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ST. KITTS AND NEVIS

SELECTED ISSUES

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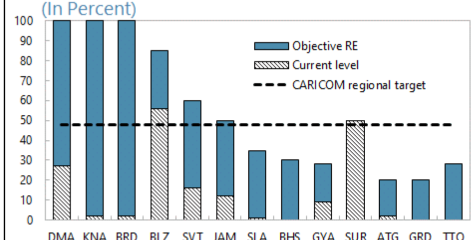
ECONOMIC BENEFITS FROM ENERGY TRANSITION

A. Introduction

1. **The economic benefits of the renewable energy transition can be challenging to measure and sometimes unclear.** Some studies[1] suggest that the overall economic impact can be uncertain because it depends on various factors, such as the speed of adoption of renewable energy (and the related investment), carbon pricing, and regulatory measures aimed at reducing greenhouse gas (GHG) emission.[2] While the increase in investment needed to expand renewable energy generation can stimulate economic activity by creating a positive demand shock, it can also pose a negative productivity shock because renewable energy investment does not directly increase the overall capital stock; rather, it replaces GHG-generating capital with "green" capital stock, without necessarily affecting the overall productive capacity of the economy. Moreover, financing this transition could potentially crowd out other productive investments in the economy. Furthermore, the cost of transition depends on the relative productivity of renewable and fossil fuel technologies and may be subjected to uncertainty in technology advancement.

2. **The overall effect hinges on several factors**. First, the effect on local employment and investment depends on the extent of the domestic component used to build the new green capital. Second, the positive impact of reducing fossil fuel energy imports on external trade and national income must be weighed against the cost associated with financing the additional green investment to prevent crowding out other profitable investment. Lastly, investment in renewable energy has the potential to lower energy prices (especially in energy dependent countries), although the benefits depend on how the gains are distributed, after factoring in the expense of decommissioning brown assets.

Objective RE Share in Energy Mix by 2023 vs. Current Level
(In Percent)



Source: United Nations Framework Convention on Climate Change (UNFCCC) 2016.

3. **Small island economies, particularly those in the Caribbean, could present a unique case where the renewable energy transition could lead to substantial positive effects.** These economies share common characteristics that simplify this assessment. Most are heavily reliant on energy imports for electricity generation, mainly fossil fuels, leading to high and fluctuating energy prices influenced by global markets. Their reliance on tourism also renders them vulnerable to energy price swings through airlift costs. Furthermore, their limited industrial sector facilitates the decommissioning of outdated fossil fuel infrastructure in a straightforward and cost-effective manner during the transition with limited destruction of the existing capital stock. Given these traits, small island economies stand to benefit substantially from the renewable energy transition. A large

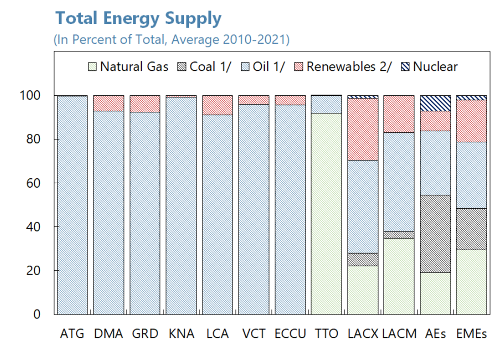
[1] See Pisani-Ferry (2023) Part II chapter 8 for a summary.

[2] Like the energy-retrofitting of energy inefficient buildings or the ban on oil-fired boilers (to increase the take-up of heat pumps).

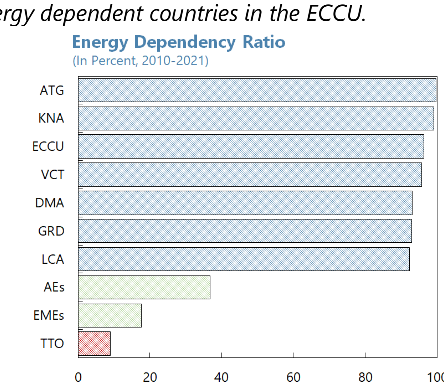
reduction in electricity prices would benefit households, increase corporate profits, and enhance the competitiveness and productivity of the private sector. While the initial positive demand shock from renewable energy investment might be offset by import leakages, the negative supply impact is likely limited, as the amount of brown assets—for example, fossil-fuel generators run by local utilities or hard to abate industrial capital—is small or already fully amortized, implying minimal displacement effect.[3] Regarding financing, potential crowding-out effects could be cushioned by utilizing external concessional finance earmarked for renewable transition projects. Moreover, financing options such as Purchasing Power Agreements, where external investors (Independent Power Producers, IPPs) cover initial investment costs and spread repayments over long periods, can alleviate financing constraints.

Figure 1. St. Kitts and Nevis: Key Macroeconomic Indicators

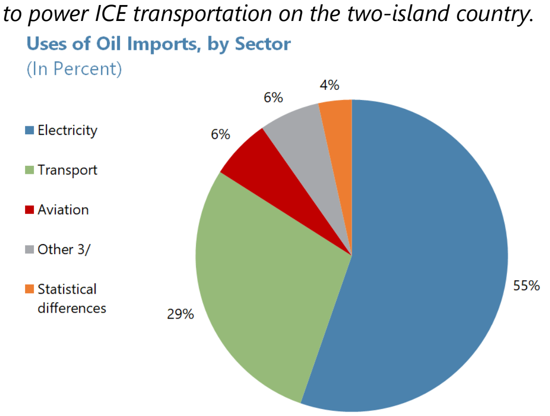
St. Kitts and Nevis is reliant on oil for energy, as is the rest of the ECCU.



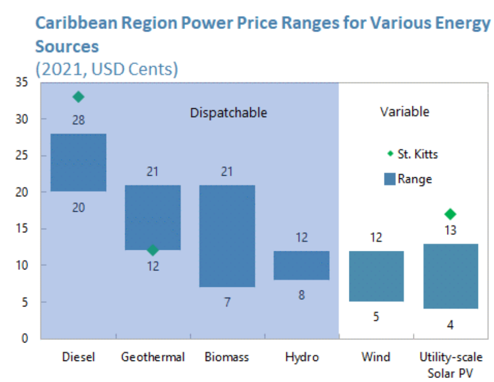
Even by regional standards, St. Kitts and Nevis is one of the most energy dependent countries in the ECCU.



Most of the imported oil is used to generate electricity and to power ICE transportation on the two-island country.



This dependency makes diesel generated power prices quite high, but alternative sources more attractive in terms of KW/h price.



Sources: IRENA; Trinidad and Tobago Article IV (IMF 2024); United Nations' Department of Economics and Social Affairs; and IMF staff calculations.
Note: AEs = Advanced Economies, EMEs = Emerging Economies, ECCU = Eastern Caribbean Currency Union, LACX = Latin America and Caribbean net energy exporters, LACM = Latin America and Caribbean net energy importers. Coal is comprised of primary production and related products; oil is comprised of crude oil and oil products.
1/ Renewables include biofuels and waste, electricity, and heat.
2/ Residual is comprised of international marine and aviation bunkers, and stock changes.
3/ Other includes use by households and industry, and non-energy uses.

[3] For sample, in small island economies, a widespread transition to electricity vehicles (EVs) does not result in the same negative shock that might in a country with automobile production. Instead, the shifts to EVs simply alters over time the composition of durable goods imports without causing significant displacement in the automotive industry.

4. **Cheaper and more stable energy prices can also support macroeconomic stability.** In addition to the aforementioned effects, low and stable energy prices can mitigate the adverse impact from terms-of-trade shocks and reduce inflation volatility, thus contributing to smoothing out economic cycles. Stable energy prices can foster a business climate that encourages the emergence of economic activities spurred by affordable energy, thus opening opportunities for economic diversification. In addition, low energy prices can encourage investment in productivity-enhancing capital.

