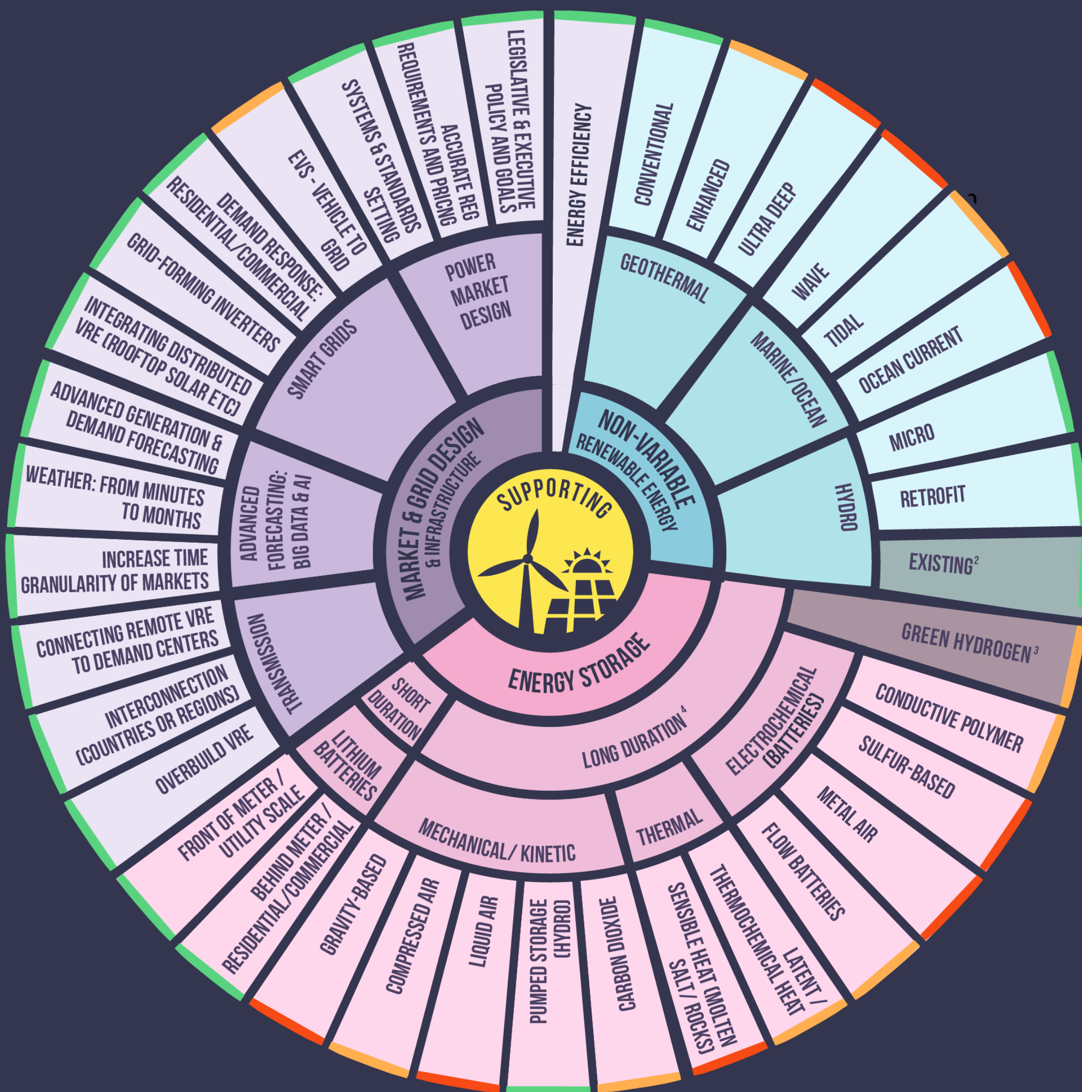
- **Energy Efficiency:** Energy efficiency is described by the IEA as "the first fuel of a sustainable global energy system."[35] The IEA stated in its 2022 Energy Efficiency report that "the largest energy efficiency opportunities of the future will be found in emerging and developing countries."[36] Using energy more efficiently increases energy security and lowers costs for consumers. The largest areas for improvement are generally in buildings and transport.

