



# Costa Rica: **Energy Matrix**

A Sustainable Model, Unique in the World



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Energy Matrix

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# A Worldwide Recognized Model

Since the middle of the last century, Costa Rica explores its renewable sources in a planned and balanced way; it is possible thanks to a diverse, sustainable, optimized and economical matrix. This matrix guarantees the energy supply thanks to the participation of the public and the private sector.

Costa Rican model, unique in the world, has allowed 99.4% electric coverage of the country's households with excellent quality and 95% generation from renewable sources.

Indeed, Costa Rica exhibits an exceptional matrix based on clean resources: hydric, geothermal, wind, solar and biomass, together with a minimal portion that comes from thermal generation. The latter source works as installed capacity backup.

All these renewable sources, except for geothermal energy, depend on climate.

Hydropower is seasonal dependent; during the dry season, the river flow reduces below average, and during the rainy season the opposite happens.

Wind is also seasonal. During the dry months, the speed increases and it does production, and it reduces during the rainy season.

The biomass harvest also depends on climate. Solar energy is variable and is produced only half of the day. Thanks to this farsighted schema, ICE's National Power Model has been worldwide recognized during the last years.

This document includes a description of our model, its history, challenges, transformations and milestones from 1949 to the present.



# Quality, Renewable and Solidary Electricity Since 1949

- The Costa Rican Institute of Electricity (ICE) enhances and strengthens a model based on sustainability, equal access, and national safety together with environment friendly natural resources exploitation.

Nowadays, Costa Rica is powered through a unique and interconnected system managed exclusively by ICE.

This grid covers 99.4% of the country, the second with the highest penetration in Latin America.

Under this structure, it bases its generation mainly on these five renewable sources in production level order: water, Earth's heat, wind, solar, and biomass. As a complementary and backup source, there is hydrocarbon.

The demand in the country rounded the 11 334 GWh in 2019 mainly in the Metropolitan Area (GAM), the service is provided with the same robustness and quality that the one provided to the rest of Costa Rica.

## Electric Park



These are the five biggest hydroelectric facilities that include a water reservoir; Arenal (Guanacaste and Alajuela), Cachí (Cartago), Angostura (Cartago), and Pirrís (San José) and Reventazón (Limón).

The one based on Earth heat is located at the Alfredo Mainieri Protti Geothermic Camp (previously named Miravalles) and at the Las Pailas Geothermic Plant in Guanacaste.

In fact, expertise and knowledge in geothermal energy lead ICE to consider its Generation Expansion Plant by developing the Borinquen Project in Guanacaste in 2026-2030: two plants that will total an installed capacity of 55 MW.





📍 Pirris Hydroelectric Plant.

The wind plants (the ones managed by ICE and by the private sector) are located on the mountaintops of Guanacaste and Zona de Los Santos.

### The solar energy production has three strands

- The first one is the power incorporated to the national grid by ICE from its plant in Miravalles (Guanacaste).
- The second one is the distributed generation; this modality allows people to produce their own power and pump the surplus into the grid.
- The third one is the electrification of indigenous zones, or wireless energy because of specific conditions.

The biomass (from sugarcane waste) is located at the northwest part of Costa Rica and is bounded to sugar refineries.

### Mixed System

- The major part of the energy comes from the projects created and developed by ICE since its foundation on April 8th, 1949.
- According to the Laws from 1990 and 1995, ICE must buy 15% to 30% of the energy for the country from private companies.
- Those associates (cooperatives, investors or individuals) must produce energy from renewable sources.



# A path marked by water energy

**San José** is one of the first cities in the world to light up its streets with electric power. Two engineers installed 25 street lamps powered by a hydropower plant.

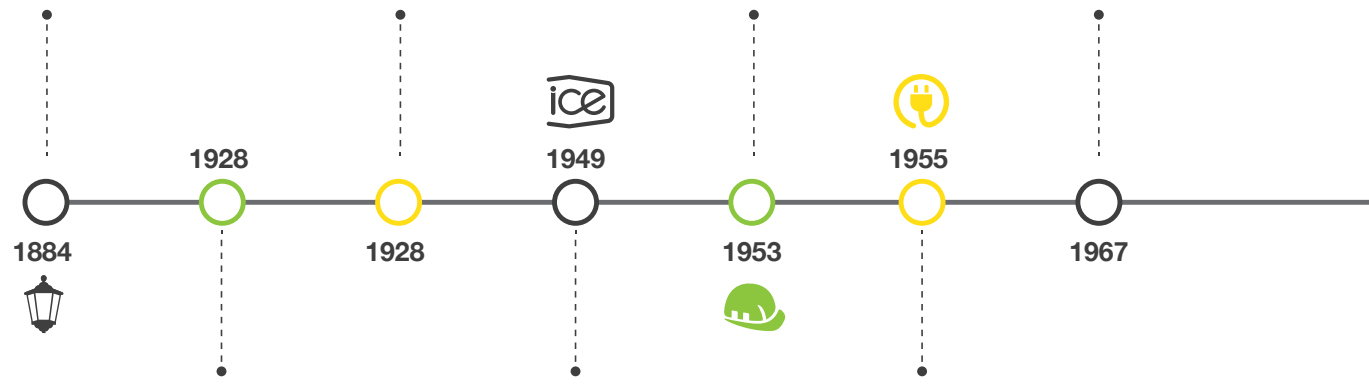
The **National Service of Electricity** is created by Act 77. This institution was in charge of nationalizing the hydroelectric sources. However, its participation was truncated because of the Great Depression in 1929, and the subsequent recession.



