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World Future Council

UTS Institute for Sustainable Futures

SCENARIO: 100% RENEWABLE ENERGY IN COSTA RICA

Summary for policy-makers

ABOUT THIS REPORT

This Summary for policy-makers highlights the key findings of a technical study on achieving 100% Renewable Energy in Costa Rica that was conducted by the University of Technology Sydney–Institute for Sustainable Futures, as part of a project led by the World Future Council and La Ruta del Clima to support Costa Rica in achieving its decarbonisation goals. It further distils a number of policy recommendations that flow from the trajectory towards 100%RE as identified by the study. The full technical study as well as the accompanying policy roadmap is available on the World Future Council website (www.worldfuturecouncil.org).

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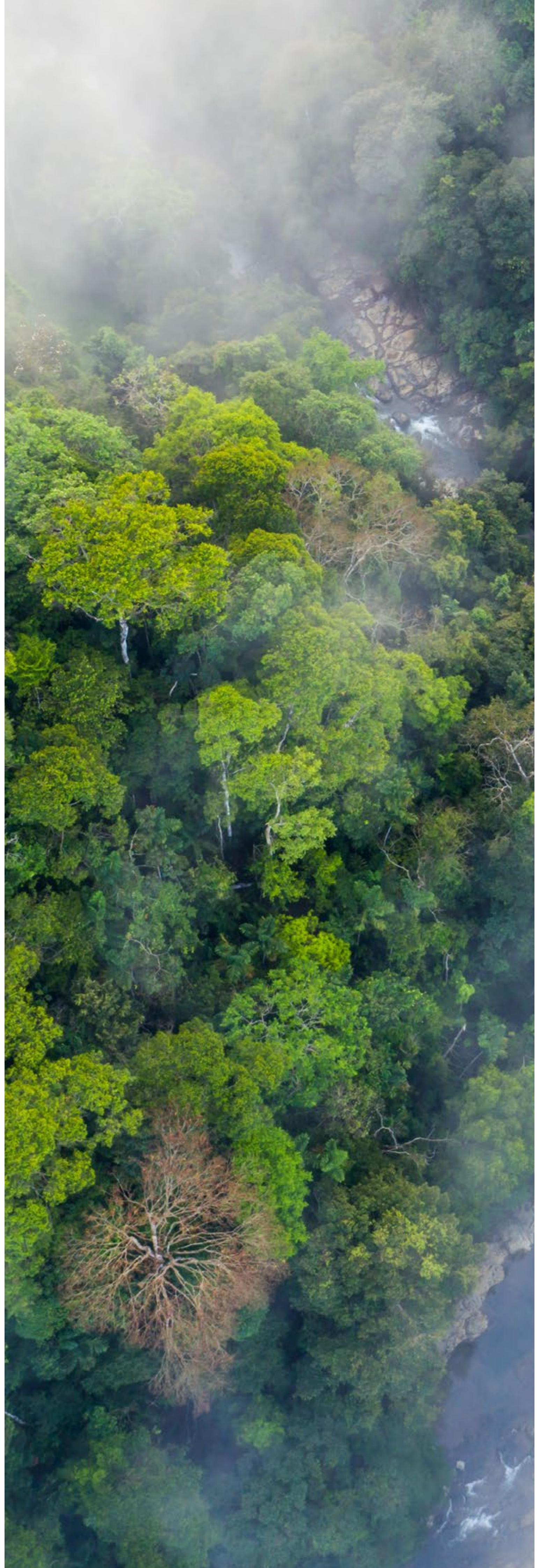
ABOUT THE WORLD FUTURE COUNCIL (WFC):

The WFC works to pass on a healthy planet and fair societies to our children and grandchildren. To achieve this, we focus on identifying and spreading effective, future-just policy solutions and promote their implementation worldwide. The Council consists of 50 eminent global change-makers from governments, parliaments, civil societies, academia, the arts and the business world. Jakob von Uexkull, the Founder of the Alternative Nobel Prize, launched the World Future Council in 2007. We are an independent, non-profit organisation under German law and finance our activities from donations.



SCENARIO: 100% RENEWABLE ENERGY FOR COSTA RICA

Summary for policy-makers

This summary is complementary to the **Policy roadmap for 100% Renewable Energy in Costa Rica – Achieving a fully decarbonised energy system**.

KEY FINDINGS

- **Costa Rica's abundant renewable energy resources can supply all required energy across all sectors,** including the increased electricity demand for electric vehicles. Only 6% of Costa Rica's solar power potential (approx. 196 GW) and 25% of its wind power potential (approx. 15 GW) would suffice to achieve 100%RE. Both energy resources are primarily concentrated in the north-western region of Guanacaste.

- **Solar PV:** The calculated potential for utility-scale solar power plants (PV) under all restrictions is 203,000 MW.[1] In addition, there is potential for distributed generation (rooftop solar PV) in the Greater Metropolitan Area of San José.

- **Wind:** Costa Rica has about 15 GW on-shore wind potential for utility-scale wind farms and an additional 27 GW of off-shore wind potential. Off-shore wind however, has not been considered, due to its proximity to maritime protected areas.

- **Costs:** Both scenarios show that 100%RE can save almost US$1 cent per kWh of power generation costs.

- **Investments & fuel cost savings:** Around US$ 40 billion needs to be invested over the next 30 years in order to achieve 100%RE in Costa Rica (industry, heating, electricity, transport). That is around US$ 10 billion (US$ 333 million/year) more than under current policy projections. Fuel cost savings accumulate to US$ 5.9 billion from 2020-2050. They can therefore finance 47% of additional investments under RE1, and 68% of additional investments under RE2.

- **Transport:** Costa Rica's transport sector can become completely decarbonised by 2050. Electricity and (sustainable) biofuel production will be the main pillars, while hydrogen generated with renewable electricity may be complementary for the transport sector.

- **Heating:** Biomass will remain the main contributor to industrial heating processes, with increasing investment in highly efficient modern biomass technologies and substitution of the remaining fossil fuel consumption by renewable electricity already in 2040.

