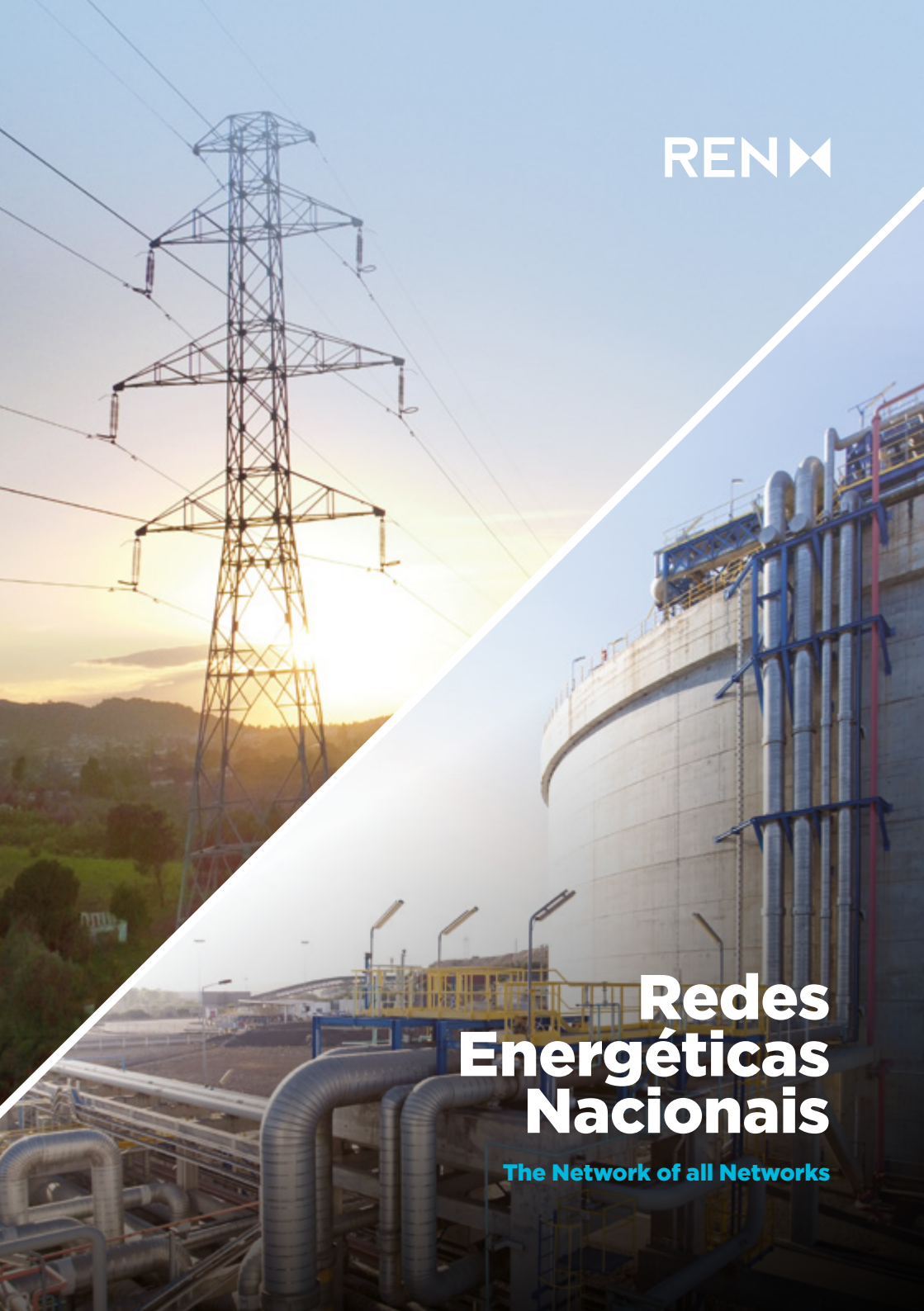


REN

Redes Energéticas Nacionais

The Network of all Networks


REN

The Network of all Networks

REN's role in the Energy Sector
Electricity and Natural Gas

PDIRT & PDIRGN
Development and Investment Plans

Management of the SEN
and the National Electricity Dispatch

Natural Gas Underground Storage and Liquified Natural Gas Terminal at Sines

R&D NESTER

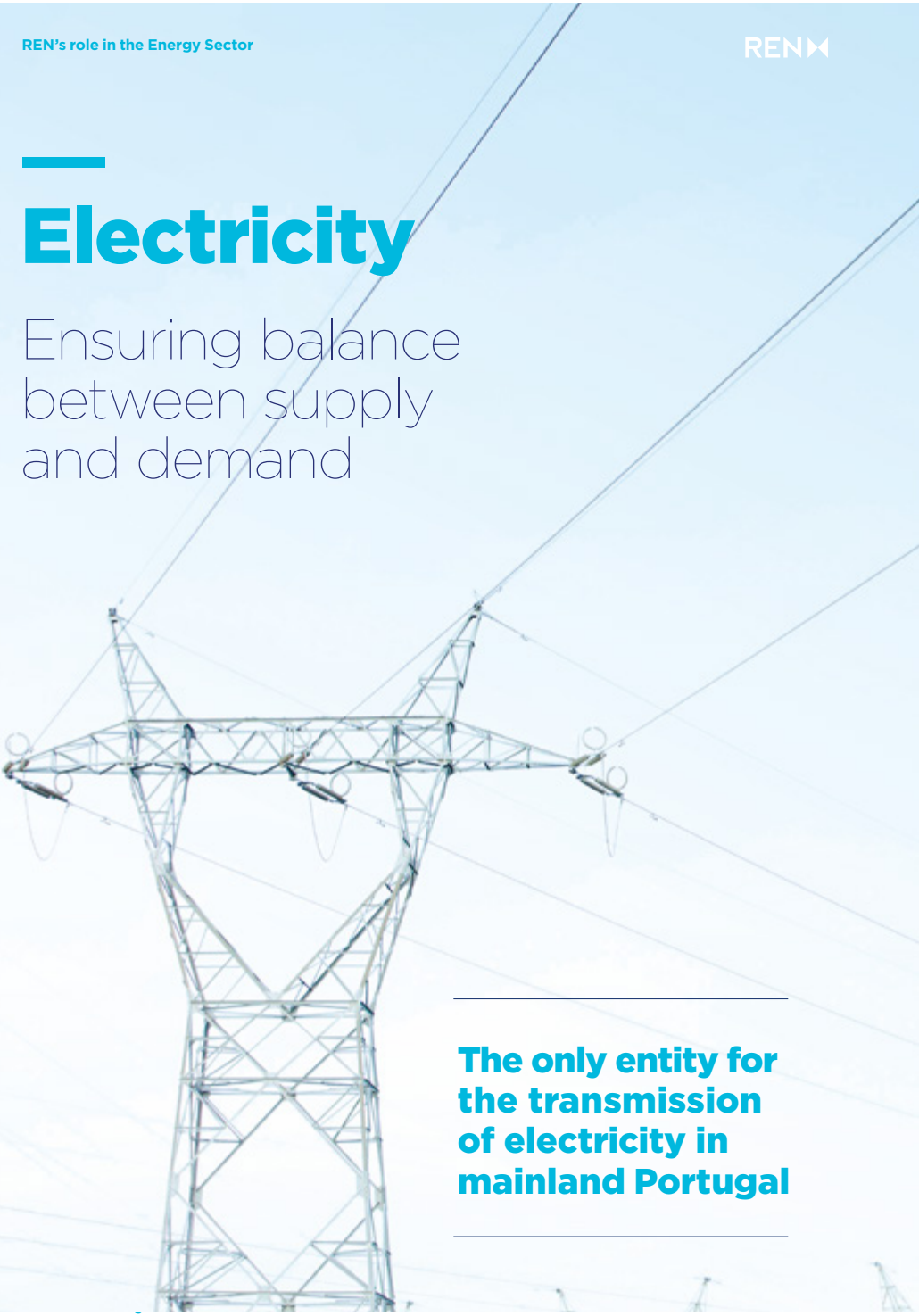
Shareholder structure

Glossary

REN

Electricity

Ensuring balance between supply and demand



The only entity for the transmission of electricity in mainland Portugal

Electricity 2017

9,111 MW
Transmission Peak

49.6 TWh
Electrical Energy **Consumption**

40 %
Energy from **Renewable Sources**

6.6”
Average Interruption Time

8,907 km
Electrical Lines

REN's role in the electrical sector

An example of balanced integration of renewable energy into the electrical system

REN operates the National Transmission Network (Rede Nacional de Transporte de Eletricidade - RNT), which connects the producers to the consumption centres and to the network of the neighbouring country, ensuring equilibrium between the supply and demand of energy. It is the only entity for the transmission of electricity in mainland, under a concession contract signed with the Portuguese Government. The number of producers in Portugal has increased significantly, with the development of renewable energies.

The concession includes the planning, construction, operation and maintenance of the RNT and encompasses, as well, the overall technical management of the National Electric System, to ensure the harmonious functioning of the infrastructures that compose up the system and the continuity of service and security of the supply of electricity.

REN operates the Ancillary Services Market, guaranteeing equilibrium between the production and the consumption

REN is responsible for the National Dispatch and the Network Operations Centre, infrastructures for the operation and supervision of the National Electric System (SEN)

Fanhões 1
View from the substation

Loures 2
High-voltage lines

of electricity through efficient, transparent and competitive market mechanisms, including cross-border exchanges of those services. Information on the System Services Market is made available to market agents and the general public through a Market Information System (www.mercado.ren.pt)