Beginning of the **La Garita Hydropower Plant's** construction, this is the first structural project from ICE, funded by the National Bank System and ICE's own financial resources. It is inaugurated in May, 1958 with an installed capacity of 30 MW.



Finishes the construction of **Cachi Plant**; this was the biggest hydropower project in the country in more than a decade.



**Starts the organized struggle** to nationalize the hydropower sources. The "Liga Cívica" (Costa Rican Social Movement) encourages citizen and politician movements to create rules for this service. At that time, the country did not have a vision of energy, and its security on this field was in danger because of the lack of legislation.

**ICE is born** on April 8th by Act 449. Its main job is *"to rationally develop the sources that produce physical energy..., mainly hydraulic resources, in the country... for the purpose of strengthening the national economy and maximize well-being for the people in Costa Rica"*.

Implementation of the **National Plan of Electrification 1955-1965**. The purpose of this plan was to integrate and potentiate the development of a unique and efficient system for the country.



Throughout this decade, the **Central Arenal**, base of the national generation, is built. This visionary project implied the unification of a natural lake with an artificial lake, the replacement of two towns, and the construction of several reservoirs.

By Law, ICE must buy 15% of the energy production in the country to private generators (producers) in the structure called "Parallel generation".

A Law Reform to buy electricity from private entities is approved. Another 15% is added to the original; from this moment and on, the maximum amount will be 30% of the national production.



1968



1970

1979



1990



1994



1995



2000



Nationalization of CNFL. ICE acquires this company and continues the electrification of the Costa Rican Metropolitan Area (GAM).

Arenal starts working and pushes the expansion of the national grid; it becomes the ICE's biggest project that year. Electricity is delivered to more places in the country stimulating development on the surrounding areas.

The first phase of **Miravalles Geothermic Project** starts operations. In this way, ICE incorporates its second source of renewable energy to the matrix and diversification begins.

After three weeks during which the social sectors in Costa Rica protested, the Government decides to withdraw the Bill called **"Combo Energético"** from the National Assembly. This Bill had the purpose of opening the energy market and therefore, a complete change in ICE's mission and structure.





ICE counts **75 days** of non-hydrocarbon energy production. This fact becomes news all around the world. Besides that, ICE signs two agreements to sell advisory services in terms of geothermic energy to Bolivia and hydric energy to El Salvador.

In January, President Solís signed the **Ley de Incentivos y promoción para el transporte eléctrico** (Act for Incentives and Promotion for Electric Transportation). ICE and CNFL participate actively in the Wording of the Act as technical advisors.

In order to reduce **75% of carbon emissions** and promote the transport sector's decarbonization, in December, ICE acquires 100 electric vehicles.



2002

2015

2016

2018

2020

Inauguration of **Tejona Wind Plant** in September. 30 Turbines started working since January. This is the third source of renewable energy that ICE added to its grid.



Costa Rica inaugurates the **Reventazón Hydropower Plant** in Siquirres with a generation capacity of 305.5 MW; this plant can supply power for 525,000 Costa Rican households.

ICE provides power service for **94.4%** of households, businesses, and industries in the country. This numbers are huge if we compare them with the average 14% percent coverage in 1949.