- **Infrastructure:** To harvest Costa Rica's onshore wind and solar resources, the power grid must be able to transport large loads from the west coast further inland to the load centres of Costa Rica. Decentralized power can shoulder a significant part of the residential sector demand.

- **Storage:** Under all scenarios, the share of variable generation will not exceed 30% by 2030 in any region, except in Guanacaste, where the share will already be around 80% as it has the largest PV and wind potential. To avoid curtailment about 4,200 MW storage are required in RE1 by 2050 and 10,000 MW in RE2.

1 The restrictions are: land use (restricted by nature conservation, agricultural, commercial, or urban use); maximum 10km from existing transmission lines and contiguous areas (fractured areas of less than 1 km^2 are excluded); only on land with a slope of less than 30% angle (non-mountainous areas).

INTRODUCTION

Costa Rica is a global leader when it comes to ensuring electricity production comes from renewable energy sources. With a 98% share of renewables in its electricity matrix and solid achievements to prevent deforestation—around 25% of the country's land area is in protected National Parks and other protected areas—Costa Rica is at the forefront of environmental sustainability, climate action and driving the renewable energy transition.

Wanting to go even further, Costa Rica has adopted the *National Decarbonization Plan* in February 2019 to achieve a net zero emissions economy by 2050, in line with the objectives of the Paris Climate Change Agreement. The planned measures, activities and improvements also form part of the country's updated Nationally Determined Contributions (NDCs) that Costa Rica will present in 2020 to the UNFCCC, and demonstrate and strengthen its commitment to reduce greenhouse gas emissions and participate in the global effort to avoid a temperature rise above 1.5 degrees Celsius with respect to the pre-industrial era.

As the Costa Rican President, Carlos Alvarado Quesada, noted during the launch of the Plan, "Decarbonisation is the great challenge of our generation and Costa Rica must be among the first countries to achieve it, if not the first."

The biggest challenge will be to increase the share of renewables in energy consumption. More than 60% of energy consumption in the country is from petroleum derivatives. 64% of Costa Rica's emissions come from energy use, and more than two thirds of that is from transport. A critical part will thus be to decarbonise the transport sector. The growing demand for personal vehicles, the majority of which run on petrol, is keeping a high share of fossil fuels in the country's energy consumption. The Decarbonization Plan aims to have 70 percent of public transport powered by electricity in 2035—and 85% by 2050.

Another goal for Costa Rica is to diversify its electricity mix, in order to reduce dependencies on hydropower during increasingly strong dry seasons.

This study aims to complement these efforts and show pathways to 100%RE in order to meet the decarbonisation challenge.

SCOPE OF THE STUDY AND METHODOLOGY

The World Future Council commissioned this report financed by the Leonardo DiCaprio Foundation[2] to provide input into Costa Rica's plan to achieve 100% renewable energy and decarbonize its economy.

The research was led by the University of Technology Sydney–Institute for Sustainable Futures (UTS-ISF). This report provides a technical and economic analysis of long-term energy and power development plans for Costa Rica. The analysis is based on the [R]E24/7 energy access pathway methodology developed by the Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) and is based on the long-term energy scenario model of the Institute for Thermodynamics of German Aero Space Centre (DLR), energy models developed for various UTS-ISF surveys, and the [R]E 24/7 model.

The partner organisation in Costa Rica for this project was La Ruta del Clima.

The long-term scenario—LT [R]E 24/7—has been used to re-model the Plan de Expansión de La Generación Eléctrica (GEP 2019) which was published in May 2019. The REFERENCE scenario is consistent with the GEP 2019. In addition, the study modelled two alternative renewable energy scenarios: RENEWABLES 1 and RENEWABLES 2. This model takes into account all sectors (power, heat, and transport) and includes cost and energy-related CO_2 calculations.

The [R]E 24/7 power sector analysis tool computes the annual demand for up to five different years (here 2020, 2030, 2040, and 2050) and the load curves for a full year (8760 h). The hourly load curves are required for the simulation of the demand and supply for each of the seven regions of Costa Rica. The results are the development of loads, generation mix, and storage demand.

2 In July 2019, the Leonardo DiCaprio Foundation (LDF) merged under Earth Alliance, which consists of LDF, the Emerson Collective and Global Wildlife Conservation.

ASSUMPTIONS FOR SCENARIO DEVELOPMENT

The scenario-building process for all scenarios includes assumptions about policy stability, the role of future energy utilities, centralized fossil-fuel-based power generation, population and GDP, firm capacity, and future costs.

- **Policy stability:** This research assumes that Costa Rica will establish a secure and stable framework for the deployment of renewable power generation. In essence, financing a gas power plant or a wind farm is quite similar. In both scenarios, a power purchase agreement, which ensures a relatively stable price for a specific quantity of electricity, is required to finance the project. Daily spot market prices for electricity and/or renewable energy or carbon are insufficient for long-term investment decisions for any kind of power plant with a technical lifetime of 20 years or longer. In short, the better the investment certainty, the lower the cost of capital.

- **Strengthened energy efficiency policies:** Existing policy settings (i.e., the energy efficiency standards for electrical applications, buildings, and vehicles) must be strengthened to maximize the cost-efficient use of renewable energy and achieve high energy productivity by 2030.

- **Role of future energy utilities:** With the 'grid parity' of rooftop solar photovoltaics below most current retail tariffs, this modelling assumes that energy utilities of the future will take up the challenge of increased local generation and develop new business models that focus on energy services, rather than simply on selling kilowatt-hours.

- **Population and GDP:** All three scenarios are based on the same population and GDP assumptions.