5. **For countries with significant renewable energy sources, exports of energy or energy-intensive products could lead to substantial improvements in external sector positions.** Countries with the most renewable energy potential stand to gain the most benefits. While these indirect benefits may take time to materialize, they are already observable in certain countries where the development of renewable energy predates the current wave of transitions (see para 18 and Annex II).

6. **The energy landscape of St. Kitts and Nevis calls for energy reform.** The two islands of St. Kitts and Nevis rely heavily on fossil fuels, primarily diesel, to power their grids without interconnection (Figure 1). The diesel generators used by the utilities companies on both islands are costly, with retail and commercial electricity prices among the highest in the region.[4] Moreover, the base electricity price has remained unchanged since 2010. Although an energy commission mandated under the Public Utilities Act is tasked with determining energy prices based on technical factors such as price recovery, it has yet to be activated.

7. **The rest of the paper will delve into empirical analyses and discuss policy implications.** The analysis uses cross-country examples to examine the channels through which the adoption of renewable energy on a large scale can yield numerous long-term economic benefits. It will also provide an overview of a few countries' experience in leveraging abundant renewable energy resources to grow and diversify their economy. Then it will discuss how public policies can address the trade-offs arising from renewable energy development and help make the most of this transition.

B. What Channels are at Work?

The Electricity Supply Channel

8. **Replacing fossil fuels with renewable energy could increase the productivity of electricity generation.** The increase is potentially large for St. Kitts and Nevis given its high cost of fossil-fuel-based electricity generation. The country’s current cost is about 0.33 USD per kWh (Cable

[4] Retail and commercial prices are highly subsidized through an oil surcharge whose cost is borne by the budget when diesel price exceed a certain threshold (28 cents per kWh). With this subsidy, the utility company in St. Kitts does not fully pass on the cost of electricity to users, the residual cost being socialized through a budgetary transfer to the electricity utility.

Co UK, 2021). In comparison, the global average levelized cost of electricity (LCOE)[5] was 0.068 USD per kWh for geothermal and 0.048 USD per kWh for solar photovoltaic (PV) in 2021 (IRENA 2021). The estimated costs are higher in the Caribbean—reflecting smaller project scales—at 0.12 USD per kWh for geothermal, 0.11 for solar PV, and 0.21 USD per kWh solar plus battery storage (Masson et al. 2020). Based on these estimates, the cost of electricity generation in St. Kitts and Nevis could be reduced by more than half.[6]

9. The growth impact of lower electricity cost is estimated for St. Kitts and Nevis. The main channel affecting economic growth is that lower electricity costs reduce the input costs for domestic downstream industries—this is the first-round effect. The first-round effect from the productivity of electricity generation to GDP can be approximated following the growth accounting framework from Hulten (1978). This approach suggests that a 2/3 reduction in the cost of electricity generation will lead to an increase of GDP by 1.1 percent (see Annex I for details).

10. Renewable energy transition improves the resilience of electricity supply and mitigates the potentially large negative impact of a supply disruption. Benefits from energy resilience is potentially large for in St. Kitts and Nevis because of its vulnerability to shocks, including global energy supply shocks and natural disasters. The Inter-American Development Bank (IDB) estimates that benefits from energy resilience is about ¾ of the benefits from lower energy costs (Masson et al. 2020).

The Total Factor Productivity (Tfp) Channel

11. Another channel is aggregate TFP. There are many ways transitioning towards renewable energy can lead to an increase in productivity. For example, renewable energy transition could lead to better allocation of capital and labor towards sectors that are more energy efficient. It could also catalyze the development of new sectors as discussed below.

12. Large TFP improvements are found to be associated with transformational cases of renewable energy transition. Transformational cases are countries that increased their renewable energy consumption as a share of total energy consumption by 10 percentage points or more over a five-year period (Figure 2).[7] A difference-in-differences analysis reveals significant productivity gains 5 years after the transition compared to 5 years before the transition (see Annex I for details). TFP growth is on average 2.5 percent higher while labor productivity growth is on average 0.5

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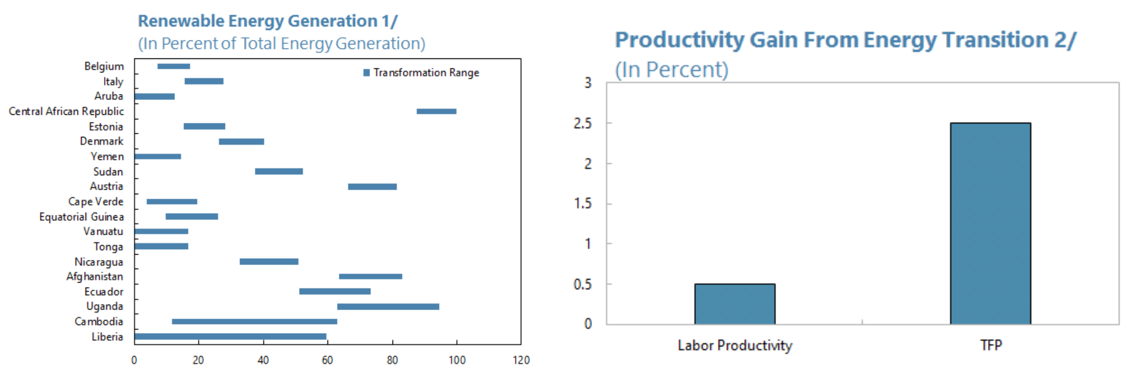
[5] The International Renewable Energy Agency (IRENA) estimates the global weighted average of LCOE based on newly commissioned utility-scale renewable power plants. LCOE is a measure of the annual production cost of electricity. LCOE is calculated as the sum of the net present value of capital expenditure and operating costs of electricity generation over the lifespan of the generator, divided by its expected lifetime. Note that installed costs and capacity factors for geothermal are project and site specific. Therefore, the global weighted average values could vary across years particularly when deployment is relatively thin.

[6] For example, 100 percent of electricity generation from geothermal would impl a saving of 2/3 while a 75-25 percent mix of geothermal and solar PV implies a saving of ½, if 35 MW of solar plus storage capacity replaces 9 MW of baseload.

[7] Cases that reverted the energy transition during the sample period are dropped. Data source on energy consumption: .

percent higher (Figure 2, right panel). One advantage of using the transformational cases instead of incremental cases—countries that gradually increase their use of renewable energy—is that that it mitigates concerns of reverse causality. For transformational cases, it is less likely that the large and abrupt transitions are caused by contemporaneous macroeconomic conditions. Moreover, transformational cases are more informative for St. Kitts and Nevis because its pipeline solar PV and geothermal projects, once completed, have the capacity to cover 100 percent or more of domestic electricity needs.

Figure 2. St. Kitts and Nevis: Transformational Renewable Energy Transition



Source: Ember-climate.org, IMF International Financial Statistics, Penn World Table, and IMF staff calculations.
1/ This figure plots renewable energy generation as a share of total energy generation before and after for transformational energy transition cases. Transformational cases are defined as countries that increased their renewable energy generation as a share of total energy generation by 10 percentage points or more over a five-year period.
2/ This figure plots the average differences in labor productivity and TFP 5 years after the transition and 5 years before the transition for transformational cases of transition. The differences are estimated using a difference-in-differences model (see Annex for details).