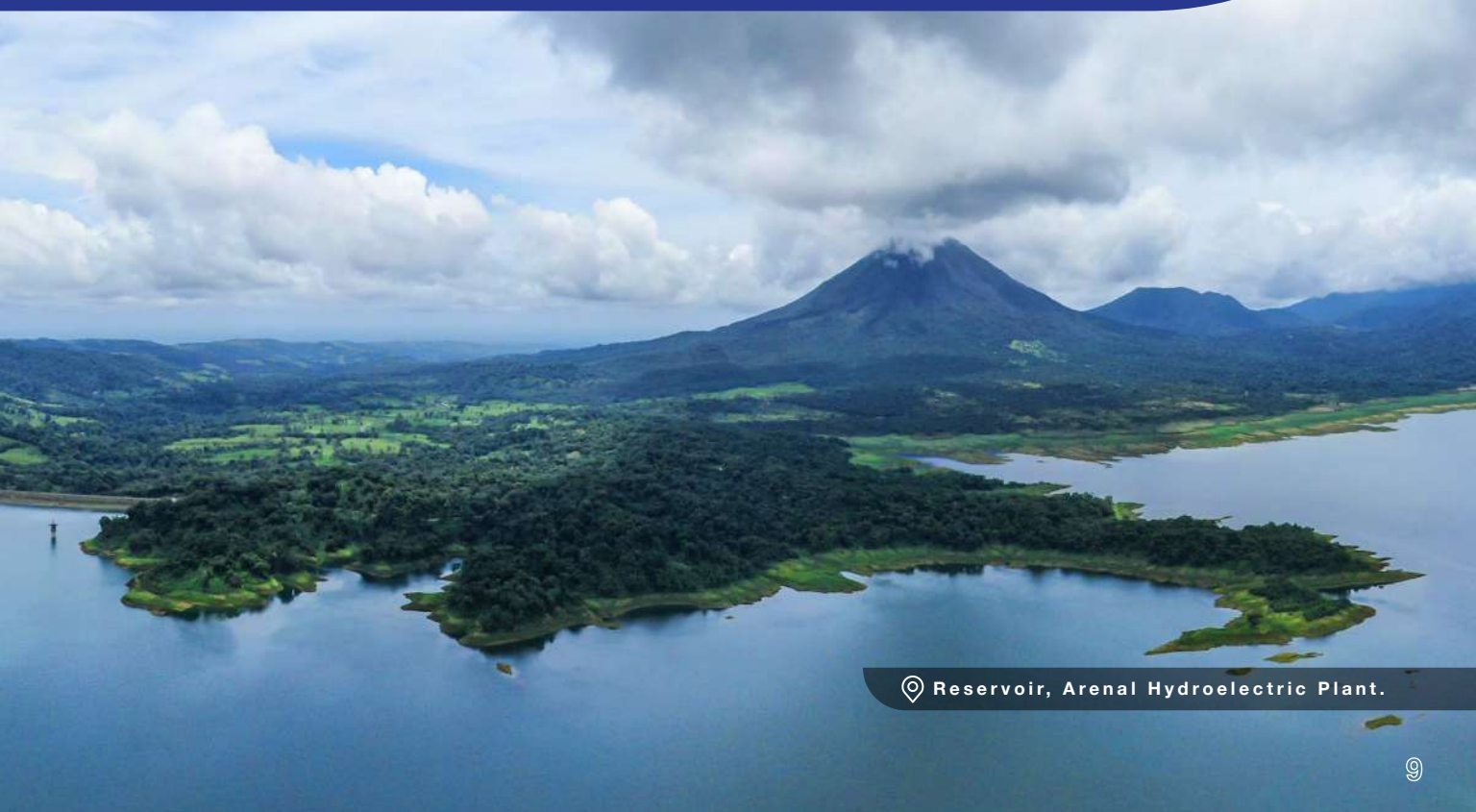






# A Diverse Matrix

- ICE's production focuses on hydropic, geothermic, wind, solar, and biomass resources. The hydrocarbon works as a complement and "backup" since every renewable source, except for Earth heat, depends on climate.



📍 Reservoir, Arenal Hydroelectric Plant.



The Energy Matrix is the total percentage of all natural resources from which energy is derived and then transformed into electricity to supply households, business and industries.

In Costa Rica, ICE is in charge of managing and controlling this matrix through its National Control Center (CENCE) and the National Electric System (SEN). These entities enable ICE to preserve quality and to monitor and guarantee power security in the Costa Rican territory.

### Renew and Preserve

The Costa Rican electric matrix is based –according to the Law that created ICE and the ones that added private generation- on responsible exploitation of the natural resources in the country.

Thanks to its geographic and topographic location, Costa Rica initially focused the production on its more abundant resource: water.