- **Cost assumptions:** The same cost assumptions are used across all three scenarios. Because technology costs decline as the scale of deployment increases rather than with time, the renewable energy cost reduction potential in both RENEWABLES scenarios may be even larger than in the REFERENCE scenario because of the larger market sizes. The reverse is true for the fuel cost assumptions because all the scenarios are based on the same fossil fuel price projections, but whereas both RENEWABLES scenarios have a significant drop in demand, the REFERENCE scenario assumes an increased demand (due to private transport), which may lead to higher fuel costs. Therefore, these costs should be considered conservative.

ASSUMPTIONS FOR RE1

The RENEWABLES 1 scenario (RE1) is designed to meet Costa Rica's energy-related targets and to lead towards a pathway of 100% renewable energy by 2050. Diesel power plants will be phased-out by 2025 and replaced by renewables in this scenario. Both the heating and the transport will start to replace fossil fuels with electricity where it is economically possible. Thermal renewables for heating mainly solar and bio energy based generation replace fossil fuels. Energy efficiency and renewable energy generation technologies follow moderate implementation growth rates during the first decade until 2030. Electric mobility grows steadily over the entire modelling period (until 2050) and replaces combustion engines entirely by 2050. The RENEWABLES 1 case aims to remain at today's energy related CO_2 emission level despite economic and population growth for the entire energy sector and decarbonize the power sector between 2020 and 2025.

ASSUMPTIONS FOR RE2

The RENEWABLES 2 scenario (RE2) is more ambitious than the RENEWABLES 1 case, but follows the same technology pathways. The decarbonisation of the transport sector will be achieved by 2050, leading to a higher electric demand as in the RE1 case. Energy efficiency plays an accelerate role and leads to a 15% lower final energy demand compared to RE1. The RENEWABLES 2 case has the target to decarbonize Costa Rica's energy sector entirely by 2050.

We only use validated data for our 100% RE scenarios. Therefore, we are facilitating in-depth dialogues with key stakeholders from national and local governments, utilities, parliament, businesses and civil society.

STUDY FINDINGS

Costa Rica's Renewable Energy Mix

Costa Rica is among a handful of countries that is running on 100% renewable electricity for most of the year. In fact, 2018 was the fourth year in a row that Costa Rica generated more than 98% of its electricity from renewable sources. Costa Rica has so far primarily used hydropower for electricity generation—it made up 72% in 2017/18—and the country is close to maximizing its potential. Biomass and geothermal resources are utilized both in the heating and power sector. In order to reduce dependencies on hydropower during increasingly strong dry seasons, the country has started to diversify its electricity mix. In 2018, wind power made up 15% of the electricity mix, up from 4% in 2011.

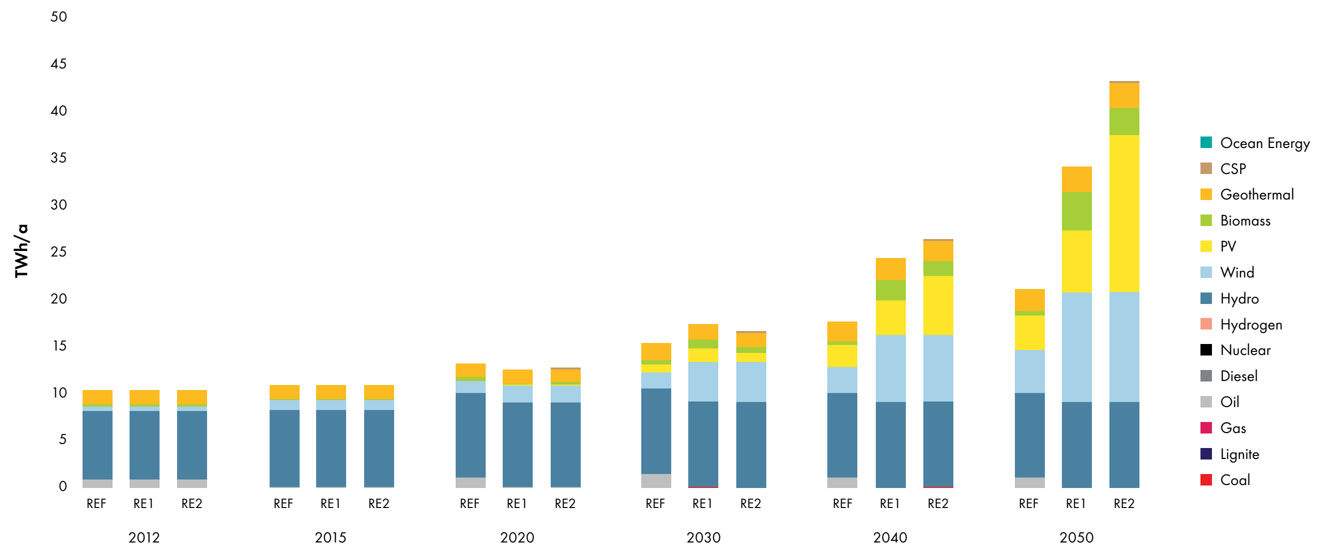
Costa Rica's current plans for future development of the power capacities would maintain a share of over 90% renewable electricity. Under those projections, it would be hard for the system to meet the additional power demand of the transport sector in case of a shift to electric mobility. Therefore, the transport sector could increasingly be dependent on imported oil while carbon emissions would continue to rise even with a decarbonised power sector. The current installed power plant capacity stands at 3.5 GW, with a majority coming from hydro power (2.4 GW).