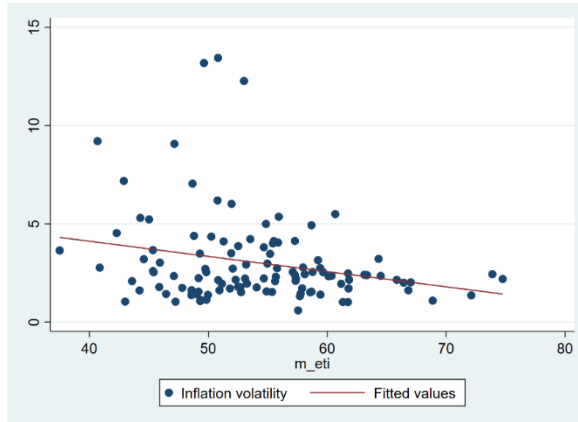
The Inflation Channel

13. Transitioning to domestic renewable energy sources could stabilize domestic energy prices and reduce the volatility of inflation. By reducing the reliance on imported fossil fuels, the transition could mitigate the impact from global energy market fluctuations due to factors such as geopolitical tensions, supply disruptions, and changes in extraction costs. Renewable energy, including from solar and geothermal sources, has lower overall operating costs compared to traditional fossil fuels once the infrastructure is in place (although they typically have higher upfront capital and financing costs). This can lead to lower energy expenditure and potentially lower overall consumer prices. Moreover, renewable energy supply is usually based on long-term contracts between energy producers and consumers providing predictability for both parties regarding energy prices, through price setting mechanism over decades.[8] Consistent with these mechanisms, countries farther along in the energy transition have lower volatility of consumer price inflation, on average, thanks to more stable energy prices (Figure 3). While marginal pricing frameworks still

[8] For instance, the Purchasing Power Agreements negotiated for the solar project has a duration of 25 years and the electricity price is set for an initial period of 10 years.

generate meaningful energy price fluctuations for countries not "price makers" in the energy market (like large oil producers or countries close to 100 percent renewable and thus energy independent), countries achieving to increase the share of renewable beyond a certain threshold can reduce inflation volatility meaningfully: above a 60 percent ETI countries experience on average ½ of the CPI volatility experienced by countries on the left of the scatterplot.

Figure 3. St. Kitts and Nevis: Energy Transition Index and Inflation Volatility



Source: IMF International Financial Statistics, World Economic Forum, and IMF staff calculations.
Note: This figure plots the WEF Energy Transition Index (ETI) and inflation volatility. The ETI, produced by the World Economic Forum, benchmarks 120 countries on their current energy system performance and on the readiness of their enabling environment. Each dot represents the country average of ETI and inflation volatility during the same period.

The External Account Channel

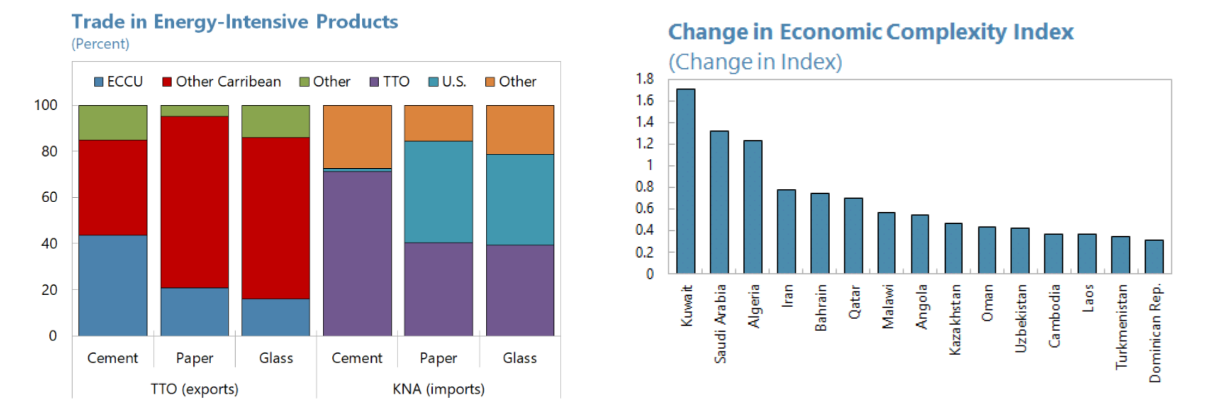
14. Transitioning to domestic renewable energy sources could bolster a country's external financial position. This shift has the potential to enhance the trade balance and reduce the current account deficit by reducing reliance on energy imports. Countries with advanced renewable energy technologies stand to benefit from exporting energy directly (such as through green hydrogen or its derivatives such as methanol), exporting energy intensive products, or from exporting renewable energy equipment and associated technologies. Moreover, countries that have committed to a renewable energy transition are likely to attract foreign investment in their renewable energy infrastructure. This influx of foreign direct investment has the capacity to fortify the country's external financial position.

15. The renewable energy projects in St. Kitts and Nevis projects are expected to have a notable impact on the external account. During the investment phase, the current account is anticipated to deteriorate due to higher imports. However, once operational, significant savings are forecasted from reduced fuel imports. For instance, the launch of the solar facility is estimated to decrease St. Kitts's utility company (SKELEC) fuel imports by 40 percent, resulting in annual savings of about $37 million USD. Two scenarios illustrate the impact of increased renewable capacity: in a self-sufficiency scenario covering 100 percent of electricity needs, annual fuel import savings equate to 3.7 percent of GDP, improving the current account from deficit to a surplus of about 1.5 percent of GDP. In an aspirational scenario with domestic needs covered and 50 MW of exports, the current account surplus further rises to about more than 5 percent of GDP (Box 1).

The Sectoral Diversification Channel

16. A sharp reduction in energy costs in St. Kitts and Nevis could promote sectoral diversification. High energy costs can prohibit economic diversification, particularly into energy-intensive industries. Within the Caribbean, energy importing economies, such as the ECCU, tend to have very small manufacturing sectors. In contrast, the manufacturing sector is much larger and diverse in Trinidad and Tobago, which has very low electricity costs thanks to its domestic production of natural gas. Trinidad and Tobago has a comparative advantage in manufacturing energy-intensive products such as cement, glass, and paper, and as a result it exports these products to ECCU countries and the broader Caribbean. The expected decline in electricity costs in St. Kitts and Nevis could allow the development of more energy-intensive industries, increasing diversification and reducing imports of energy-intensive products (Figure 4).

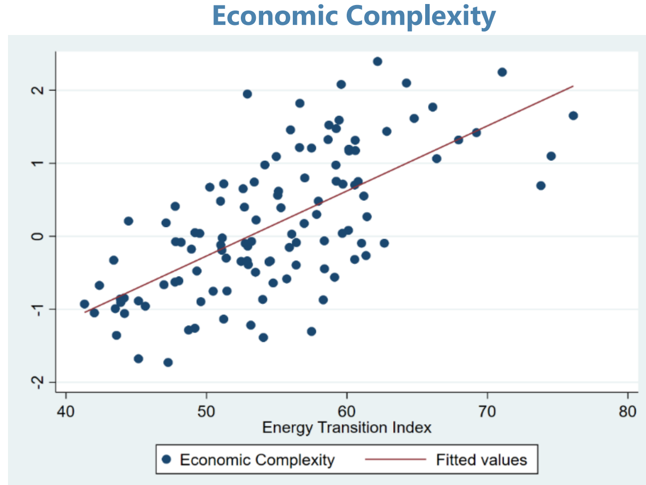
Figure 4. St. Kitts and Nevis: Energy and its Impact on Trade and Development



Sources: UN Comtrade; Atlas of Economic Ecomplexity; and IMF staff calculations
Note: Figure shows the top 15 countries with the largest increase in their economic complexity index over the period 2011-21.