REN is responsible for the National Dispatch and the Network Operations Centre, infrastructures for the operation and supervision of the National Electric System (SEN).

The Dispatch supervises the functioning of the power plants and the transmission network in real time – including the international exchanges made through the interconnecting links with the Spanish network – guaranteeing equilibrium between the production and the load using as needed the mobilization of the system services. The National Dispatch room monitors follows the electrical production from the various sources found in the SEN, including the production of renewable energy.

The Network Operations Centre monitors the status of the equipment of the network that carries that energy over more than 8,900 km of overhead and underground lines and takes the responsibility for the coordination with the distribution network at the border points.

The activity of very high voltage transmission of electricity (150, 220 e 400 kV) is carried out on the RNT, through a concession granted by the Portuguese Government to REN, under a regime of public service of exclusivity.

In 2017, electrical energy consumption reached 49.6 TWh, the maximum power at the RNT was 9,111 MW. The high quality of service provided by REN continues to be a source of pride for the company. In 2017, the average interruption time was only 6.6 seconds.

The electrical power plants are located in places suitable for facilitating their production: close to energy sources, next to rivers, at places where there is wind or prolonged exposure to the sun. But these places do not coincide with the locations where energy is consumed, so that it must be carried over kilometres of very high voltage lines, most of overhead type, although in some circumstances they are underground.

Of the energy mix produced in our country, in 2017, energy from renewable sources represented about 40% of the total consumption (a percentage that varies from year to year depending on whether the year is wet or dry). Recognising the importance of this type of energy for environmental sustainability, REN's experience and international recognition in the matter of integrating renewable energy into the SEN has led to it being considered one of the prime examples of balanced integration of renewable energy into the electrical system.