The RENEWABLES scenarios aim to reduce the fossil fuel consumption as fast as is technically and economically possible and leverages Costa Rica's largely untapped potential for expanding generation of renewable energy sources, other than hydropower and geothermal. Under

TABLE 1:
PROJECTIONS OF RENEWABLE ELECTRICITY GENERATION CAPACITY

In MW		2015	2020	2030	2040	2050
Hydro	REF	1,935	2,356	2,375	2,375	2,375
	RE1	1,935	2,342	2,401	2,401	2,401
	RE2	1,935	2,342	2,401	2,401	2,401
Biomass	REF	40	82	85	86	104
	RE1	40	43	167	403	793
	RE2	40	48	120	285	555
Wind	REF	396	408	490	810	1,318
	RE1	396	737	1,552	2,527	4,115
	RE2	396	737	1,552	2,527	4,116
Geothermal	REF	208	262	322	375	415
	RE1	208	262	322	336	385
	RE2	208	262	322	336	385
PV	REF	3	28	585	1,517	2,472
	RE1	3	35	1,093	2,770	5,080
	RE2	3	56	741	4,762	12,857
Total	REF	2,682	3,123	3,858	5,165	6,684
	RE1	2,681	3,347	5,437	8,417	12,774
	RE2	2,681	3,384	5,038	10,290	20,313

FIGURE 1:
BREAKDOWN OF ELECTRICITY GENERATION BY TECHNOLOGY



the scenarios in the study, wind power (onshore) and solar photovoltaic power are expected to be the main pillars of the future power supply, complemented by contributions from bio-energy and geothermal power plants. The solar photovoltaic figures combine both (distributed generation) rooftop and utility-scale photovoltaic plants. The potential for offshore wind is significantly lower than that for onshore wind, therefore wind power generation under both RENEWABLES scenarios will concentrate on onshore wind. The scenarios recognise that diversity is required to keep storage demand low and security of supply high, and thus utilizes all renewable power technologies. Hydropower is expected to remain an important pillar of Costa Rica's power supply but its capacity will grow slowly and within economic and ecological limits. The same would apply to the expansion of biomass. The supply from all bio-energy facilities supported by sustainable biofuels and hydrogen is a key issue and may come from either within Costa Rica or from certified imports.

The scenarios further project the rapid introduction of very efficient vehicles to the transport sector to replace oil-based combustion engines. This will lead to an overall renewable primary energy share of 61% in 2030 and 78% in 2050 in the RE1 scenario and 100% in 2050 in the RE2 scenario.

The distributions are based on the regional solar and wind potentials and the regional demand, and aim to generate electricity where the demand is located. Whereas solar photovoltaic power generation is modular and can be installed close to the consumer or even integrated into buildings, onshore wind must be kept at a distance from settlements. Therefore, onshore wind must be clustered into wind farms with double digit megawatt capacities.

Both RENEWABLES scenarios aim for an even distribution of variable power plant capacities across all regions of Costa Rica by distributing the utility-scale solar photovoltaic accordingly. However, Guanacaste is Costa Rica's only region with significant wind resources, which requires both a significant increase in transmission capacity to connect this region with all other regions in Costa Rica, as well as higher storage capacities than in other parts of the country. By 2030, variable power generation will reach 15%–20% in all regions while dispatch generation under both RENEWABLES scenarios will remain at around 70%. The only exception is Guanacaste that will reach around 80% variable power generation by 2030 and which requires grid expansion and enforcement.

Solar

Costa Rica has tremendous potential for solar PV. When restricted by its proximity to power lines and terrain slope (no higher than 30%)[3], Costa Rica has over 8,000 km2 of land on which 200 GW of solar power can potentially be harvested by utility-scale solar farms. To avoid conflicts with national parks and other competing uses of land, only perennial cropland and open bush land were included in the analysis. Only utility-scale solar energy has been included in the analysis. The additional rooftop potential has not been done but it's clear that the Greater Metropolitan Area (GAM) (San José in particular) have potential for rooftop solar.

Solar photovoltaic is surprisingly underutilized compared to the available solar resource and the low generation costs. This is due to unfavourable policy in regard to grid connection, feed-in rates and construction permits. Solar PV is the key new and additional renewable energy technology for Costa Rica but an improvement of legislation for grid connection and installation is required to achieve those market volumes.

3 The restrictions are: land use (restricted by nature conservation, agricultural, commercial, or urban use); maximum 10km from existing transmission lines and contiguous areas (fractured areas of less than 1 km2 are excluded); only on land with a slope of less than 30% angle (non-mountainous areas).

Wind

Currently, Costa Rica's total installed wind power capacity is about 408 MW of onshore wind farms.

Taking into account restrictions related to nature conservation, agricultural, commercial or urban use of land, mountain areas and designating only land areas (at least 10km) away from transmission lines, there is still around 15 GW of onshore wind potential in Costa Rica.

Almost all wind farms would be located in Guanacaste, the province with the most favourable wind conditions. Equally, the majority of storage facilities will be required in Guanacaste because this region has Costa Rica's largest wind resources and a significant proportion of the wind generation is concentrated here. Off-shore wind has not been considered in this study, due to conflicts with maritime protection areas.