17. Abundant access to energy is associated with increased economic complexity. Countries that have large domestic production of energy have seen, on average, larger increases in economic complexity in the past decade (Figure 4). Many of these countries are large oil and natural gas producers and therefore have access to cheap energy sources. However, there are also several countries where renewables, chiefly hydropower, is the primary source of electricity production. A rapid increase in electrification has also been found to catalyze industrial development (Kassem 2018).

Figure 5. St. Kitts and Nevis: Energy Transition and Economic Complexity



Source: IMF International Financial Statistics, World Economic Forum, and IMF staff calculations.
Note: This figure plots the WEF Energy Transition Index (ETI) and Economic Complexity Index (ECI). The ETI, produced by the World Economic Forum, benchmarks 120 countries on their current energy system performance and on the readiness of their enabling environment. The ECI is produced by Harvard University's Growth Lab, and represents the capability and knowledge of a country based on the complexity, diversity, and ubiquity of its product exports. Each dot represents the country average of ETI and ECI during the same period.

18. More broadly, the renewable energy transition is also associated with increased

economic complexity. Countries that are more advanced in energy transition—measured by the World Economic Forum's Energy Transition Index—tend to have higher economic complexity (Figure 5). This relationship remains true for different types of countries—those with high income and those with middle- and lower-income. It also remains true for countries with large or small oil exports. In other words, this relationship is not because of how rich a country is, or how much oil it produces. This is consistent with the notion that cheaper energy production supports economic complexity, and cheap energy production can come from renewable energy as well as from the endowment of traditional resources such as oil and natural gas.

Box 1. Illustrative Scenarios on the External Account Channel

St. Kitts and Nevis portfolio of renewable energy projects is currently composed of one future solar energy facility in St-Kitts and one geothermal project in Nevis.

The solar project with a total investment of 80 million USD is expected to be fully operational in 2026. This utility scale solar photo-voltaic power generation unit should provide 35MW of peak capacity but contribute on average to one third of the needs of St. Kitts' grid, about 9 MW. Peak solar power generation will be used to power a Battery Energy Storage System

- (BESS) of 43 MW that will allow to maintain baseload capacity on solar generation (by maintaining power in case of short overcast weather phase), shift some of the solar energy to night consumption and will contribute to rebalancing the grid when peak hours surge happen.
- **The geothermal project** was launched with an initial investment of 17 million USD for drilling and exploration, that was provided by through a contingent loan of the Caribbean Development Bank (acting as intermediary for the Green Climate Fund). The construction stage is expected to take three years (2025-27). The geothermal power plant is expected to be operational with a planned capacity of 30 to 45MW (corresponding to three production wells of 10 to 15MW). The unit price of electricity once this project operational is expected to decline by around 63 percent for Nevis' utility company (NEVLEC), the utility provider in Nevis. The cost of electricity generation is anticipated to decrease by around 45 percent for the Federation.

The projects are poised to impact external accounts significantly. The current account is expected to deteriorate during the investment phase due to high imports demand. Once the projects are operational, they are expected to generate savings from lower fuel imports. Staff assumed that the operational launch of the solar facility will reduce the Island utility company fuel import by about 40 percent (4 mil gallons of diesel for total annual imports of 10 million) resulting in annual savings of about 100 mil EC (37 mil USD). The solar project is financed with a mix of foreign equity (about 25 percent of the total investment) and domestic loans, hence a small impact on primary income through profits outflows according to staff calculations.

The potential impact of increased renewable capacity is depicted through two scenarios. In a self-sufficiency scenario where renewable energy projects fulfill 100 percent of the country's electricity generation needs, annual fuel import savings could reach 3.7 percent of GDP, improving the current account from a deficit of about 2½ percent of GDP to a surplus of about 1½ percent of GDP in 2029. In an aspirational scenario, with renewable energy projects covering domestic needs and exporting 50 MW of electricity, the export revenue could amount to about 4 percent of GDP. Consequently, the current account surplus may further increase to about more than 5 percent of GDP.

19. **A few countries have been able to reap the fruits of renewable energy transition to give a meaningful boost to economic growth.** Iceland and Kenya are two interesting cases, for they highlight how cheap and abundant energy can buttress economic diversification and contribute like in Kenya to a dramatic increase in income per capita. In Iceland's case, large renewable energy

production has helped overcome the handicap posed by a geographic location away from main trade routes, a small population, and a challenging climate, while also enabling the development of high-tech, high value-added service activities, and even agriculture, allowing the country to reach a GDP per capita above most G10 countries.[9] In Kenya the surge in renewable energy production since 1990 has powered electrification, generating large productivity gains and enabling, together with other factors, a fourfold increase in income per capita towards middle-income status (country cases are elaborated on in Annex II).

C. Policies for Enabling Economic Benefits of Energy Transition

20. The positive economic scenario outlined above comes with multiple caveats. Maximizing the economic benefits from exploiting renewable energy sources requires a set of policy initiatives and intentional planning by country authorities in utility management, energy pricing, natural resource taxation and infrastructure project planning (see below). The external environment is also instrumental for near-term developments. The cost of investment has sharply increased with the tightening in global financial conditions. The financing plans of renewable energy projects have been impacted by mounting costs of raw materials and supply chain disruptions. The adverse price movements and tighter financing conditions faced by Independent Power producers (IPPs) have also complicated the negotiations for many utility-scale power generation PPA agreements, generating delays and uncertainty. To make the most of energy transition plans, the policy agenda should feature a few priorities.

Preparing a National Integrated Resource Plan (IRP) for Electricity Production

21. Multiple factors must be considered by governments and utility providers in the new energy landscape. These factors include the potential capacity of different renewable energy sources, base load versus peak power use, environmental footprint, resource diversity, and volatility in the fuel and commodities markets. Preparing a national Integrated Resource Plan (IRP) for electricity production is critical in this regard. An IRP is a roadmap to meet forecasted energy demand using both supply and demand side resources to ensure reliable service to customers in the most cost-effective way. IRPs were first developed in the 1980s as U.S. utilities started making plans for meeting future energy demand. Historically such plans featured generation, transmission, and distribution additions needed to meet growing demand. Nowadays these roadmaps need to include PPAs agreements negotiated with IPPs, renewable energy, upgrades to aging and vulnerable transmission and distribution infrastructure, and growth in decentralized (customer-originated) energy resources. The Caribbean Center for Renewable Energy and Energy Efficiency (CCREEE), CARICOM's specialized agency for renewable energy transition, is finalizing an IRRP for St. Kitts and Nevis whose delivery is expected in 2024.

22. Renewable energy planning in small island economies should be based on a forward-looking assessment of the renewable potential as well as rigorous procurement processes.

[9] With a PPA-adjusted GDP per capita of USD 55,567, Iceland stands behind the USA, Switzerland, and the Netherlands, but ahead of Sweden, Germany, Belgium, Canada, UK, France, Italy, and Japan.

Negotiations with IPPs should follow regular public procurement rules and tax concessions made in PPA negotiations need to be evaluated for their pluri-annual costs in terms of foregone revenue and reported in annual budget documents. The governance and financial structure of utility companies should be evaluated, including the publication of audited financial statements. Peer country experiences suggest that commercially managed arms-length utility companies (whether owned by the public sector or not), with pricing schemes guaranteeing full cost-recovery, are better positioned to bear the investments necessary to support the transition to renewable energy production. The financial standing of local utility companies is important to calibrate the ramping-up of infrastructure spending, and to determine whether investment efforts should be borne directly by the government, if infrastructure investments in the power grid (for simple upgrade or resilience) cannot be provided for by the local utility. Finally, the regulatory amendments needed to buy electricity from small PV producers (including net metering and feed-in tariffs) should be considered with a view to facilitate investment in the grid.