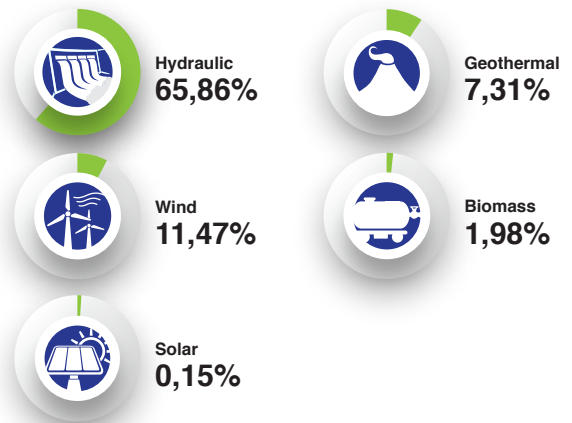
Throughout the years and with the technological advances-always focusing on preservation- during the decade of the 90s, the Earth heat was incorporated, through geothermal camps close to the northeast volcanos.

In the two recent decades, ICE promoted the use of wind, with the participation of the private capital; more recently, ICE uses solar energy and biomass energy (from sugar cane waste)

## Our Installed Capacity

The power generation plants in Costa Rica can jointly produce 3.5 million kW. This is the average composition of the Costa Rican matrix:

### Renewable:



### Non-renewable

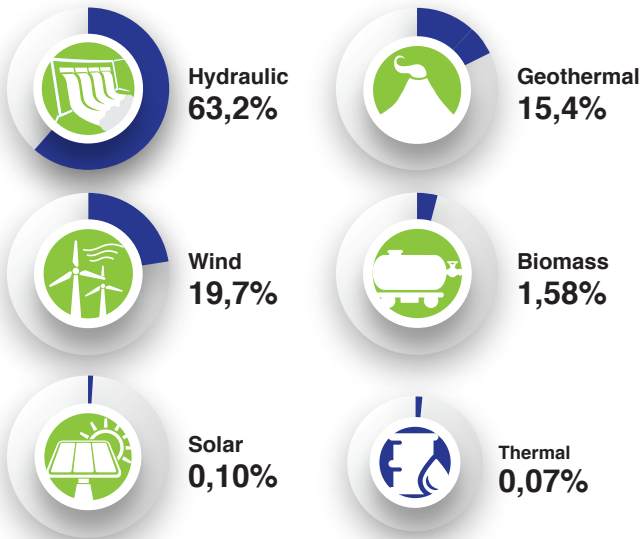


Source: CENCE, January 2020



# Power Generation during 2020

This year, ICE has only generated 0.07% of its electrical energy from thermal sources. The average composition this year has been\*:



(\*) Average as of February 2020.

(\*\*) Energy production nationwide (including what is generated to sell in the MER). Does not consider imports.

## Backup Source

Under this preservation vision, the hydrocarbon functions as a complementary and contingency element, this because all the other sources, except for the geothermal, are climate depending.

In other words, when the combination of all the main sources is not enough to sustain the need of energy in the country, it is necessary to produce thermal energy burning fuels, mainly fossils.

**Costa Rica possesses the cleanest and the better-quality power matrix in Latin America. In 2020, 99,93% of the power production in the country comes from renewable sources.**



# National Electrical Park with 444 Installed Units

- It is the sum of hydroelectric, geothermal, wind, solar, and biomass plants in the whole territory. It includes the private participation and the concessions that ICE will recover in an agreed period.

Where is the energy that we are consuming right now being produced?

In the whole national grid

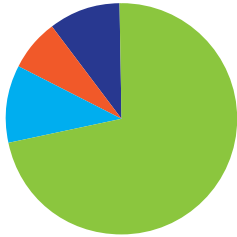
This is the most accurate answer to describe the National Electric System (SEN).

The energy produced in Guanacaste can be used in Puntarenas or Limón, in other words, the unique interconnection guarantees quality and supply at any place in the country.

The national electrical park is made of 444 generator installed units of a different value (every turbine, rotor, or transformer that is in a plant). For a better appreciation they can be divided according to the resource they used to work.

## Installed Capacity 2020

Producer	% participation*
ICE	74,13%
Utilities**	11,01%
Private	7,18%
BOT***	7,68%



(\* ) The percentage of participation does not correspond to the number of installed units.

(\*\* ) CNFL, ESPH, JASEC and cooperatives.

(\*\*\* ) Modality "key in hand" build-operate-transfer. The agreement according to law, establishes that the private operator is in charge of the project, its exploitation and delivery to ICE.

