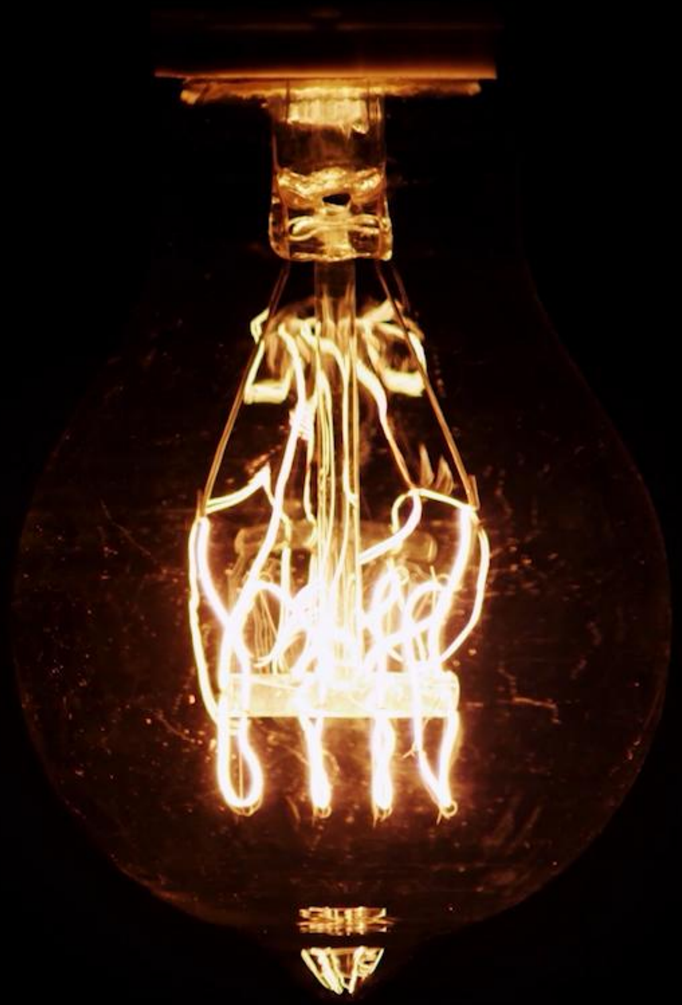
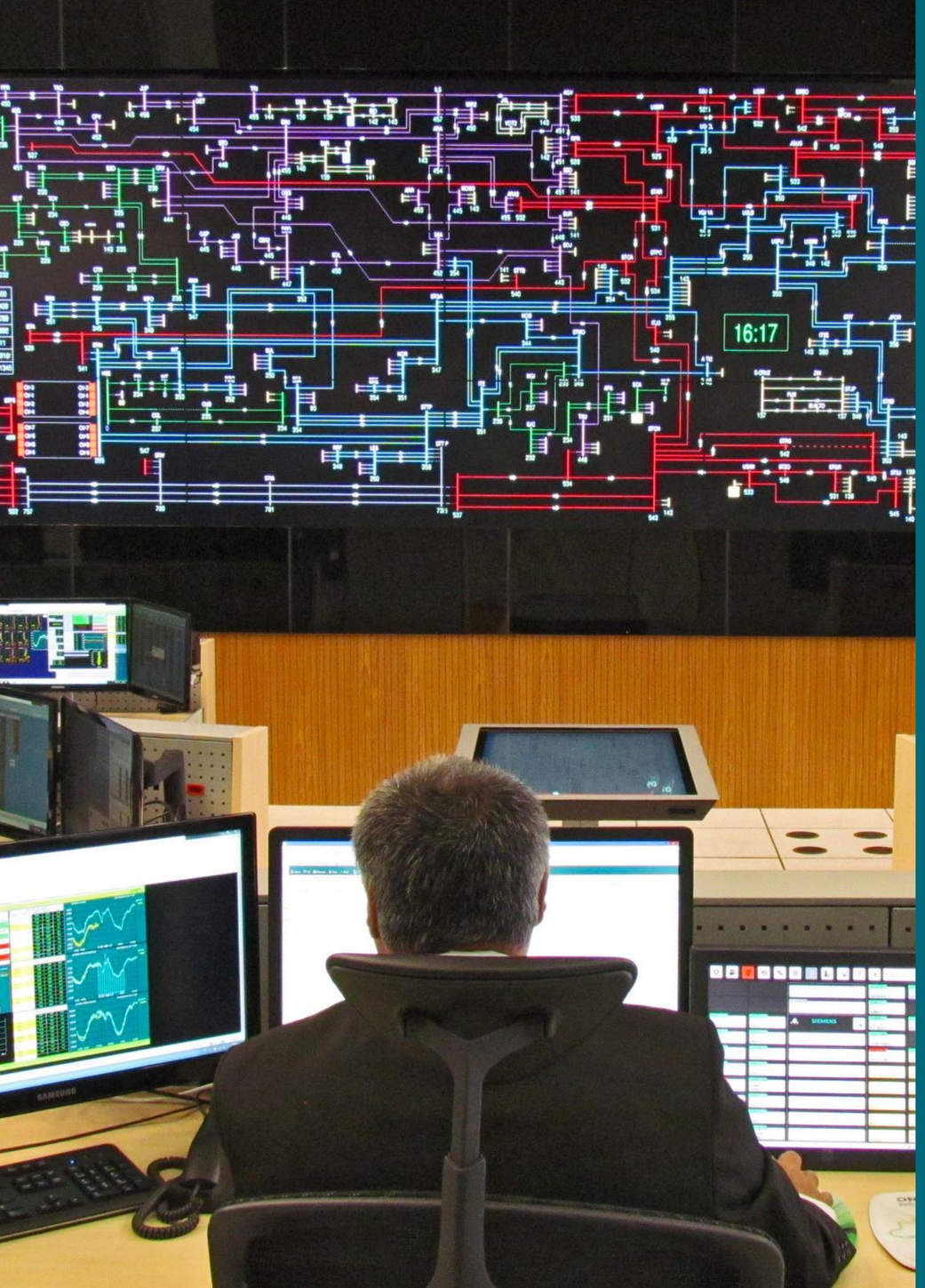
AVEVAWORLD