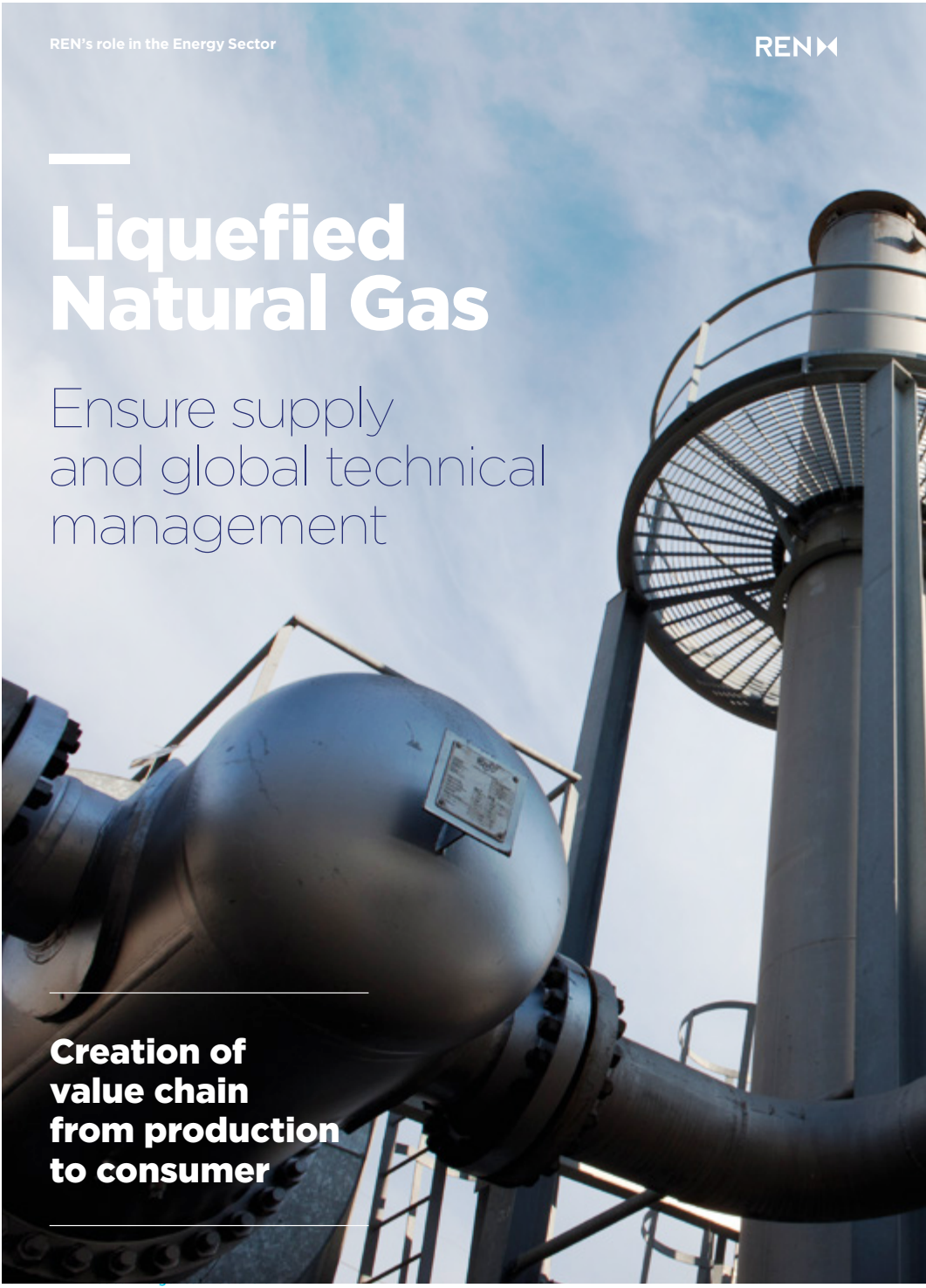
40%

of the total consumption was produced from renewable sources

REN

Liquefied Natural Gas

Ensure supply and global technical management



Creation of value chain from production to consumer

Natural Gas 2017

71.0 TWh
Energy transmitted
RNTGN

69.7 TWh
Natural Gas Supplied to
End Consumers

333 $Mm^3(n)$
Maximum Underground
Storage Capacity

1,375 km
Gas Pipeline

0.0' min/output points
Recorded DIPS
Average duration of
interruptions per output point

REN's role in the Natural Gas Sector

REN is responsible for the transmission of high-pressure natural gas and for the overall technical management of the National Natural Gas System up to the year 2046, under concession contracts signed with the Portuguese Government.

REN Gasodutos operates the National Natural Gas Transmission Network (RNTGN), which receives natural gas at the Spanish border, at the outlets of the underground storage installations at Carriço (REN Armazenagem) and at the LNG regasification terminal at Sines (REN Atlântico) and delivers it to the distributors or end customers of high-pressure gas; it carries out the overall technical management of the National Natural Gas System, which ensures the coordination of the functioning of the high-pressure transmission infrastructures, the underground storage and the LNG terminal, guaranteeing integration with the operation of the distribution networks and ensuring the continuity and security of the supply. REN Gasodutos is also responsible for the elaboration of the proposal of development and investment plans for RNTIAT – National Natural Gas Transmission Network, Storage Infrastructures and LNG Terminal.

There are two interconnecting points between the National RNTGN Transmission Network and the transmission network of Spain: Campo Maior - Badajoz and Valença do Minho – Tuy. Both interconnection points act as entry and exit points of the high pressure network, ensuring the physical reversibility of the gas flows between Portugal and Spain.

Besides the Natural Gas Transmission Network (RNTGN) and the Liquefied Natural Gas (LNG) terminal at Sines, REN has 6 caverns and 1 surface station for the underground storage of natural gas.

In the underground installations in the Municipality of Pombal, at Carriço, high-pressure natural gas is stored in gaseous form in caverns created inside a salt dome by the process of leaching with fresh water, at depths of over one thousand metres.

This underground storage is an important infrastructure for the establishment of strategic reserves, with the goal of endowing the energy system with the ability to satisfy:

- The security requirements of the gas supply to protected customers in the event of a breakdown in the supply of gas to the country, by constituting the security reserves mandated by law
- The needs for optimisation of logistics for the supply of the portfolios of various marketers, in terms of the obligations for the contracted capacities in the various infrastructures and in terms of the management of commercial stocks
- The needs for optimisation of the cost of the raw material by the marketers
- The needs of the Systems Manager for the providing of system services to make the residual compensation for the equilibrium between inputs and outputs of the transmission network.

At the Liquefied Natural Gas (LNG) terminal at Sines, the gas is received in liquid form. Following the unloading of the methane tankers, the LNG is sent to intermediate storage tanks. In line with the indications of the market agents, the LNG is pumped as a liquid, vaporised by heat exchange with sea water using special exchangers and injected into the high-pressure network at the terminal delivery point into the high-pressure transmission network.

Sines is the only natural gas terminal in Portugal. These infrastructures are especially important, due to three factors:

- Security of supply – diversification of the supply sources and the supply routes;
- It not only gives agents access to LNG sources with long-term buy orders, but they can also receive loads from spot transactions made under advantageous conditions
- Additionally, it offers the possibility of supplying LNG by tank truck to regasification units located in areas of the country that are not yet served, directly or indirectly via distribution networks, by the high-pressure transmission network, and in the future, it will allow the leveraging of the penetration of new types of LNG on a small scale, specifically in highway transports and bunkering activities of the maritime sector.

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2


3

Sines
LNG Terminal 1

Carriço
Underground storage 2

Bucelas
Building 3

PDIRT & PDIRGN

PDIRT

Development and Investment Plan for the Transmission Network of Electricity

The Development and Investment Plan for the Electricity Transmission Network (PDIRT) is a fundamental planning instrument of the national energy policy. Drawn up by the Transmission System Operartor (REN) and presented in odd-numbered years, each PDIRT covers the period of the following ten years.

The draft proposal of the PDIRT is submitted to the Directorate-General of Energy and Geology (DGEG) of every odd-numbered year. Following interaction with that authority, REN carries out a revision of the document. The revised version is delivered by DGEG to the Regulatory Entity of Energy Services (ERSE), whose responsibility it is to promote the corresponding public consultation.