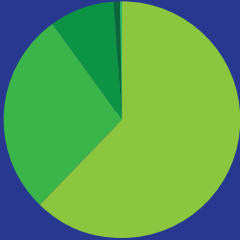




# In which resource condenses each producer its quota (installed capacity)?

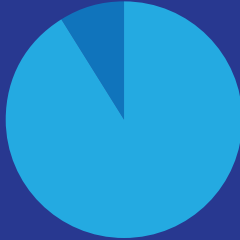
## ICE %

● Water	69,09%
● Thermal	19,45%
● Geothermal	10,74%
● Wind	0,68%
● Solar	0,05%



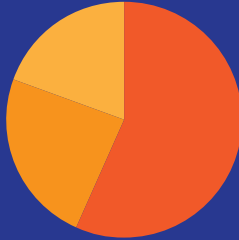
## Utilities %

● Water	85,46%
● Wind	13,52%
● Solar	1,02%



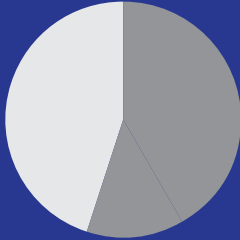
## Private %

● Water	29,59%
● Wind	50,59%
● Biomass	19,82%



## BOT%

● Water	56,65%
● Wind	43,35%



Source: CENCE, January 2020

The Act 7200 rules that, either under the private generator modality or under the BOT (Built, Operate, and Transfer to ICE) model, private companies must “exploit” only renewable sources.

Central Valley Wind Park.



# Certified Power

- By 2020, 26 electricity generation plants of the Costa Rican Institute of Electricity, ICE, have international certifications in quality, environment, and health and occupational safety.

Solidary, planet friendly and with the highest technical level. These virtues have been certified under international standards.

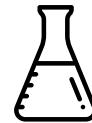
The energy produced in the country-and that is delivered to the citizens, traders, and industries-meets the first world standard; "it is a steady, safe and confident flow, not only for the people that participate in the generation process but also for customers and the environment".

It is set up in the ISO and OHSAS certifications, handled by Negocio de Generación Eléctrica (Power Generation Business) from ICE and validated by the Colombian Institute of Technical Standards and Certification (ICONTEC), since 2009.

## These are the certifications:



Health and Occupational Safety:  
**OHSAS 18001**



Laboratory Accreditation:  
**ISO 17025**



Quality:  
**ISO 9001**



Environment:  
**ISO 14001**





# Plants Certified by ICE

These are the certified plants:

- |                      |                      |
|----------------------|----------------------|
| 1. Arenal            | 14. Orotina          |
| 2. Dengo             | 15. Toro I           |
| 3. Sandillal         | 16. Toro II          |
| 4. Tejona            | 17. Toro III         |
| 5. Pailas I          | 18. Cariblanco       |
| 6. Miravalles I y II | 19. Peñas Blancas    |
| 7. Miravalles III    | 20. Guápiles         |
| 8. Miravalles V      | 21. Moín             |
| 9. Boca Pozo         | 22. Río Macho        |
| 10. Garita –Ventanas | 23. Cachí            |
| 11. Echandi          | 24. Angostura        |
| 12. Pirrís           | 25. Reventazón       |
| 13. Garabito         | 26. Miravalles Solar |

Source: Electricity Management, 2020.

(\*) Note: The CNFL has triple certification in its plants.

The Compañía Nacional de Fuerza y Luz (ICE's Metropolitan Area Electric Company) possesses ten generation plants that produce renewable and certified energy.



## Hydropower

- |                     |                |
|---------------------|----------------|
| 1. Balsa Inferior   | 6. El Encanto  |
| 2. Belén            | 7. Electriona  |
| 3. Brasil           | 8. Río Segundo |
| 4. Cote             | 9. Ventanas    |
| 5. Daniel Gutiérrez |                |



## Wind

- |                          |
|--------------------------|
| 10. Eólica Valle Central |
|--------------------------|



Pirrís Hydroelectric Plant.

# Water: Vital, the Heart of the Grid

- The power accumulated in water is the main source of electricity supply in Costa Rica (65.86% of the grid). Because of its capacity of sustaining high power, it is the irreplaceable renewable source in the national matrix.

The kinetic energy of the bodies of water is “key” to help Costa Ricans to carry out their work from lighting a bulb, power hospitals, study centers and industries, or just charge their cell phones batteries.

It was also foundation for ICE to begin thinking of and develop amazing projects of energy infrastructure; in that way, ICE accomplished the legal mandate of providing electricity to the national territory.

## How it works?

There are two main factors to produce energy from water: its volume and its fall. In other words, the gravity force takes a great volume of the liquid to an engine room through what engineers call a “penstock”

Once there, the high-speed water flow moves the huge turbines. These turbines generate electricity. It is then transformed and routed to the national grid.

There are two types of hydroelectric plants, according to their dam: the run-of –the- river plants, and the pumped-storage plants. The first ones do not accumulate water, the others do, and those are the ones used to support high generation projects like it is Reventazón.