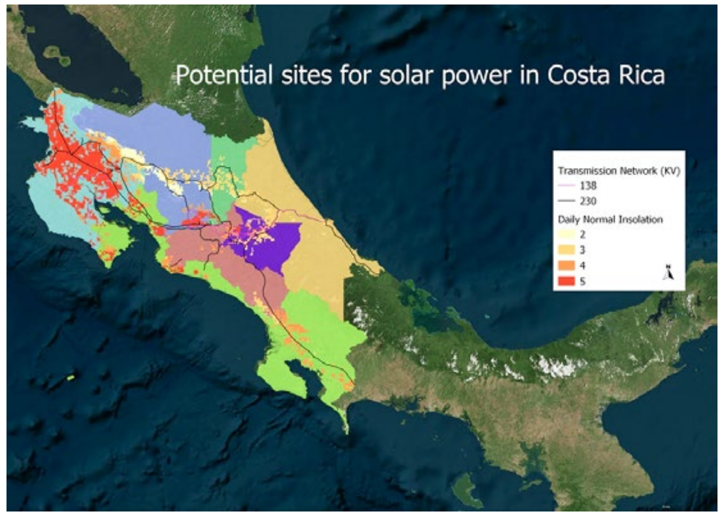


FIGURE 2:
POTENTIAL FOR UTILITY SCALE SOLAR ENERGY GENERATION IN COSTA RICA

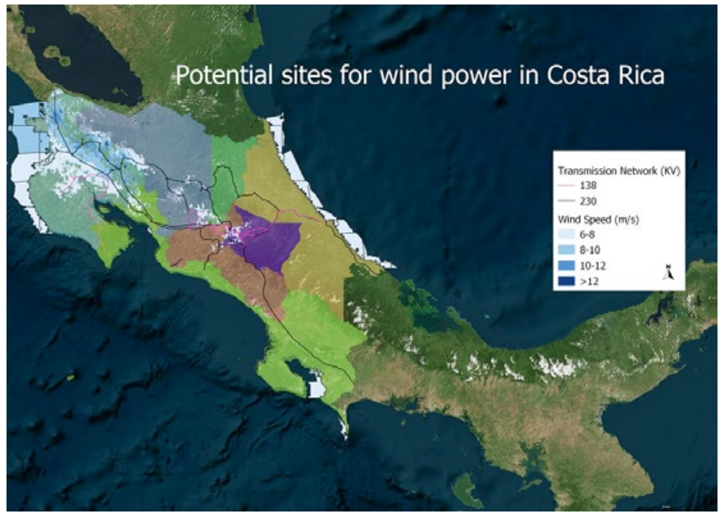


FIGURE 3:
ON- AND OFFSHORE WIND ENERGY GENERATION POTENTIAL IN COSTA RICA

Hydro

The installed capacity of hydro power has dominated as a major renewable power capacity in Costa Rica in the last decades—it made up 72% of electricity generation in 2017/18. Hydro power has only minor potential for further increase because Costa Rica's utilization rate for hydro power plants is already close to the maximum level in regard to sustainability. Under both scenarios, hydro will be taken over by solar photovoltaics in 2040, while it stays at around 2,400 MW capacity.

Biomass

Today, renewables meet around 60% of Costa Rica's energy demand for heating, with the main contribution coming from biomass. Different studies put the sustainable use of biomass potential in Costa Rica at different levels—between 580 MW and 2,530 MW. The scenarios reveal that biomass will remain the main contributor for heating (mainly industrial heating), requiring increasing investment (of around US$ 3.6-3.75 billion) in highly efficient modern biomass technologies. In the scenarios, biomass will make account for 9,537 MW (RE1) and 6,706 MW (RE2), respectively, for heating by 2050 (see table 2).

Geothermal

Under the scenarios, geothermal power will play an important role in heating and cooling, requiring investments in geothermal heat pump technologies. Geothermal capacity is estimated at 385 MW by 2050 under both scenarios for electricity generation capacity and at 990 MW for renewable heat generation. Considering the market for geothermal technologies is relatively small, installation costs are high.

Costs

Under the REFERENCE scenario, power generation costs will remain around US$ cent 6.0 per kWh until 2030 and decrease slightly to US$ cent 5.3 per kWh by 2050. The RE1 scenario will lead to slightly lower average generation costs of US$ cent 5.4 per kWh by 2030 and US$ cent 5.1 per kWh by 2050. The most favourable results in 2050 will be in the RE2 scenario, in which the shares of solar photovoltaic and wind power are high, with lower requirements for fuel and lower capital costs for installation. However, until 2030 costs are identical to RE1. Generation costs start to turn out lower by 2040, and by 2050 the RE2 leads to US$ cent 4.5 per kWh, almost US$ cent 1 below the REFERENCE case.

TABLE 2:
INSTALLED CAPACITIES FOR RENEWABLE HEAT GENERATION

in MW		2020	2030	2040	2050
Biomass	REF	3,528	4,578	5,580	6,868
	RE 1	3,602	5,751	10,319	9,537
	RE 2	3,503	5,276	8,748	6,706
Geothermal	REF	46	114	138	159
	RE 1	46	135	603	990
	RE 2	46	135	603	990
Solar heating	REF	0	144	161	183
	RE 1	78	638	2,378	4,106
	RE 2	77	637	2,377	4,104
Heat pumps	REF	11	32	50	88
	RE 1	11	275	1,236	2,476
	RE 2	11	492	1,714	3,506
Total	REF	3,585	4,868	5,929	7,298
	RE 1	3,737	6,799	14,536	17,109
	RE 2	3,637	6,540	13,442	15,306

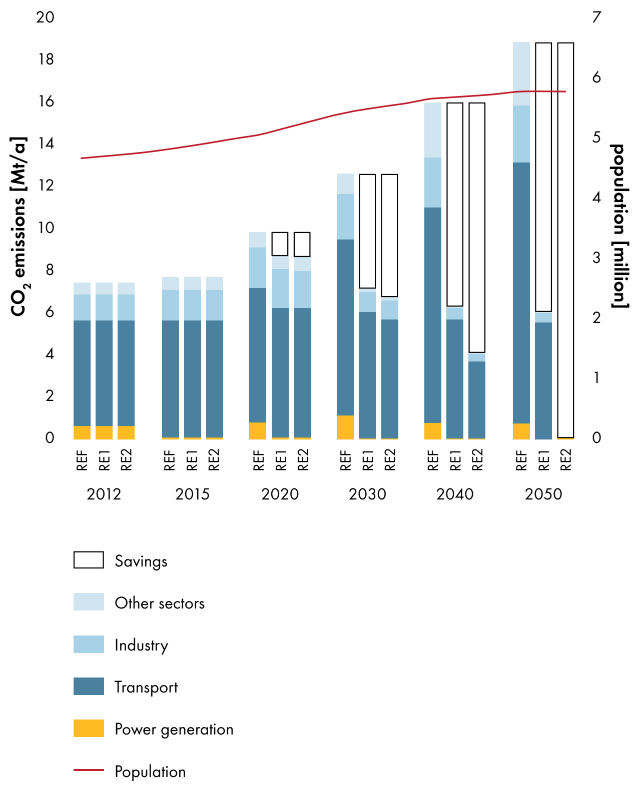
CO_2 Emissions

Costa Rica's energy-related CO_2 emissions will increase from 7.6 million tons to 12.5 million tons between 2015 and 2030 and reach 18.8 million tons CO_2 in 2050 under the REF scenario (see figure 4).[4] Energy related carbon emission will also increase under the RE1 scenario to 7.2 million tons CO_2 by 2030, but decrease afterwards to 6 million tons CO_2 by 2050, only one third of the emission of the REF case.