Energy Pricing Policy and Regulatory Framework for Feed-In Tariffs

23. Electricity prices in small island economies, currently largely driven by oil and gas prices, will ultimately reflect renewable energy generation as the transition unfolds. For example, in St. Kitts and Nevis, the PPA prices negotiated recently for the solar project could generate a decrease of about 50 percent in electricity prices. With the future addition of Nevis's geothermal facilities, electricity production costs in the Federation could fall below 0.1 USD per kWh.

24. Electricity pricing policy will therefore determine how the windfall from lower electricity costs will pass through to the economy. The following options should be considered:

- Full pass-through of lower electricity prices directly to final users.
- Partial pass-through to allow the utility companies to replenish their financial buffers and implement a necessary catchup in infrastructure investment to upgrade the power grids and build underground power lines for natural disaster resilience.
- Channel the savings to the budget, through energy taxation or dividend payment from the utility companies.

The optimal policy may involve a mix of these options depending on various trade-offs: evaluating short-term and long-term gains, studying the domestic economy's absorption capacity to a positive income shock generated by lower energy prices without excessive import leakages, and assessing the extent to which the resource generated by this windfall should be reinvested, saved, or used for debt reduction. With efficient markets and adequate absorption capacity, efficient allocation could be achieved by accurate pricing signals. Meanwhile, the government can play an important role in providing the necessary infrastructure, regulatory framework, and coordination with neighboring countries for energy exports. The technical evaluation of these trade-offs should be undertaken by utility companies and energy regulators, without undue political interference, before policy decisions are ultimately made.[10]

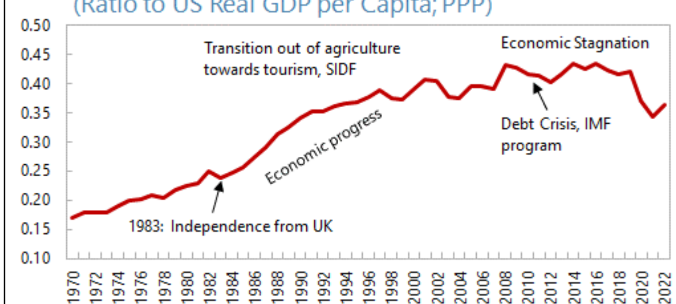
Natural Resource Taxation and Broader Fiscal Impact

25. Rent taxation, one of the least distortive forms of taxation, could be considered by policymakers as part of broader reviews of tax frameworks. The large availability of inexpensive renewable energy is akin to the existence of a natural rent. Channeling some of the economic gains from renewable energy resources to the budget could support public investment and redistribution, replenish fiscal buffer, and bolster sustainable and inclusive growth. This is particularly true for small island economies where natural disasters can rapidly deplete fiscal buffers. Beyond taxation the broader fiscal impact of the renewable energy investment should be assessed. It will depend on whether existing electricity generation has a net positive or negative fiscal impact due to waning taxes on fossil fuels used in electricity generation (and transportation) and subsidies/taxes on electricity use. This assessment should also factor in reduced fossil fuel demand as the economy electrifies, impact of tax rates on fossil fuels vs. electricity, new taxation of low carbon electricity generation and ultimately increased economic activity due to lower electricity prices.

Spatial, Geographical, And Human Limits To Economic Diversification

26. Renewable energy could spur economic diversification. Diversifying away from tourism has always been a tall order for Caribbean Islands. Income per capita growth and convergence towards the US stopped in 2010 for St. Kitts and Nevis. Natural Disasters are partly to blame, but tourism as engine of growth, following the transition out of traditional agriculture in the 1990's, has shown its limits over the last two decades. Further economic progress and convergence toward high income status requires jumpstarting new growth engines, especially as challenges loom from climate change and increasing risks of Natural Disasters (NDs) that could set back the country for decades if unaddressed. Energy can be a part of this process, together with chosen structural policies to maximize the potential economic benefits from this transition.

Real GDP Per Capita
(Ratio to US Real GDP per Capita; PPP)



Source: WEO; and IMF staff calculations.

27. Renewable energy sources could be used in various forms in small island economies like St. Kitts and Nevis. Energy exports on a large scale would be a game changer, but examples from country cases in Annex II. show that exporting energy on a meaningful scale presents important challenges. Energy exports linked to renewable energy are in most cases not direct energy

[10] In addition, differentiated pricing, setting a lower tariff during the day and higher tariff at night when solar energy wanes could better align incentives with the timing of electricity generation. This differentiation may be determined by the cost of energy storage as a proxy for differences in cost-recovery levels between day and night electricity generation.

exports, but rather trade of energy-intensive intermediary goods or commodities (e.g., aluminum sheet in Iceland, or ammonia and methanol in Trinidad & Tobago).[11] These require building an industrial base (e.g., an aluminum smelter), with heavy brick-and-mortar investment, encumbering large stretches of land, and potentially resulting in air or water pollution, something that may not be advisable for a country largely reliant on tourism. For this reason, prospects for the industrial use of energy to produce high-intensity energy products like green hydrogen and ammonia, fertilizer, agriculture and aquaculture, industrial productions of glass, cardboard, cement, special metallurgy (silica), and carbon capture and storage, should be cautiously balanced against their environmental footprint, financing modalities (to avoid a risky debt build-up) and also the extent of their downstream positive impact on the local economy. Exporting electricity to neighboring islands, while technically feasible, should be assessed on basis of the large investments needed.[12]

28. Potential "lower hanging fruits". Other alternatives could be envisaged. For instance, selling electricity to cruise ships anchoring overnight in St. Kitts and Nevis could be an avenue worth considering, given cruise ships high energy consumption[13] , reliance on expensive fossil fuel and the limited infrastructure needs required to pull power lines to ships. This would have a secondary benefit of reducing air pollution. Other potential avenues could be powering water desalination plants with renewable energy[14], developing inter-island electric ferries and water taxis, and developing a hub for short-haul electric airlines for island connections. The service sector also offers interesting prospects. Data centers, whose activity will be bolstered by the mainstreaming of Artificial Intelligence, are extremely energy intensive, and companies developing IA services are willing to source energy from renewable sources to limit their global carbon footprint. The International Energy Agency (IEA) predict that global electricity demand from data centers, Artificial Intelligence and cryptocurrencies mining could double between 2022 and 2026. Some of this demand could be met by data centers located close to cheap and abundant energy sources, like in Nevis.

29. Electrification of other domestic energy uses. Imported oil products are used for numerous other purposes beyond electricity generation. In St. Kitts and Nevis, for example, electricity generation accounts for about 55 percent of total oil imports, while road transport accounts for roughly 30 percent, the refueling of aircraft 6 percent, and most of the remainder used

[11] It should be noted though that electricity is not a perfect substitute for fossil fuel in manufacturing processes that require high heat (e.g., cement, glass, processing of some foods) and price for zero carbon energy intensive alternative products may be much higher and hence poorly competitive. Yet technological improvements will lower costs and ultimately low carbon products will likely receive a premium, especially in markets where carbon border adjustments taxation will apply.

[12] Depending on estimates, the cost of submarine power transmission cables ranges between 2 and 5 million USD per kilometer. St. Kitts' distance to Dominica is 263 km, to Guadeloupe 179 km, to US Virgin Islands 300 km, and to Puerto Rico 418 km.