**The ICE’s five great reservoirs: Arenal, Cachí, Pirrís, La Angostura, and Reventazón are the “batteries” that accumulate for weeks, months, and years the water that will become electricity.**





## Main Reservoirs

- Reventazón
- Complejo Arenal
- Angostura
- Cachí
- Cariblanco
- Garita I, II, III y IV
- Los Lotes
- Peñas Blancas
- Pirrís
- Puerto Escondido
- Río Macho
- Sandillal
- Toro I, II y III

## Participation on the Installation\*

- ICE: 72,74%
- Utilities: 15,79%
- Private: 6,42%
- BOT: 5,05%





# Wind: An Ideal Complement

- Costa Rica doubled its wind power thanks to the construction of new projects, mainly private ones. In this way, the production reached 11.5% of the matrix.

The electricity generated in the turbines moved by the wind continue increasing since ICE first incursion- in the Northwest part of the country, during the 1990s. Today, it is an essential component of the national matrix.

This is one of the simplest and oldest ways to appreciate how a natural resource is channeled with the minimal impact in the environment. Even though it is a climate dependent source, the location and topography of the country guarantee a substantial contribution to the national grid.

## How it works?

- The wind in the surface of the atmosphere increases as it rises. That is why the wind turbines are located on top of the mountains where the kinetic energy of the flow increases and can be used more efficiently.

- The blades turn and transmit power to the generating unit, connected to some accumulators that transform and incorporate the energy to the national grid.


**The biggest production of wind energy is between December and March. This period corresponds to the dry season when the rivers flow diminishes.**



## Wind Boom

- ICE operates Tejona Wind Plant in Tilarán , Guanacaste (2002)
- CNFL (An ICE's company) generates using Valle Cantral Wind Plant (2012)
- By 2020, Costa Rica totals 18 wind plants; 16 of them are located in Guanacaste.
- In 1996, Costa Rica became the first country in Latin America that used wind to generate electricity.



 Central Valley Wind Park.



# Geothermal: ICE Pioneer, the Soundest

- The heat from beneath the Earth's surface -close to the volcanoes in the country- is the third source in participation on the national electric matrix (7.31%). Costa Rica has researched and exploited it for almost 40 years. Today, Costa Rica exports its knowledge.

Unlike the rest of renewable energies, which direct or indirect origin is solar radiation, geothermal is produced based on the heat that Earth transmits from its internal layers up to the surface; it is not climate dependent.

This source is located inside Earth in a form of heat; is bounded to volcanoes, thermal waters, fumaroles, and geysers.

Even though it is a huge quantity of energy, only a small portion can be used.

## How it works?

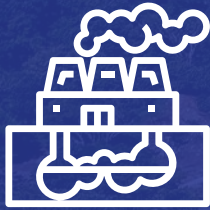
Wells are excavated to extract the steam from the bodies of water that pass above magma. This gas elevates and moves the turbines producing electric energy. The residual material will be re-injected in Earth.

People use geothermal resources in three ways:

- 1 **Electricity:** In fields that overcome 150°C
- 2 **Thermal applications in industry, services and homes:** When the temperature is close and under 100°C
- 3 Air conditioning and hot water: If the resources go under 25°C.

**Costa Rica signed an agreement with Bolivia in 2015 to advise the Andean country in the development of its geothermal plants.**





### Main plants

- Alfredo Mainieri Protti Geothermal Camp (Miravalles I, II, III y V).
- Las Pailas Geothermal Camp (I y II).
- Boca del Pozo

**ICE produces 100% of the geothermal energy in the country.**



Las Pailas II Geothermal Plant.





# Biomass: for self- consumption

- Biomass energy comes from organic waste; it can be agricultural or domestic. In Costa Rica, the main resource is the sugar cane bagasse generated by the cane refineries in Guanacaste.

ICE's work is to provide counseling and technical-environmental support to help those refineries process the sugar cane waste to produce electricity. This energy can be used by them or been added to the national grid. In this way, a big proportion of industry waste is transformed into energy.

It is a low-cost mechanism and it is complementary in the matrix during the dry season. Harvest season corresponds with the time when the hydric sources diminish.

ICE also promotes biogas generation among national producers.

Today, reuse of organic waste rounds 71 MW, which correspond to 1.98% of the grid.

## Main Projects

- Taboga Sugar Refinery
- El Viejo Sugar Refinery

Today, the participation in the generation of electricity from sugarcane bagasse is 100% private.





# Solar: Energy for All

- ICE has incorporated solar energy to its rural electrification program and at isolated places, like the indigenous zones, to guarantee access to the grid for the Costa Rican people. From 1998 to 2020, have been installed 4907 photovoltaic systems.