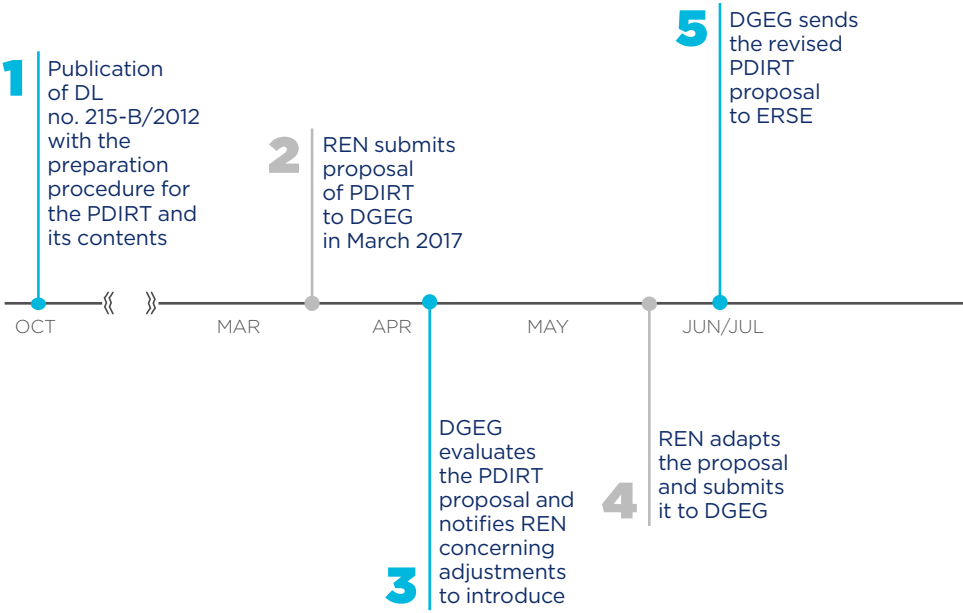
At the conclusion of that phase, ERSE analyses the comments received and issues its opinion. REN then draws up the final proposal for the Plan, based on that opinion, which is then sent to DGEG. DGEG in turn submits the Plan for the evaluation by the member of the Government responsible for the energy sector, who decides on the approval of the PDIRT proposal. The approval of the PDIRT proposal, regarding the 10-year period of 2018-27, also requires the consultation of the Portuguese Parliament.

BASE ASSUMPTIONS AND METHODOLOGIES

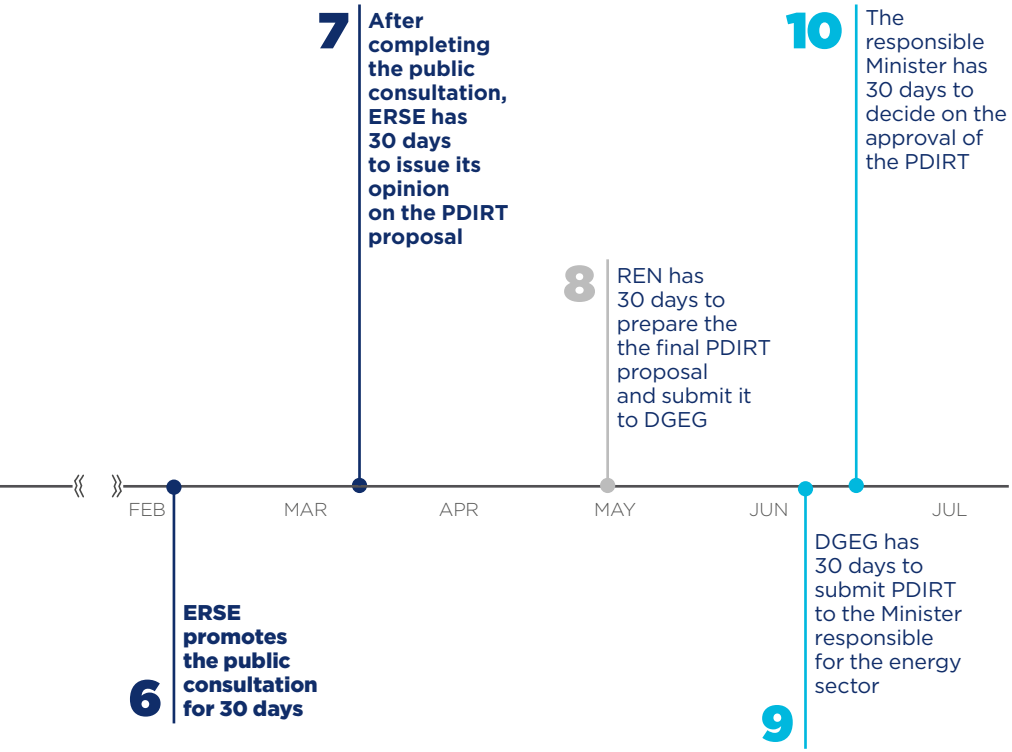
All of REN's activities – and in particular these investment plans – are subject to rigorous scrutiny and supervision by various institutions, including the Government, DGEG, ERSE, the Portuguese Securities and Exchange Commission (CMVM) and bodies of the European Union.

The PDIRT must take into account the guidelines of the energy policy and the requests for connecting new power plants and must be duly coordinated with the Development and Investment Plan of the Distribution Network (PDIRD) and the ten-year network development plan at European level and in particular with the transmission network in Spain.

PDIRT PREPARATION PROCESS [1]



PDIRT covers a ten year period



[1] **Note:** The interval of time between the end of step 5 and the start of step 6 is not defined by law.

PDIRGN

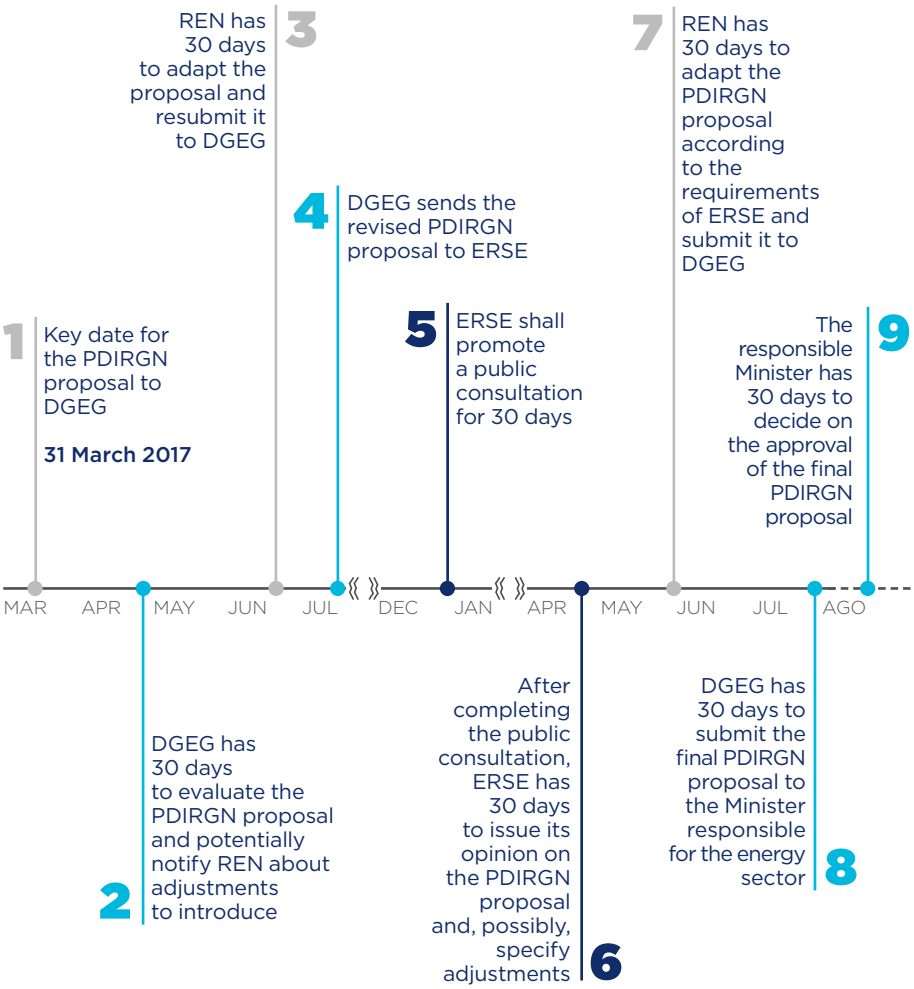
Development and Investment Plan for RNTIAT

The process for the preparation of the Development and Investment Plan for the Natural Gas Network (PDIRGN) is essentially the same as that for the process of preparing the PDIRT proposal.