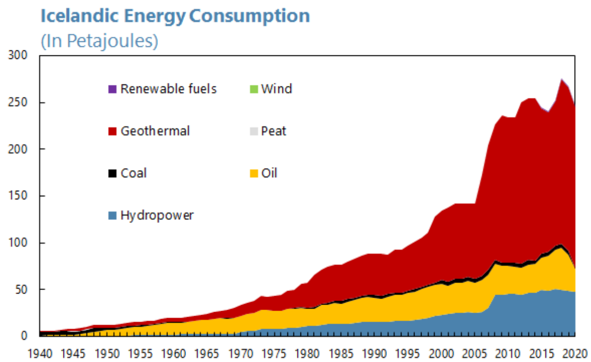
[13] A large cruise ship energy consumption, depending on size, speed, and onboard facilities, can range between 5 and 10 megawatts, akin to the power use of a small town. A port facility hosting up to 10 ships could see a total power demand of up to 100MW (source: Loyd's Register). St. Kitts' Port authorities expect that about 350 ships (hosting about 1 million passengers) will set anchor in Basseterre in total between April 24 and April 25.

[14] Desalinization using reverse osmosis is known for high energy and environmental costs, which are estimated at 4.0-4.5 kWh electric energy/m 3 and 0.08-4.3 kg CO_2/m 3 of GHG emission.

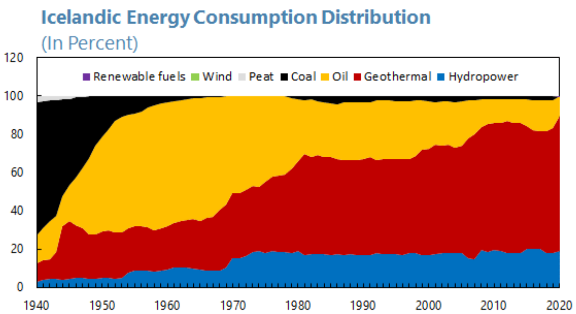
by households and businesses. Electrifying these uses of energy would enable small island economies to use any surplus renewable-generated electricity to further reduce their oil imports. In the case of transport, petrol-powered vehicles can be replaced by electric vehicles (EVs). Policymakers could start by electrifying public vehicles such as buses and could also encourage households to switch to EVs using subsidies, tax breaks, or other incentives such as free charging stations.

Figure 6. St. Kitts and Nevis: Country Case Studies: Iceland and New Zealand

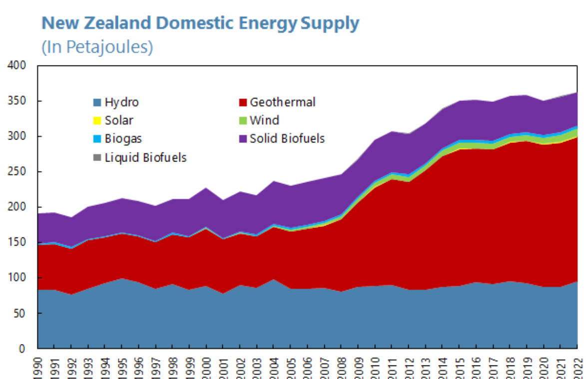
Renewable energy sources have dominated Iceland's energy sector since their transition…



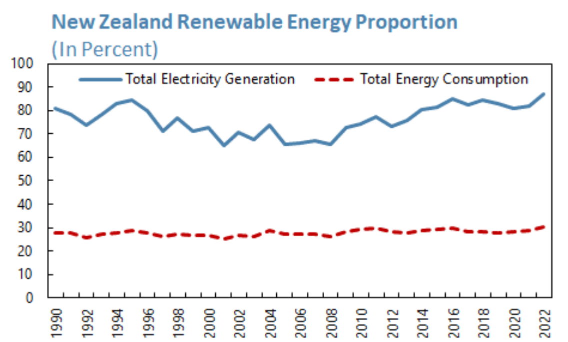
…with oil now representing only a tenth of energy consumption.



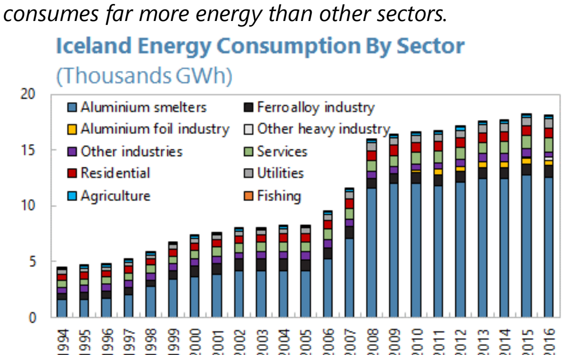
New Zealand has also made great strides in transitioning to renewable energy…



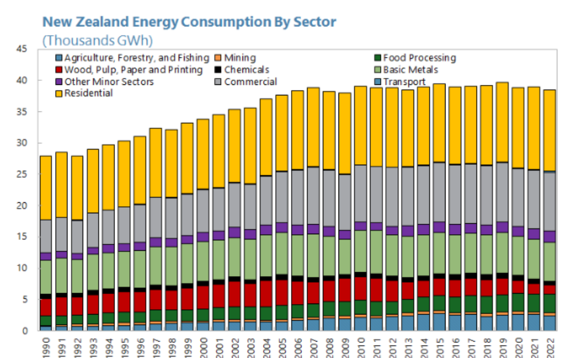
…yet consumption of renewable energy as a proportion of total energy remains low.



The rise in consumption of renewable energy in Iceland is driven by its large aluminum smelting industry, which consumes far more energy than other sectors.



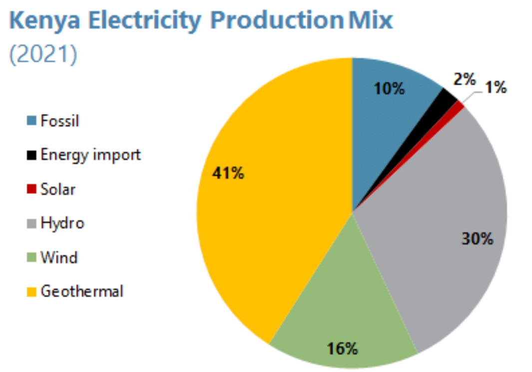
In contrast, New Zealand's energy is mostly consumed by the residential and commercial sector.



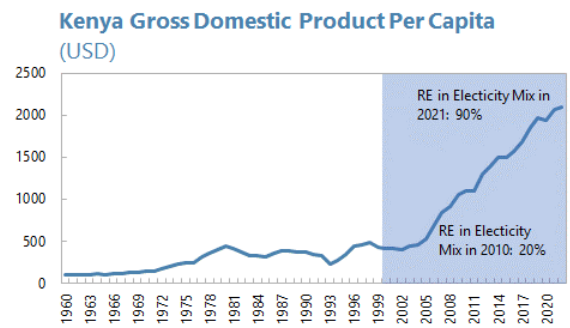
Sources: Orkustofnun; New Zealand Ministry of Business, Innovation & Employment; and IMF staff calculations.