When considering the full range of options, it is clear that no single technology or energy source will support the transition to renewable electricity alone. It will require combining strategies and technologies that suit specific geographies and economies. While some of the emerging tools listed are yet to be fully proven and commercially available, several will likely emerge as viable, affordable solutions in the coming decade. When they do, billions of dollars of investment in gas infrastructure risk becoming stranded assets. Or, these gas assets might continue operating, generating carbon emissions we cannot afford. Governments must invest in policies, tools, and technologies to speed the transition to clean energy and reject support for fossil-based energy systems.

Figure 2:

Achieving Fossil-Free Electricity[1]

Policies, Tools and Technologies for Supporting Wind and Solar



Key: Market Readiness

- Commercial
- Newly Commercial
- Demo/Pilot

For a glossary of terms go to: *priceofoil.org/100REGloss*

OILCHANGE INTERNATIONAL

Footnotes:

1. Infographic shows the many choices available for supporting wind & solar to achieve reliable, dispatchable fossil-free energy. There is no one silver bullet. Not all are necessary, although most Market & Grid Design reforms are. List is not exhaustive.
2. No new large hydropower dams should be built. Existing projects should be operated in a way that minimizes impact on vulnerable communities.
3. Converting electricity to hydrogen and back again is inherently inefficient but may make sense in some contexts. Hydrogen should be manufactured, stored, and converted back to electricity, all at the same location, in order to limit inefficiencies and leakage risks.
4. Long Duration storage is mostly not needed until over 50% VRE penetration.

3. STABLE AND SUPPORTIVE POLICIES ARE ESSENTIAL

New and emerging technologies will be crucial in reaching 100 percent fossil-free electricity. However, rapidly adopting new technology to achieve climate goals requires a supportive and stable policy environment. The IEA provides twenty key policy recommendations for supporting renewable energy.[37] We summarize some of the fundamentals below.

Renewable Energy Targets: Government-mandated targets for renewable energy capacity or generation have been critical drivers for RE growth worldwide. The IEA recommends targets for short (5-year), medium (5-10-year), and long (to 2050) terms. Setting time-bound targets provides certainty and stability for investors and utilities. The IEA also recommends goal-setting across energy sectors (electricity, heating/cooling, and transport) ideally enshrined into legislation to increase certainty. Linking these to strategic policy goals such as emissions reduction and energy security is also critical.

Other Supportive Policies: While clear targets can send the right signals to investors and energy companies, a suite of supportive policies has helped wind and solar gain significant market shares worldwide. These can include the following.[38]

- **Eliminate fossil fuel subsidies:** create a level playing field for renewables to compete.
- **VRE-specific tariffs:** feed-in tariffs that set a price for feeding power generated by rooftop solar back into the grid or power purchase agreements for utility-scale renewables provide security for investors to front the capital for renewables deployment.
- **Reduce the cost of finance:** the high cost of financing renewable energy infrastructure in many emerging economies slows their development. Governments can provide guarantees, work with international financial institutions, and provide public funding to reduce risk and cost.
- **Ensure affordable and timely grid access:** set clear rules to govern grid connections. Renewable installations often face disproportionate costs and delays in connecting to the grid due to their smaller scale and remote locations.
- **Reduce non-economic barriers:** streamline permitting without compromising public consultation, enable land access, and develop local skills and supply chains.

Maximizing renewable energy potential also requires policies that focus on the system integration of VRE. These include supporting system flexibility, such as energy storage and demand response, and designing power markets to price these flexible resources accurately.[39]

4. CONCLUSION

Despite industry claims, research shows that achieving 100 percent renewable electricity systems is feasible. Many countries are already achieving high levels of renewable energy penetration by implementing a combination of policy reforms, changes in grid operation, and the development of energy storage and other renewable energy generation. While some of the technologies needed to get to a 100 percent renewable electricity system are still under development, most technologies and policy solutions to achieve up to 80 or 90 percent renewable energy penetration are widely available.

Solving the climate crisis requires planning today for the energy system of the future. Integrating wind and solar requires designing energy systems with wind and solar at the center. These are very different systems from one with baseload gas-fired power plants. There are also many alternatives to using gas peaker plants to add grid flexibility that are cleaner and not reliant on volatile and risky gas. These options will be cheaper and more secure in the long run. Countries that are just beginning their renewable energy journey are in an excellent position to benefit from lessons learned by countries and regions that have already achieved high levels of renewable energy generation.