The planning for the National Natural Gas Transmission Network, Storage Infrastructures and LNG Terminal (RNTIAT) must ensure the existence of infrastructure capacities, the adequate and efficient development of the transmission network and the safety of the supply. It is the responsibility of REN Gasodutos, as concessionaire of the National Natural Gas Transmission Network (RNTGN), to draw up in odd-numbered years, a ten-year development and investment plan of RNTIAT. The proposed PDIRGN is to be presented by the operator of the RNTGN to the Directorate-General of Energy and Geology (DGEG) by the end of March of every odd-numbered year. The procedure follows exactly the same timeline as of the one presented regarding PDIRT. The final proposal for the PDIRGN submitted to the DGGE is then presented for the approval of the member of the Government responsible for the energy sector, accompanied by the opinion of the Regulatory Entity of Energy Services (ERSE) and the results from the public consultation it carried out. The member of the Government must consult the Portuguese Parliament for the final approval decision.

The PDIRGN takes into account the five-year plans for development and investment of the distribution networks (PDIRD), permitting the integration and standardisation of the development and investment proposals of the operators of the distribution network (ORD) in the corresponding networks.

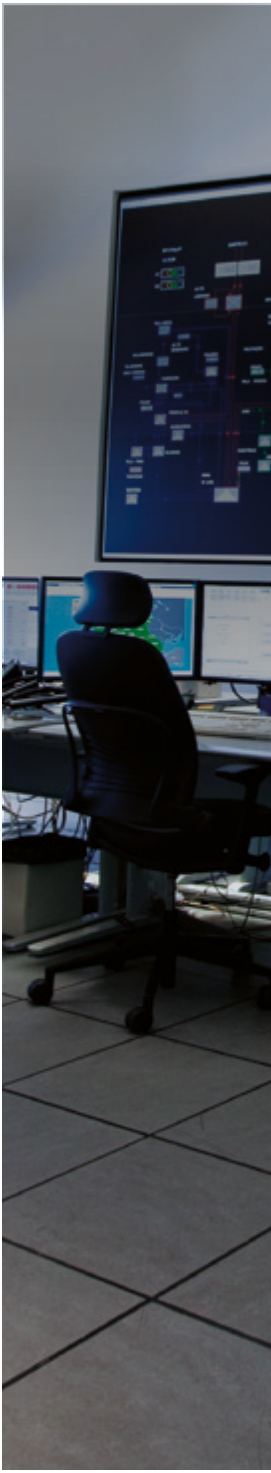
PDIRGN PREPARATION PROCESS



[1] **Note:** The interval of time between the end of step 4 and the start of step 5 is not defined by law.

Management of the National Electrical System and the National Electricity Dispatch

guarantee the secure transmission of electrical energy



SEN
National Electrical System

The management of the electrical system in Portugal mainland is carried out by REN through two control rooms that operate around the clock, year round.

The main missions of the management of the electrical system are:

- To guarantee the secure transmission of electrical energy;
- To ensure an equilibrium between production and consumption.

Electrical energy is a fundamental element of our society. Thanks to it, we have light in our homes and in public spaces. It is the engine for the conveniences we have become accustomed to, such as home appliances (TV, computers, internet, phones, hi-fi, washing machines), health and safety equipments, public and private services and many other applications; a vital element for our technology-based society; and a driving force behind the industries that give life to our economy.


operation
coordination
supervision

In order for each of us to be able to turn on a light or an appliance, a large number of professionals carry out three fundamental tasks with precision and efficiency: forecast the consumption of electrical energy; produce electrical energy; balance production with consumption; and take that energy to the places of consumption.

A very important part of these activities is carried out by workers of REN, which from its founding and through the National Dispatch, has been responsible for the operation and supervision of the National Electrical System (Sistema Elétrico Nacional - SEN), coordinating in real time the power plants and the transmission network. The Dispatch room is the centre that controls the electrical production and the status of the network that carries that energy across thousands of kilometres of very high voltage cables, schematically presented on a synoptic board that represents mainland Portugal and dominates the room.

The tasks carried out by the National Dispatch are complex and could not be performed without the highly sophisticated technological support of computers and telecommunications. This control system makes it possible to analyse thousands of pieces of data that arrive every second in real time and to send orders and commands over a private dedicated fibre optic communications network that covers the entire territory of mainland Portugal. All this information is visualised by means of the synoptic board and the computer system, and its interpretation allows the operators to control at every moment the production of all the electrical power plants and the actual global consumption of all our industries, companies and residences.

The two control rooms of the System Manager are designed to effectively handle any contingency. The servers and the

means of communication needed to ensure the management of the SEN are split between the two rooms. This security measure guarantees that the SEN will function perfectly in the hypothetical case of an incident that temporarily affects either of the rooms.

The management of the system is staffed by around 60 people, most of whom are electrical engineers.

To achieve the balance between power generation and consumption, there must be an accurate forecast of the demand for electricity at every moment of the day. This forecast is the result of the analysis of various parameters, from weather forecasts to the occurrence of events that would cause an exceptional increase or decrease in consumption, such as national holidays or long weekends taken by workers around official holidays. On the synoptic board, one of the most important graphs shows the predicted consumption over the course of a day; the consumption that is being recorded; and the portion of that consumption that is fed by plants whose production can be modified by instructions from the National Dispatch. The goal of the National Dispatch operators is to see that the production meets the national consumption needs at every instant. If there are alterations in these curves, manual or automatic commands are send to the power plants to adjust production, raising or lowering it according to the needs.