Figure 7. St. Kitts and Nevis: Country Case Studies: Kenya and Uruguay

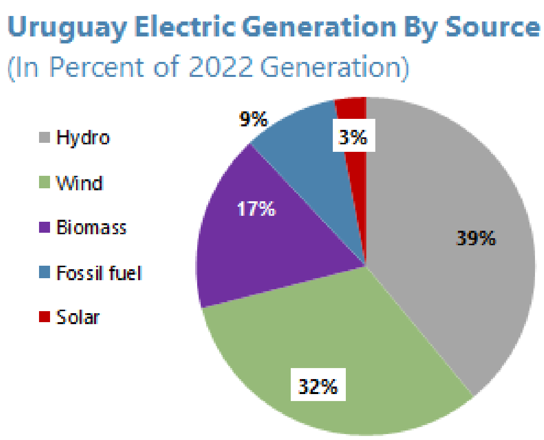
Most of the energy produced in Kenya now comes from renewable sources…



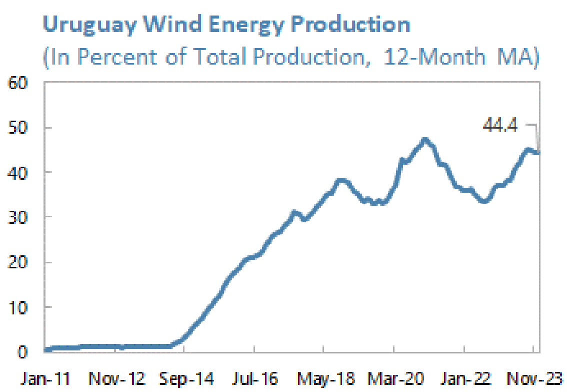
…this transformation has had a large and equitable impact on output in the country.



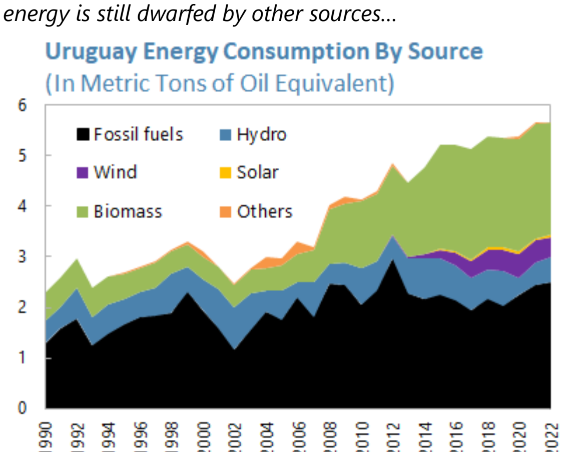
Uruguay also generates a large proportion of renewable energy…



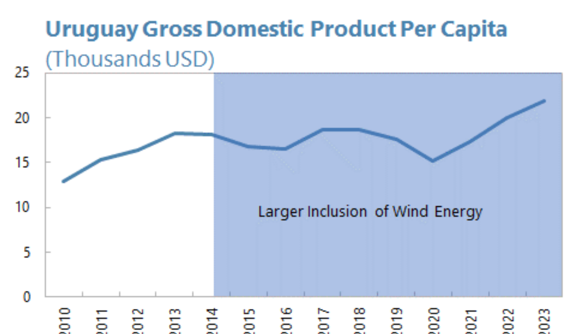
…with wind being a relatively new addition, compared to its longstanding hydropower.



However, Uruguay consumption of hydropower and wind energy is still dwarfed by other sources…



…possibly explaining why an increase in wind energy production has not significantly impacted the economy.



Sources: IEA; Federal Reserve Bank of St. Louis; Ministerio de Industria Energia y Mineria; WEO; and IMF staff calculations.

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Annex I. Estimation Methodology

This annex discusses our methodology for estimating the various channels of renewable energy transition impact.

The Electricity Supply Channel

The growth impact from lower electricity cost is estimated following the growth accounting framework of Hulten (1978). The first-round effect from the productivity of electricity generation to GDP is approximated using d(log *GDP*) ≈ λ_id(log A_i), where $\lambda_i = Y_i/GDP$ is the output-to-GDP ratio of the electricity production industry. The electricity-output-to-GDP ratio is estimated from St. Kitts and Nevis's industry composition from the national accounts data and St. Lucia's Supply-Use Table and obtain a ratio of 1.68 percent.[1] Assuming a 2/3 reduction in the cost of electricity generation, this gives an increase of GDP by 1.1 percent.

The TFP Channel

The TFP channel is estimated using a difference-in-differences (DID) approach. Data on labor productivity and TFP are from Penn World Tables for 116 countries during 2000-2019. Transformational cases are identified as countries that increased their renewable energy generation as a share of total energy generation by 10 percentage points or more over a five-year period using the data on renewable energy generation as a share of total energy generation. For these countries, the transition date is identified as the year when the five-year increase in the share of renewable energy generation first passed 10 percentage point or more. The country's average TFP growth rate five years after the transition is then compared to that five years before the transition. Specifically,

$$dY_{ct}^{5year} = \alpha + \beta Transition_{c,t} + \gamma X_{c,t-4} + \tau_i + \mu_t + \varepsilon_{it},$$

where *c* and *t* denote country and year respectively. The variable of interest is $Transition_{c,t}$ is a dummy variable that takes a value of 1 for the transition year. The dependent variable dY_{ct}^{5year} is the difference in the average annual growth rate in labor productivity or TFP five years after and five years before the transition. $X_{c,t-4}$ is a vector of controls for the country's initial economic conditions before the transition, including the country's real GDP per capita (in PPP term) and the level of labor productivity or TFP. τ_i is country fixed effects. μ_t is year fixed effects. The standard error ε_{it} is clustered by country.

[1] The Supply-Use Table (SUT) of St. Lucia is used because the SUT for St. Kitts and Nevis is not available.

Annex II. Country Case Studies

Box 1. Iceland

Iceland underwent a radical transformation of the energy system. Before the 1970s, its energy consumption primarily relying on fossil fuel and imported oil and coal. Since then, Iceland has become a pioneer in the use of geothermal energy with 100 percent of the electricity production and 100 percent of house heating is provided by domestic, renewable resources from geothermal and hydroelectricity (Figure 6).

The energy transition spurred the growth of various sectors, and the economy has become more diversified. Before the energy transition, Iceland was dominated by fishing and sheep farming. However, now the economy has diversified into new industrial and services sectors, supported by the development of clean and more efficient energy supply.

- *Aluminum smelting.* The aluminum sector is an important segment of Iceland's economy and developed following the growth of renewable energy supply. Aluminium products represent 40 percent of the country good exports. The energy-intensive process of aluminum smelting has benefited from Iceland's abundant, stable, and affordable geothermal and hydropower resources. Aluminum smelter, whose investment accelerated in the 1990s, secured through PPAs agreements low electricity prices that helped them deploy the large investments needed to build smelters[1]. Cheap energy has helped making Aluminium sheets production in Iceland competitive at the global level.
- *Data centers.* Iceland has attracted investment on data centers, which require a stable and abundant power supply, and the island is home to 10 data centers. Energy use by data centers in Iceland has reached 800GWh in 2019 (from 200GWh in 2016), and they contributed to 5.3 percent of the Island GDP in 2023.
- *Aquaculture, fish processing and greenhouse agriculture.* The availability of warm water from geothermal sources has supported the growth of aquaculture and fish processing industries. Geothermally heated greenhouses extend the growing season and help introduce produces that might otherwise be difficult to grow in the country, using electricity to produce light and heat.
- *Renewable energy technology and services*. The country's expertise in renewable energy technologies—such as geothermal exploration, development, and management—has supported the growth and exporting of services related to renewable energy.

[1] "Aluminium in Iceland", Aluminium International Today, Jan/Feb 2017.

Box 2. New Zealand

New Zealand underwent significant expansions in electricity supply from renewable energy sources. As of 2022, 87 percent of the electricity generation are from renewable sources, with about three quarters from geothermal and about one quarter from hydro and solid biofuels sources (Figure 6).

Yet the country's energy consumption still largely relies on non-renewable energy sources. As of 2022, 30 percent of total energy consumption are from renewable sources. The still high reliance on non-renewable source reflects the low electrification in some sectors. For example, petrol and diesel are used in transportation. It also reflects the high cost of electrification in some industrial process. For example, coal and natural gas are used in industrial processes and those requiring high heat may be prohibitively costly to electrify.