Over 90% of total energy related carbon emission in the RE1 case are from the transport sector and efficiency gains and the increased use of renewable electricity in vehicles will keep emission stable on current levels while the demand continued to increase. The transport sector will remain the largest source of emissions in 2050 under the RE1 scenario, with a 91% share of CO_2 generation.

The RE2 scenario will decarbonize the power and industry sectors by 2030, whereas the transport sector will remain responsible for 5.7 million tons of CO_2 by 2030, due to vehicles with combustion engines. The transport sector will become zero emissions by 2050 under RE2. Between 2020 and 2030, the RE2 scenario will reduce energy-related CO_2 emissions by 38 million tons of CO_2, whereas RE1 will save cumulative carbon emissions equivalent to 35 million tons.

FIGURE 4:
DEVELOPMENT OF CO_2 EMISSIONS BY SECTOR UNDER THE SCENARIOS



4 The base scenario referenced in the Decarbonization Plan estimates 16.26 million tons CO_2 by 2050. The difference is likely due to the base scenario using slightly higher efficiency in the average combustion engine. Costa Rica's Biennial Update Report (BUR) of December 2019 estimates just under 17 million tons of CO_2 by 2050. The REF scenario used in the study used the average values for the OECD region.

TECHNICAL AND FINANCIAL REQUIREMENTS

Infrastructure

To harvest Costa Rica's onshore wind and solar resources, as well as geothermal and bio energy potential, the power grid must be able to transport large loads from the west coast further inland, whereas decentralized power will shoulder a significant part of the residential sector demand. Onshore wind requires transmission lines to the load centres of Costa Rica. Both renewable scenarios will result in a high proportion of variable power generation (photovoltaics and wind): 33%–31% by 2030 and 54%–66% by 2050. Therefore, smart grids, demand- side management, energy storage capacities, and other options must be expanded to increase the flexibility of the power system to ensure grid integration, load balancing, and a secure supply of electricity.

Storage

In all scenarios, the share of variable generation will not exceed 30% by 2030 in all regions, except in one—Guanacaste—where the share will already be around 80% because of the concentration of on-shore wind generation. Thus, the majority of storage facilities will be required in Guanacaste (e.g. lithium batteries, utility-scale storage).

For the whole of Costa Rica, the required estimated storage capacity under the RE1 scenario will be 1.0% of the total variable generation in 2050, and 3.5% under the RE2 scenario. 4,200 MW storage is required in RE1 by 2050 and 10,000 MW in RE2.

Table 3 shows the storage and dispatch requirements to avoid curtailment under both the RENEWABLES and REFERENCE scenarios. The table identifies the capacity (= storage volume) in gigawatt hours (GWh/a) per year and the required annual through-put capacity of the storage system. It also shows the installed capacity required to avoid curtailment, in terms of the load in gigawatts (GW).

Transport

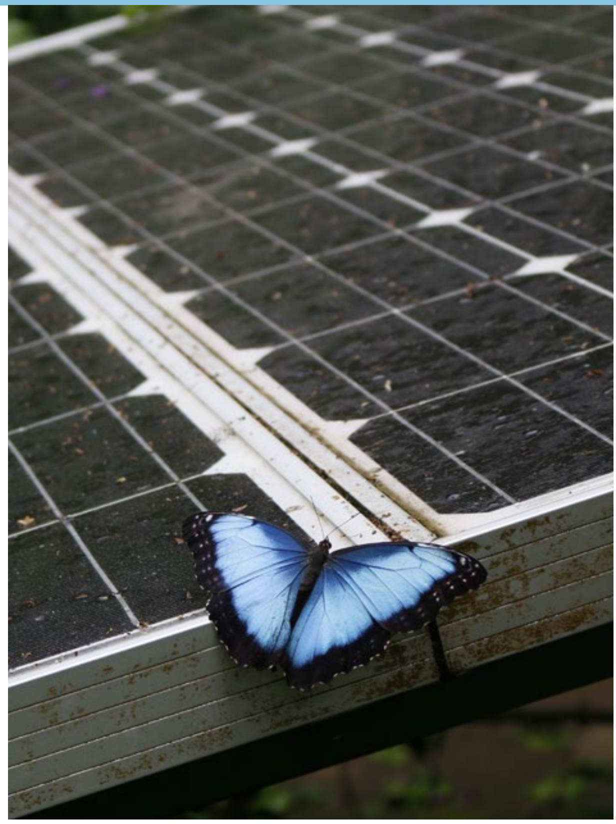
To avoid increases in—mainly oil-based—transport energy beyond 2025, the alternative scenarios implement a number of measures. It is vital to shift to efficient transport modes, such as electric buses and freight vehicles, especially in the expanding large metropolitan areas. Together with rising prices for fossil fuels, these changes will slow down the increase of car sales projected under all scenarios. However, the energy demand from the transport sector is expected to increase under the REF scenario at around 130 PJ/a by 2030 and a further increase afterwards to 160 PJ/a in 2050. In the RE1 scenario, efficiency measures and modal shifts will save 12% of the energy demand (13 PJ/a) by 2030 and 35% (60 PJ/a) by 2050 relative to the REF scenario. The RE2 scenario will completely decarbonise the sector by 2050. The use of carbon sinks and international emissions markets would not be required.

Additional modal shifts and technology switches will lead to even higher energy savings in the RE2 scenario of 58% (100 PJ/a) in 2050 compared to the REF scenario. Highly efficient propulsion technology with hybrid, plug-in hybrid, and battery-electricity-powered trains will bring large efficiency gains. By 2030, electricity will provide 11% of the transport sector's total energy demand in the RE1 scenario, whereas in 2050, the share will be 33% (RE1) and 78% under the RE2 case. Hydrogen and other synthetic fuels generated with renewable electricity may be complementary for the transport sector, but have not been taken into account in the scenarios.