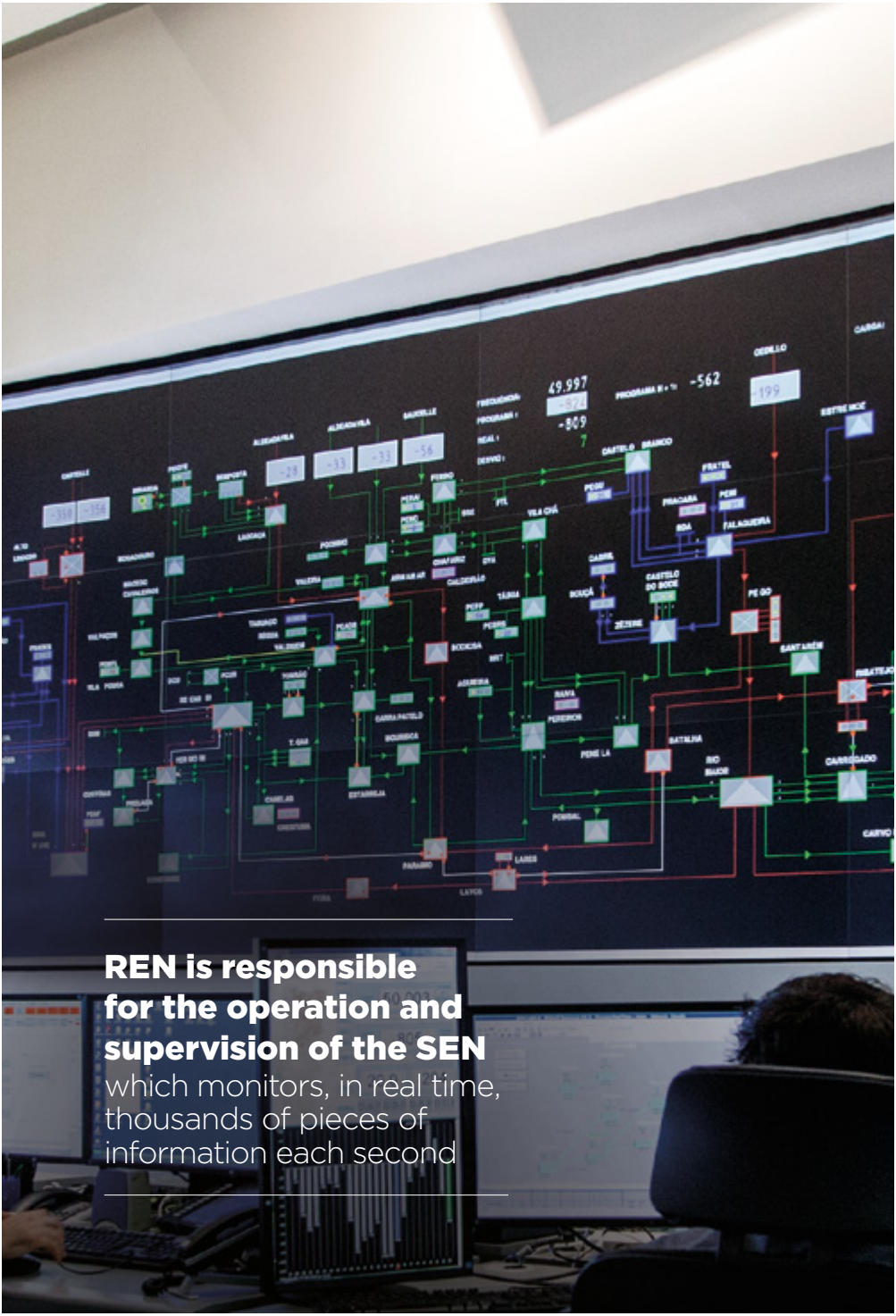
The synoptic board also shows the status of the operations of the plants and their production at every moment. The operators control the transmission of electrical energy from the power plants to the distribution networks, from the turbines of a power plant to the distribution points that supply energy to all the consumers.

Besides the different electrical power plants, the synoptic board also shows the transmission lines, with different colours to identify the various voltage levels, and arrows that indicate the direction of the flow of energy.

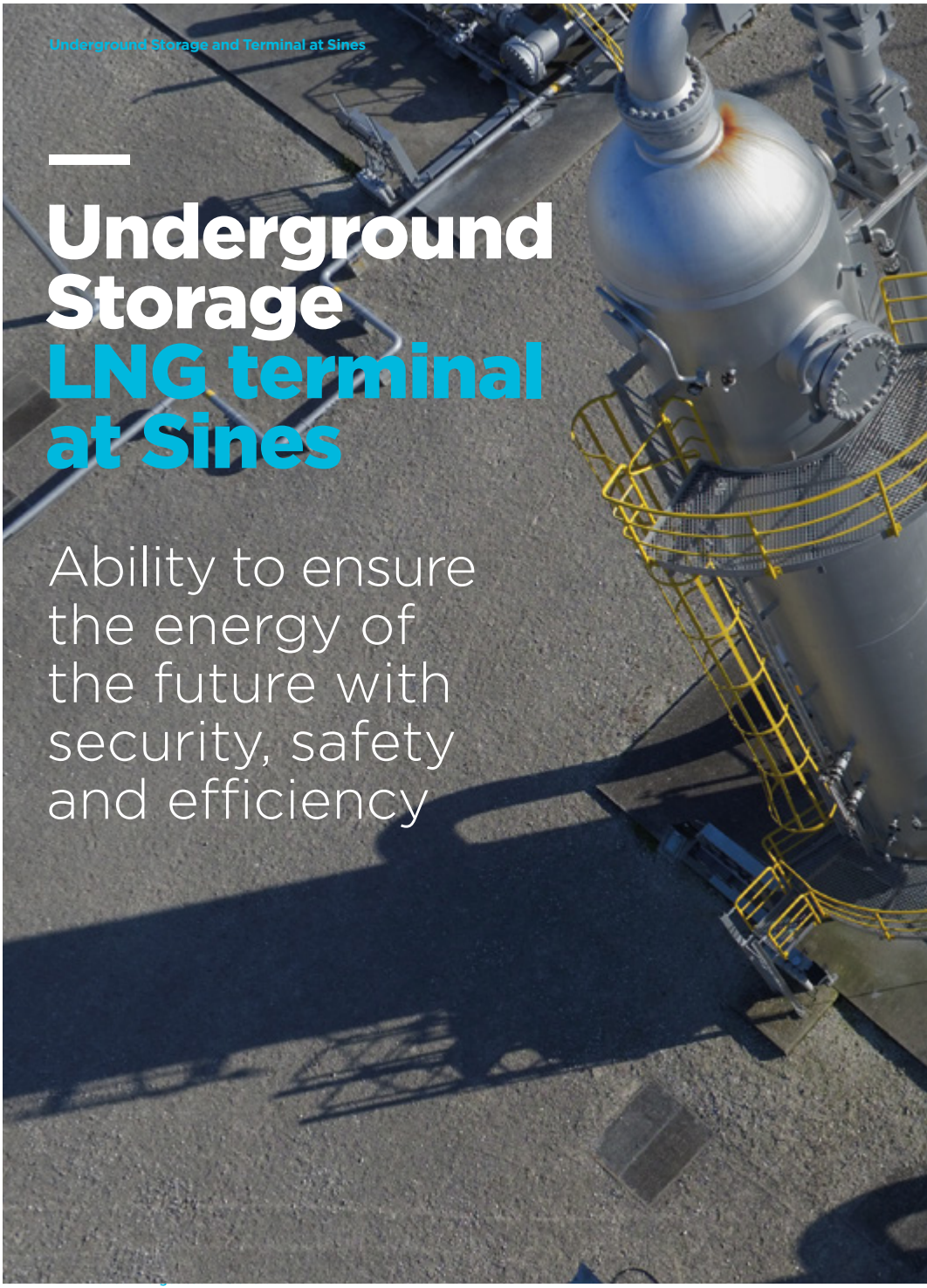
The Operations Centre is also responsible for creating the conditions to allow maintenace activities to be done in a secure and safe manner. When the lines are switched off and disconnected, they appear white on the board. For cross-border lines, the flows of energy are represented to show what is being exported or imported at any moment. These lines of external connections are fundamental, because they help maintain the equilibrium of the entire system and allow the functioning of the European electricity market with cross-border exchanges programmed for each hour of the day.