Even though solar power has the lowest portion in the matrix, it has opened new access opportunities for the population in special need (no access to the wired network) and the ones who want to produce self-consumption energy (distributed generation)

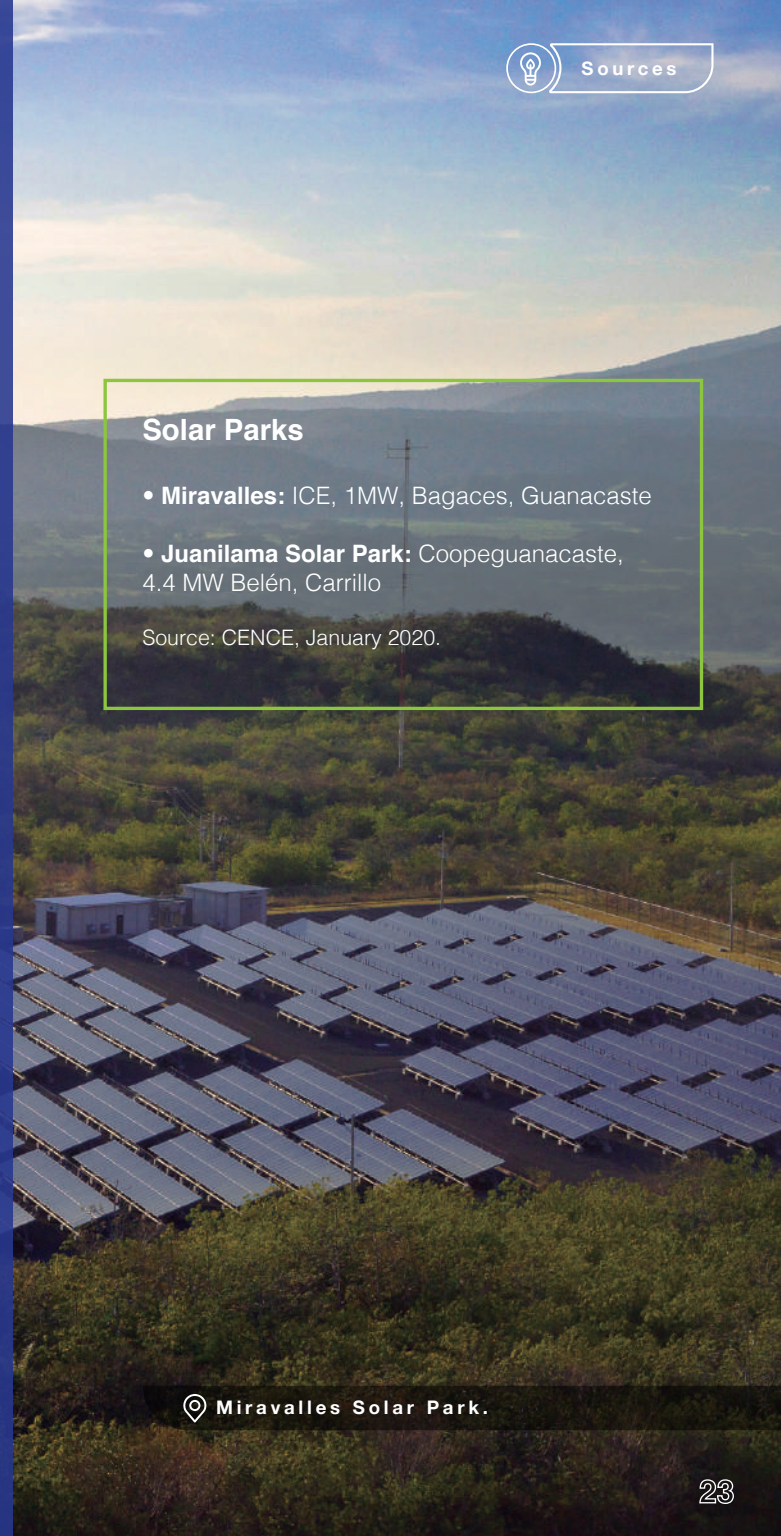
There is plant at the Miravalles zone (Miravalles Solar Park), incorporated since 2012, that provides 1MW to the electric matrix with 4,300 panels in an area of 2.7 hectares.


In 2017, Coopeguanacaste inaugurated the Juanilama Solar Park in Belén, Carrillo, with an installed capacity of 4.4 MW and 15,456 panels. Today, the solar power capacity of the National Electric System is 5,400 kW, which represents 0.15% of the total installed capacity.

## Solar Parks

- **Miravalles:** ICE, 1MW, Bagaces, Guanacaste
- **Juanilama Solar Park:** Coopeguanacaste, 4.4 MW Belén, Carrillo

Source: CENCE, January 2020.



 Miravalles Solar Park.



## Thermal: Climate “Safe”

- The use of hydrocarbons is the last “key” that ICE opens when atmospheric condition diminishes the contribution of the other sources. ICE’ thermal plants represent 13.23% of the National Grid’s capacity.