Renewable energy sources will then go on to produce electricity without any further fuel costs beyond 2050, whereas the costs for oil (imports) will continue to be a burden on the economy.

TABLE 3: ESTIMATED ELECTRICITY STORAGE REQUIREMENTS FOR BOTH RENEWABLES SCENARIOS

Storage requirement to avoid curtailment		RE1		RE2	
		Total storage throughput	Storage capacity (1)	Total storage throughput	Storage capacity (1)
Costa Rica		[GWh/a]	[GW/a]	[GWh/a]	[GW/a]
Alajuela	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	7.261	0.006	140.446	0.117
Cartago	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	0.000	0.000	80.407	0.067
Guanacaste	2020	0.000	0.000	0.000	0.000
	2030	10.666	0.009	11.088	0.009
	2050	43.639	0.036	51.491	0.043
Heredia	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	9.997	0.008	78.406	0.065
Limon	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	1.384	0.001	71.035	0.059
Puntarenas	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	12.572	0.010	81.067	0.068
San Jose	2020	0.000	0.000	0.000	0.000
	2030	0.000	0.000	0.000	0.000
	2050	1.025	0.001	215.837	0.180
Total	2020	0.000	0.000	0.000	0.000
	2030	10.666	0.009	11.088	0.009
	2050	75.878	0.063	718.690	0.599



Costa Rica is a sustainability champion. Around a quarter of the country's land area is protected and the country is home to 6% of the world's biodiversity.

Investments

INVESTMENT IN THE POWER SECTOR

Around US$7.35 billion will be required in investment in the power sector between 2020 and 2030 for both RENEWABLES scenarios to become reality, US$1.8 billion more than in the REFERENCE scenario. The REFERENCE case requires annual investments of US$550 million while both RENEWABLES case lead to around US$700—the resulting additional annual investments between 2020 and 2030 are thus US$150 million. Under all scenarios, investments in fossil power generation is minor.

For the whole modelling period until 2050, the REFERENCE and the RENEWABLES 1 case have similar investment needs of US$30 billion over 30 years. The RENEWABLES 2 scenario requires higher investments—a total of US$40 billion over the same period of time, due to higher electricity needs as a result of the electrification of the transport sector. The additional investments in power plants are already reflected in the average generation costs (see previous section).

SAVINGS

In the long term, until 2050, the fuel cost savings in the RE1 scenario will reach a total of US$5.3 billion up to 2050, or US$180 million per year. The fuel cost savings in the power sector under the RE2 scenario will be similar to RE1, but will save additional fuel costs in the transport sector. Comparing this with electricity generation costs at around US$700 million, the full decarbonisation of the transport sector can result in fuel cost savings of up to US$1.5 billion by 2050. Renewable energy sources will then go on to produce electricity without any further fuel costs beyond 2050, whereas the costs for oil (imports) will continue to be a burden on the economy.

INVESTMENT IN HEATING

Both RENEWABLES scenarios will require a major revision of current investment strategies in heating technologies. In particular, solar thermal and geothermal heat pump technologies will require significant increases in installations if their potentials are to be tapped for the—mainly industrial—heating sector. The use of biomass especially for industrial heat demand will be substantial as well.

Renewable heating technologies are extremely variable, from unglazed solar collectors to very sophisticated enhanced geothermal and solar systems. The investment volumes in all three scenarios will be significantly different: the REF case requires US$2 billion, the RE1 and RE2 both US$5 billion. The large differences are due to a total system change of the heating generation. In the long term, until 2050, cost projections can only be quantitative estimates. The RENEWABLES scenarios will require around US$16.5 billion in total to be invested in renewable heating technologies up to 2050 (including investments in replacements after the economic lifetimes of the plants), or approximately US$550 million per year.

POLICY RECOMMENDATIONS

1 Set a 100% Renewable Energy target for both energy production and consumption and embed it across all sectors of the economy

Formulating a target that is time-bound and measurable, as well as detailed in scope and reflected in high-level political obligations, is essential to increase the confidence required by utilities and private and public investors to make large-scale and long-term investments, such as in transmission and distribution grids. By increasing investment certainty, ambitious targets can also attract domestic and international investors, ultimately making it easier to achieve the target. Experiences from the European Union have shown that targets can help to raise awareness amongst citizens and thus build support among citizens and businesses.

2 Prioritize solar PV and onshore wind development

In order to meet future energy demand through 100%RE, Costa Rica will need to diversify its electricity matrix, thereby keeping storage demand low and security of supply high, while reducing dependencies on hydropower, which is vulnerable to increasingly strong dry seasons. The study further highlights the significant potential for distributed rooftop solar PV in the Greater Metropolitan Area of San José (GAM). The potential can be unlocked by the introduction of a Feed-in tariff scheme allows end-users to also produce energy and sell this for a fixed price for every kwH produced for a fixed period.

3 Introduce a Feed-in Tariff scheme

A feed-in tariff should be introduced to incentivise the development of a decentralised energy system. Such a FiT can play an important role for solar home systems in and around San José by making people not just consumers, but also producers of energy. Typically, FiTs grant priority access to the power grid and guarantees energy producers a fixed price for ever kilowatt hour produced for a fixed period (typically 20 years). The fixed price usually decreases over time, to ensure technical innovation. This fixed price should be high enough to ensure a return on investment. The fixed price and exact period of the tariff should be differentiated by types of energy source, size of plant as well as years of operationalising the project. The extra costs resulting from a FiT are usually shared among all energy users via a small surcharge on energy bills.

4 Enhance storage capacities

Given that Guanacaste will produce more energy than it consumes, storage capacities should be enhanced. To do so, storage options need to become economical viable for energy producers and households. This could be done by mandating that a certain amount of the return of the FiT is being re-invested into storage capacities. Equally, the introduction of a subsidisation scheme where households, hotels and industry either receive a re-payable loan or other forms of financial incentives from the government to strengthen storage capacities is possible.