ENDNOTES

1 See for example: American Petroleum Institute information advertisement in The Washington Post. Why natural gas will thrive in the age of renewables. Undated. [*link*]

2 Oil Change International, 'Burning the Gas Bridge Fuel Myth: Why gas is not clean, cheap, or necessary.' May 2019 [*link*]

3 Ember, Global Electricity Review 2023. [*link*]

4 Ember, Global Electricity Review 2023. [*link*]

5 Denholm, P. et al. "The challenges of achieving a 100% renewable electricity system in the United States". Joule. Volume 5, Issue 6, 16 June 2021, Pages 1331-1352. [*link*]

6 Ibid.

7 Mai, T. et al. "Getting to 100%: Six strategies for the challenging last 10%". Joule. Volume 6, Issue 9, P1981-1994, September 21, 2022 [*link*]. Also see [*link*]

8 Ibid.

9 Giles Parkinson, 'South Australia set to become first big grid to run on 100% renewables. Climate Home News. September 16, 2022. [*link*]

10 U.S. Energy Information Administration. "New Renewable Power Plants Are Reducing U.S. Electricity Generation From Natural Gas". CleanTechnica. 1-18-22. [*link*]

11 California Energy Commission. "2021 Total System Electric Generation". Accessed 5-22. [*link*]

12 U.S. Energy Information Administration. "Hawaii". 2-17-22. [*link*]

13 Jones, Caleb. "Hawaii closes last coal-fired power plant as ban begins". Associated Press. 9-1-22. [*link*]

14 Hawaiian Electric. "Maui Electric History". Accessed 9-1-22. [*link*]

15 Maui Now. "Maui Renewable Energy Project Would Enable Retirement of the Kahului Plant in 2024". 9-17-20. [*link*]

16 National Renewable Energy Laboratory. "NREL Methods Assist Maui in Approaching 100% Renewable Operations". 7-30-21. [*link*]

17 Sustainable Energy Authority of Ireland. "Developing renewable energy is central to Ireland's climate change strategy. It contributes to security, cost competitiveness and sustainability goals". Access 5-22 [*link*]

18 Scottish Government. "Annual Energy Statement & Quarterly Statistics Bulletin". 12-23-21. [*link*]

19 United Kingdom Department for Business, Energy & Industrial Strategy. "Contracts for Difference." 5-13-22. [*link*]

20 Denholm, P. et al. "The challenges of achieving a 100% renewable electricity system in the United States". Joule. Volume 5, Issue 6, 16 June 2021, Pages 1331-1352. [*link*]

21 Schmitt, K. et al. "Variable Renewable Energy Integration and Planning Study (English)". The World Bank. 10-20-20. [*link*]

22 Asia Natural Gas & Energy Association. Japan Gas Policy Brief. [*link*]

23 Zsuzsanna Pató, "Navigating towards net-zero power system: it is not the 'heading' but the 'course'", June 16, 2022. Regulatory Assistance Project. [*link*]

24 U.S. Energy Information Administration."Battery storage applications have shifted as more batteries are added to the U.S. grid." November 01, 2021. [*link*]

25 Long Duration Energy Storage Council [*link*]

26 Mike Soraghan, 'Hydrogen could fuel U.S. energy transition. But is it safe? E&E News. Energy Wire. 08/20/21 [*link*]

27 Michael Bernard, 'Morocco, Algeria, Egypt: Assessing EU Plans to Import Hydrogen from North Africa'. Corporate Europe Observatory and The Transnational Institute. May 15, 2022. [*link*]

28 Ibid.

29 Ilissa B. Ocko and Steven P. Hamburg. 2022. Climate consequences of hydrogen emissions. European Geosciences Union. [*link*]

30 IRENA 'Innovation Outlook: Ocean Energy Technologies.' 2020. [*link*]

31 Ocean Energy Systems 'OES Vision for International Deployment of Ocean Energy (2017).' March 08, 2017. [*link*]

32 National Renewable Energy Laboratory, Geothermal Anywhere.[*link*]

33 See *https://www.quaise.energy/*

34 2023 Statistical Review of World Energy [*link*]

35 IEA, Energy Efficiency 2022. December 2022. [*link*]

36 Ibid.

37 OECD/IEA '20 Renewable Energy Policy Recommendations. October 2018. [*link*]

38 Ibid.

39 Ibid.

ADDITIONAL RESOURCES

Oil Change International gas webpage

The Regulatory Assistance Project (RAP)

The International Renewable Energy Agency

EMBER - Energy think tank focused on clean electricity

OILCHANGE INTERNATIONAL

October 2023

www.priceofoil.org