In the event of a disturbance in the functioning of the system, the operators act quickly to restore the security and safety conditions. The action plans are tested on a simulator, which is regularly used to train the operators, reproducing situations that have already occurred or others that might occur in the future.

The proper functioning of this complex system operated through the National Dispatch means that all of us consumers can have at our disposal the supply of electrical energy we need at any moment of the day or night, continously throughout the year.



REN is responsible for the operation and supervision of the SEN which monitors, in real time, thousands of pieces of information each second



Underground Storage LNG terminal at Sines

Ability to ensure the energy of the future with security, safety and efficiency


NATIONAL
operating storage capacity
43 % SINES
57 % CARRIÇO
Carriço
333 Mm³(n)
CAPACITY
20 days
CURRENT AVERAGE
total domestic consumption in 2017

Underground Storage

Besides the Natural Gas Transmission Network (Rede Nacional de Transporte de Gás Natural - RNTGN) and the Liquefied Natural Gas (LNG) terminal at Sines, REN has an underground storage infrastructure located in Carriço (Municipality of Pombal), consisting of six high pressure natural gas storage cavities and a common surface for the entire complex.

The subterranean caverns for the storage of natural gas are pockets that are nearly cylindrical in shape, built in the subsoil and located at depths of 1000 to 1400 metres. Each one is 200 to 300 metres high and 60 to 70 metres wide.

These gas cavities are built using a process of leaching, which consists of injecting fresh water into underground rock salt masses through holes drilled for the purpose, thereby progressively dissolving the salt. After treatment, the resulting brine is extracted and disposed of in the sea.

The Underground Storage at Carriço has a storage capacity of 333 $Mm^3(n)$ of natural gas. This capacity represents about 20 days of the total domestic consumption average in 2017, which may contain the country's mandatory security reserves and also provide capacity for exclusively commercial use by market agents, and represents 57% of the current operating storage capacity of natural gas in Portugal. The remaining 43% of capacity is located at the Sines Terminal in the form of LNG.

1

2

3

1 **Carriço**
Towers
Underground storage

2 **Carriço**
Underground storage

3 **Carriço**
Underground storage

Carriço was chosen as the storage site based on the analysis of the known geological settings in Portugal mainland. Of the various locations analysed, this site presented the greatest potential for the project, due to:

- Geographic location – proximity to the main gas pipeline and the ocean, in this case for the disposal of the brine produced, and an aquifer, from which the water needed for the leaching process was taken;
- Lower environmental impact;
- Suitable geological features, as there was a saline mass at depths between 500 and 1500 metres, and typically, the caverns are constructed at depths of 1000m to 1400m.

The underground storage constitutes an important infrastructure for the establishment of strategic reserves.

The Underground Storage at Carriço has a storage capacity of 333 $Mm^3(n)$

LNG Terminal at Sines

One of the most competitive terminals in Europe

Natural Gas (NG) is a fossil fuel originating from the decomposition of organic material under the effect of high pressure and temperature, found in the seabed hundreds of millions of years ago;

Liquefied Natural Gas (LNG) is NG that, due to the lowering of its temperature, condenses and enters into liquid state. Compared to other fossil fuels, such as coal or crude oil:

- Natural Gas is the fossil fuel that burns cleanest (especially when it comes from LNG);
- It is the most abundant fossil fuel (considering the methane hydrates);
- It is compatible with biomethane (100% natural and renewable fuel - zero emissions);
- Its density is lower than that of air;
- It is non-toxic.

In Portugal, Sines is the only LNG terminal. LNG terminals are especially important due to three factors:

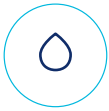
- Security of the supply – diversification of the sources of supply;
- Bargaining capacity for the Market Agents;
- Ability of the country to acquire NG (LNG) on the spot market;
- Possibility of supply of LNG by tank truck - offering the supply of NG in places where there is no gas pipeline and simultaneously, the direct distribution of LNG, making a whole new set of uses feasible.

The construction of the present-day Liquefied Natural Gas Terminal at Sines began in 2000. In October 2003, the first ship was received and in 2004 the terminal was officially inaugurated. In 2009, the expansion project for the terminal began, with the construction of a third tank, which was completed in 2012. The Terminal therefore acquired a storage capacity of up to 390,000 cubic metres of LNG and the ability to transfer it to other ships.

Due to its characteristics of a deep-water port, its storage capacity and strategic location, the LNG Terminal at Sines is one of the most competitive terminals in Europe and a benchmark on the world stage. It has exceptional conditions to receive deep-draught ships with large capacity and therefore the costs per unit transported are lower.

In addition, the annual availability of the port of Sines is unequalled when compared with other European ports that are more subject to tidal conditions. Sines can also function as a depot for the redistribution of LNG to smaller ships that serve locations with a more difficult access, especially for the new solutions of small-scale LNG supply.

The terminal is an infrastructure with the capacity to fully supply the country in the case of an emergency. Gas from the Sines terminal has a potential geographic zone of influence that extends into the interior of the Spanish network. This capacity means that, in the case of necessity, Portugal can participate in supplying Europe through its interconnection with France. This terminal capacity thus allows Europe to attenuate its dependence on natural gas.



390,000 m^3

storage capacity of the LNG Terminal at Sines

Sines
LNG
Terminal

Sines
LNG Terminal
Peer

Sines
LNG Terminal
Peer

R&D NESTER

Strategic innovation for integrated sustainability

The R&D Nester research and development centre (www.rdnester.com) is the product of a partnership between REN and the State Grid Corporation of China (SGCC), to develop new tools, methodologies and strategies, in tune with the new energy paradigm and to promote the planning, management and operation of more efficient and sustainable energy systems.