5 Pursue energy efficiency measures in tandem with deployment of RE

Existing policies on energy efficiency standards for electrical applications, buildings and vehicles, must be strengthened to maximize the cost-efficient use of renewable energy and achieve high energy productivity. Efficiency savings in the transport sector will result from fleet penetration by new highly efficient vehicles, including electric vehicles, and changes in mobility. Significant energy efficiency gains can also be achieved through increased efficiency measures in process heat for industries, notably through waste heat utilisation technologies.

6 Electrify the transport sector to achieve complete decarbonisation

Introduction of efficient e-cars which can be charged either at charging stations or at home by using rooftop-solar systems is a must. Likewise, swift introduction of fleet vehicles for public transportation is necessary: existing train lines, in addition to the planned line around San José, should be revived to connect the GAM to the coasts. Existing plans should be expanded to include more rural areas of Costa Rica. This should be complemented by a drastically improved bus system: single sign-on rides, low fares to increase attractiveness, and a common framework for bus operators to increase frequency and reduce delays.

7 Ensure biofuel production within environmentally sustainable limits

Biofuels will be necessary to decarbonise the transport sector. Nevertheless, the production from biofuels from fuel-crops such as sugar cane should be ensured to be environmentally sustainable. In other words, monocultures should be avoided at any circumstances. Rather, completion by hydrogen and syn-fuels should be considered.

8 Increase sector coupling

Increased sector-coupling between industry, transport and heating should be considered to increase efficiency of renewable energy capacities. Power utilities can encourage this in order to manage demand-side management possibilities and maximise the cross-benefits of integrating higher shares of RE. As most industrial processes take place in the GAM where also most (public) transport will be, this becomes even more crucial in that area.

9 Explore financing mechanisms for RE development and other decarbonisation measures

To scale up RE deployment, scale-up of both public and private funding is essential. Cash flow certainty is critical for renewable energy projects to manage risks and facilitate investments. To increase the number of bankable projects and decrease (perceived) risks associated with RE projects, the Central Bank of Costa Rica can take on a stronger role in providing risk free financing and increased private capital through cooperation with multilateral banks such as the Central American Bank for Economic Integration[5].

5 For more information, please see the World Future Council's publication "Unlocking the trillions to finance the 1.5°C limit", available here: https://www.worldfuturecouncil.org/unlocking-the-trillions/.

GOVERNANCE RECOMMENDATIONS

1 Engage stakeholders from all sectors in the energy field

In order to achieve 100% RE and the complete decarbonisation of the economy, as well ensure that the benefits of this process are distributed fairly across different sectors and regions in the country, different stakeholders and segments of society need to be engaged. Further, specific open-access and inclusive policies should be implemented, as these engage citizens and communities, offer targeted incentives, and create long-term investment certainty for citizens, communities, local businesses and international investors.

2 Develop a policy framework for capacity building

Implementing a 100% RE strategy requires effective awareness raising among all sectors of society and education of citizens, legislators/parliamentarians and government officials. First, strengthening and expanding curricula and vocational training in schools (promotion of apprenticeship schemes), universities and other learning institutions on the technical, financial and policy implications of the decarbonisation process helps develop the necessary workforce. This should also include retraining those who will lose the jobs they had in the old energy system. Second, citizens' awareness should be strengthened through reports and campaigns involving the public sector, private sector and non-governmental groups on the socio-economic benefits of RE.

3 Integrate renewable energy into urban and spatial planning

The largest part of Costa Rica's industrial activity takes place in the greater metropolitan region around San José. It is also the most densely populated area in the country. Therefore, urban and spatial planning play an important role in Costa Rica's energy system. Urban policy-makers need to coordinate both horizontally across municipal departments and local stakeholders, as well as vertically across multiple levels of governance towards a common goal of 100% RE. Urban planning thus requires priority areas, which in the case of Costa Rica should be to decarbonise the GAM with a special focus on transport, industry and residential areas, whilst increasing resilience of the energy system. A working group should be established with urban planners with expertise in each of these areas, citizens, government institutions (MINAE, MOPT, SEPSE), local government authorities, local energy providers and ICE to guarantee a holistic policy framework.

4 Integrate renewable energy into rural development policies

Economic activity is concentrated in and around San José. To strengthen local economies in rural regions of Costa Rica, it is necessary to unleash the transformative power of renewable energy. In fact, the OECD found that regions with successful RE integration often link it with rural development policies. Further, these policies are driven by local needs and policies, rather than national policies. Promoting distributed energy systems in rural areas thus tends to improve local socio-economic conditions and can revitalise communities left behind. Eventually, an energy system should be created which re-invests returns into encouraging innovative business models, especially for SMEs, and improved infrastructure and education. This could include innovation of disruptive new technologies which are cross-cutting in nature, such as sensor-based systems for monitoring crops, soil, fields and livestock or enhance digital traceability of product chains.

5 Strengthen decentralisation and political decision-making of local governments

To unleash the full transformative potential of renewable energy, local governments and communities need to participate to make sure measures are tailored to local needs. Further, actor diversification in the energy system can increase resilience thereof by reducing need for grid extension by prioritising energy consumption close to production. The law regulating private concessions thus needs to be updated. Spatial planning should further consider specific economic activities of each sector and place particular emphasis on equal opportunities for both rural and urban population within a region. Costa Rica's local governments enjoy comparatively little decision-making power which is in part due to financial constraints. Flexible financing solutions are therefore crucial for building a distributed, local energy system. Pay-as-you go schemes, which allow for modular instalment of RE technologies, could be considered and promoted as a Public-Private-Partnership between the government and technology-providing businesses. In addition, RE installations could be subsidised through repayable grants which could be paid for through energy bills within a certain time-frame or through low-interest and long-term loans.

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