While geothermal energy is primarily used for electricity generation, a small fraction of geothermal steam is used for direct heat. These include drying paper or milk in industrial processes, residential or commercial heating. Other use of geothermal sources includes aquaculture and horticulture, with geothermal energy used to heat glasshouses to reduce the production costs for flowers and vegetables.

New Zealand's electricity consumption increases following the expansion of renewable energy supply. Yet the relative share of electricity consumption across sectors remains relatively stable (text chart), in contrast with Iceland, where the energy consumption of industry processes increased substantially because geothermal led to rapid development in the aluminum smelting industry (text chart).

The Iceland and New Zealand cases show that the impact of renewable energy transition on sector development depends on country context. In both countries, abundant, affordable, and clean energy has spurred the development of sectors such as aquaculture, eco-agriculture, and tourism. Yet the two countries differ in the type and extent of industrial processes developed following the transition.

Box 3. Kenya

Geothermal energy has been a game-changer for Kenya's economy. It has resulted significant transformations in the energy sector, boosting productivity, and contributing to economic growth. Kenya's energy mix has undergone a notable transformation with the integration of geothermal energy, while other renewable sources have brought the share of fossil fuel in power generation to 10 percent (Figure 7). Geothermal power has emerged as a key pillar of Kenya's energy sector, alongside hydroelectric power and other renewable sources, and accounts for approximately 30 percent of the country's total electricity generation in 2020.

The shift towards geothermal energy has reduced Kenya's reliance on fossil fuels for electricity generation. By tapping into abundant geothermal resources, Kenya has diversified its energy sources, enhancing energy security and resilience to volatile fuel prices. This transition has reduced GHG emissions but also mitigated the environmental impact associated with fossil fuel combustion, aligning with Kenya's commitment to sustainable development and climate action. The integration of renewable energy has had an important impact on supply chains and productivity across various sectors. Reliable and affordable electricity from geothermal power plants and other renewable sources has bolstered industrial productivity by providing a stable power supply for manufacturing, processing, and other industrial activities. The industrial sector has experienced enhanced operational efficiency and cost savings, leading to increased output and competitiveness.

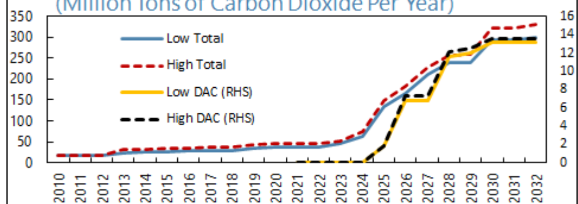
Anecdotal evidence suggests a link between renewable energy adoption and industrial productivity. Industries powered by geothermal energy have reported higher production levels, reduced downtime from power outages, and improved quality control measures. This boost in productivity has cascading effects on employment generation, supply chain efficiency, and overall economic performance, contributing to Kenya's economic growth trajectory. These factors have collectively contributed to an increase in GDP per capita, reflecting the positive impact of renewable energy on income levels and overall economic prosperity. Energy sector reforms and the growth of renewable in the electricity production mix has accompanied a steep increase in GDP per capita growth in Kenya (5 times over in 20 years).

Annex III. Potential for Carbon Capture in St. Kitts and Nevis

Box 1. A Deep Dive into Carbon Capture and Storage

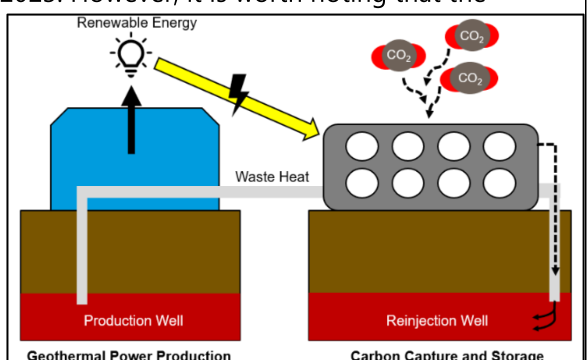
The geothermal and solar power production being developed in St. Kitts and Nevis is estimated to possibly provide more energy than domestic demand can absorb. The increase in available energy makes the implementation of two carbon capture and storage (CCS) methods more economically feasible. The first method of CCS is point source capture (PSC), where CO_2 is separated from the flue gas or other exhaust of industrial production plants. PSC can potentially capture more than 90 percent of CO_2 from hydrogen production plant exhaust steams. The second method of CCS is direct air capture (DAC), where large amounts of air are drawn into filter banks or cooling towers that chemically bind CO_2 to be stored later. The captured CO_2 is compressed and liquefied and transported by pipelines (or truck and railway for small quantities). Finally, the liquid CO_2 is pumped more than a mile underground into suitable geologic formations such as saline or basalt formations, unmineable coal seams, organic shale, and oil and natural gas reservoirs.

Announced Capture Capacity 1/
(Million Tons of Carbon Dioxide Per Year)



Sources: IEA CCUS Projects Database; and IMF staff calculations.
1/ Capture capacity sums only include capture or full chain projects. "Total" series include direct air capture (DAC) and point source capture. Data for 2023 and later based on proects under construction or planeed to be constructed.

St. Kitts and Nevis can use these CCS methods to help reach its climate goal of a 61 percent reduction in total CO_2 emissions (compared to 2010) and allow the country to sell carbon credits. In 2022, St. Kitts and Nevis produced 102.1 percent of the total CO_2 emissions it did in 2010, falling far behind its climate goal. Between the two methods of CCS, DAC has a greater potential in helping St. Kitts and Nevis reach its climate goals. This is because of the country's small industrial base, with manufacturing constituting only 2.9 percent of GDP in 2023. However, it is worth noting that the availability of cheaper energy from renewable sources may lead to an expansion of the country's industrial sector. DAC plants require relatively little area to operate. For example, Iceland's Orca plant covers less than 20,000 sq. ft. and captures up to 4,000 tons of CO_2. They are also compatible with the geothermal infrastructure to be developed in St. Kitts and Nevis. Using geothermal infrastructure to inject captured CO_2 into the geothermal reservoir is estimated to reduce costs by 23 percent on average.



Source: IMF staff.

Instead of helping St. Kitts and Nevis attain its climate goal, the sequestration of CO_2 could rather be sold as carbon credits to firms to lower their net carbon footprint. The sequestration cannot be counted twice for both the country's climate goals and for any carbon credits it sells. The price of these carbon credits ranges from \$600 to \$1000 per tCO_2 when sold through the voluntary carbon market as large subscription packages. For example, Climeworks—owner of Iceland's Orca DAC plant—sold credits to JPMorgan Chase for about \$800 per ton in 2023. This level of pricing is relatively

Box 1. A Deep Dive into Carbon Capture and Storage (concluded)

high and reserved for private, large scale deals involving DAC carbon removal; typical pricing is around $65-110 per tCO_2 on the open market. DAC plants are estimated to sequester CO_2 at $200-$700 per ton including capture, transport, and storage. With the right price, using DAC technology to sell caron credit could be profitable for St. Kitts and Nevis. However, implementation of DAC could be limited by the energy demand of about 1.2 megawatt hours per ton of CO_2 (likely less due to geothermal synergy). Another issue is that DAC projects in the past have been delayed and gone over budget. Despite the costs and issues of implementing DAC, it is 2-3 times cheaper than the abatement of "residual emissions" are uneconomically or technically infeasible to reduce (e.g. biofuel used to reduce air travel's carbon footprint).