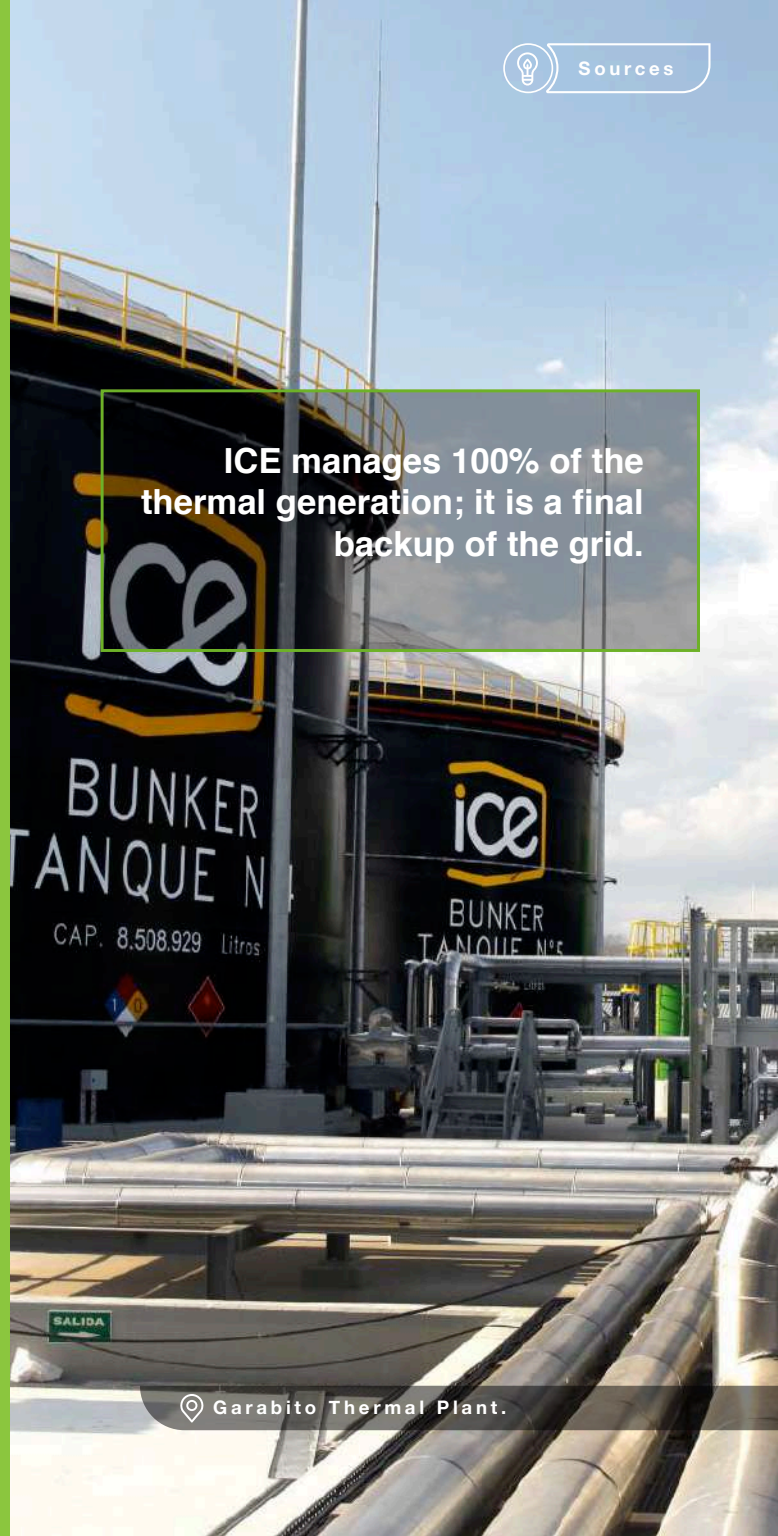
To guarantee national electrical safety ICE keeps an installed potency in thermal plants that can be used quickly to avoid power cuts and to accomplish its job of guaranteeing the national electric security.

The thermal support includes five plants that total 11 units with an installed capacity of 474,112 kW, 13.23% of the National Installed Capacity.

### Thermal Plants

- Moín Gas
- Moín Gas-CNFL
- Guápiles
- Orotina
- Garabito

Source: CENCE, January 2020.



**ICE manages 100% of the thermal generation; it is a final backup of the grid.**





Installation of solar panel.



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● Guanacaste  
Wind Park.

● Miravalles III  
Geothermal Plant.

● Miravalles  
Solar Park.