With its goal of being an international reference point in energy innovation and research, some of the research areas include:

- the integration and management of a high level of penetration of widely varied renewable energy, such as wind and solar production
- network planning with the incorporation of energy storage technology
- the development of new architectural designs for more efficient electrical substations, through the use of information and communication technologies (ICT) (Substation of the future / Smart Substation)

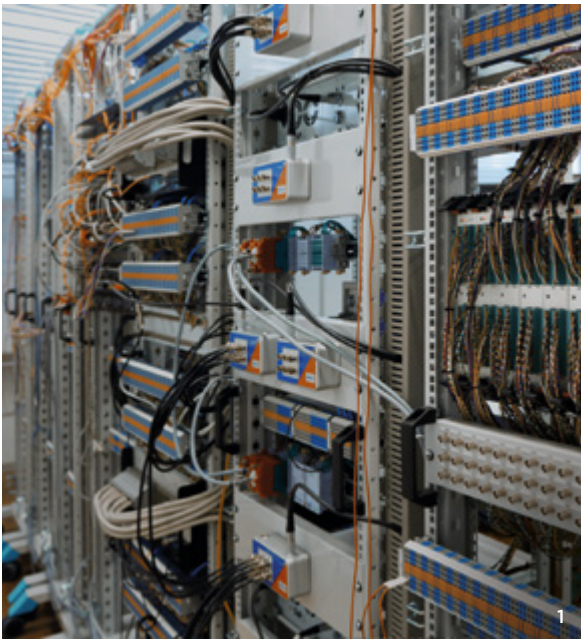
- the analysis and use of flexibility and network interconnections to minimise operating risks
- the project design, development and implementation of tools and methodologies for coordination between network operators to reduce operating risks
- energy markets, system services and their evolving features.

These subjects are developed in projects within the context of programmes such as Horizonte2020 and INTERREG of the European Commission, MIT-Portugal/FCT, European Space Agency (ESA) or in conjunction with the structures of REN and SGCC.

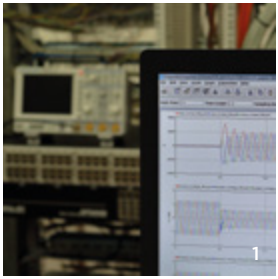
R&D Nester currently participates in projects with more than 60 partners in over 15 countries and has signed various protocols of cooperation with universities, laboratories, industry, and domestic and foreign associations.

In addition, it participates in various key European and world-wide groups (ETIP-SNET and CIGRE) in the reflection on and definition of innovative solutions for energy systems of the future.

R&D Nester has a laboratory that allows it to analyse and test advanced solutions for energy systems, which is listed on the Smart Grid Laboratory Inventory of the European Commission.

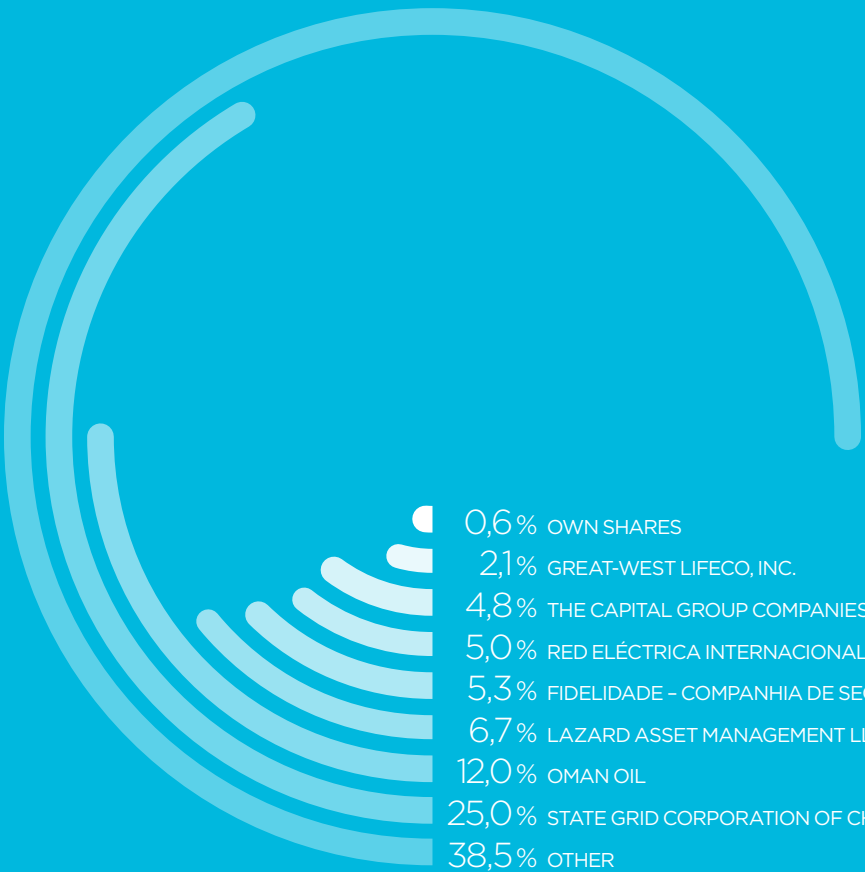


R&D
NESTER



1 **R&D Nester Laboratory**
Smart Grid Laboratory
Inventory

Shareholder structure



0,6 %	OWN SHARES
2,1 %	GREAT-WEST LIFECO, INC.
4,8 %	THE CAPITAL GROUP COMPANIES, INC.
5,0 %	RED ELÉCTRICA INTERNACIONAL, S.A.U.
5,3 %	FIDELIDADE – COMPANHIA DE SEGUROS , S.A.
6,7 %	LAZARD ASSET MANAGEMENT LLC
12,0 %	OMAN OIL
25,0 %	STATE GRID CORPORATION OF CHINA
38,5 %	OTHER

Glossary

Technical

Bunkering – operation to supply fuel to a ship, for its propulsion

CIGRE - Conseil International des Grands Réseaux Électriques

CMVM - Portuguese Securities and Exchange Commission

DGEG - Directorate-General of Energy and Geology

ERSE - Regulatory Entity of Energy Services

ESA - European Space Agency

ETIP SNET - European Technology & Innovation Platforms

ICT - Information and Communication Technologies

LNG - Liquefied Natural Gas

NG - Natural Gas

ORD - Operators of the Distribution Network

PDIRGN - Development and Investment Plan for the Natural Gas Network

PDIRD - Development and Investment Plan for the Distribution Network

PDIRT - Development and Investment Plan Network for the Electricity Transmission Network

RNT - National Transmission Network of Electricity in mainland Portugal

RNTGN - National Natural Gas Transmission Network

RNTIAT - National Natural Gas Transmission Network, Storage Infrastructures and LNG Terminals

SEN - National Electrical System

SGCC - State Grid Corporation of China

Units

km - kilometre

kV - kilovolt

m^3 - cubic metre

Mm^3 - million cubic metres

MW - megawatt

TWh - terawatt-hour

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