Every idea is a power,



Operador Nacional do Sistema Elétrico

Maximizing Renewable Energy Utilization:

Impact of AVEVA PI System on Grid Efficiency at ONS

Kaio Kopko and Leonardo Bezerra

April 2025

ONS Operador Nacional do Sistema Elétrico

ABOUT

Private, non-profit legal entity under the regulation and supervision of **ANEEL (Brazilian Electricity Regulatory Agency).** ONS does not own any energy generation, transmission or distribution assets.

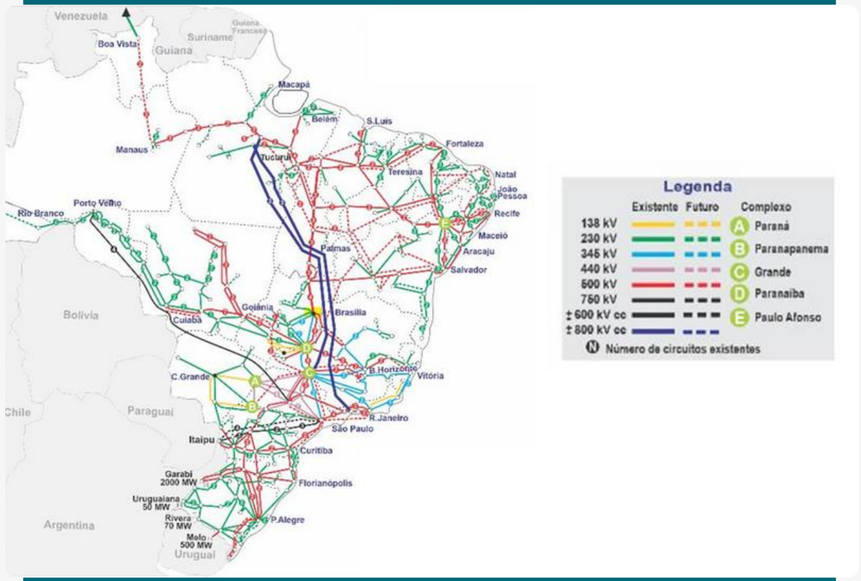
MISSION

To guarantee the **supply of electricity in the country,** with quality and a balance between security and the overall operation cost.

LEGAL STRUCTURE

Article 13 of Law No. 9,648/98 (as amended by Law No. 10,848/04), regulated by Decree No. 5,081/04.

Brazilian Interconnected Power System



Extension of transmission lines

2024: 174,750.000 km

2029: 183,560.000 km

Equipment

Supervised Assets (2025)

130,000+ electrical units monitored by ONS's SSC

Energy load

Peak: 106 GW

2/26/25 2:45 PM

Renewables record

March 15, 2024

Load supplied by 92%

of renewable energy

Brazilian Electricity Matrix

Installed and Expected Capacity (MW)

March/2025 | Dec/2029

Hydro

Installed
46% - 108.1 GW

Expected Capacity
41.6% - 108.7 GW

Thermal

Installed
16.8% - 39,2 GW

Expected Capacity
13.2% - 36.4 GW

Wind

Installed
14.1% - 33.2 GW

Expected Capacity
13.7% - 35.9 GW

Solar*

Installed
23.1% - 17.1 GW

Expected Capacity
30.8% - 23.7 GW

*MMGD included

Brazilian Electricity Matrix

Installed and Expected Capacity (MW)

March/2025 | Dec/2029

In 2025, **84%** of Brazil's electricity generation from **renewable sources**

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Hydro generation is losing its dominance

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23.1% - 17.1 GW

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30.8% - 23.7 GW

*MMGD included

In 2029, 45% of the matrix of **Wind and Solar**

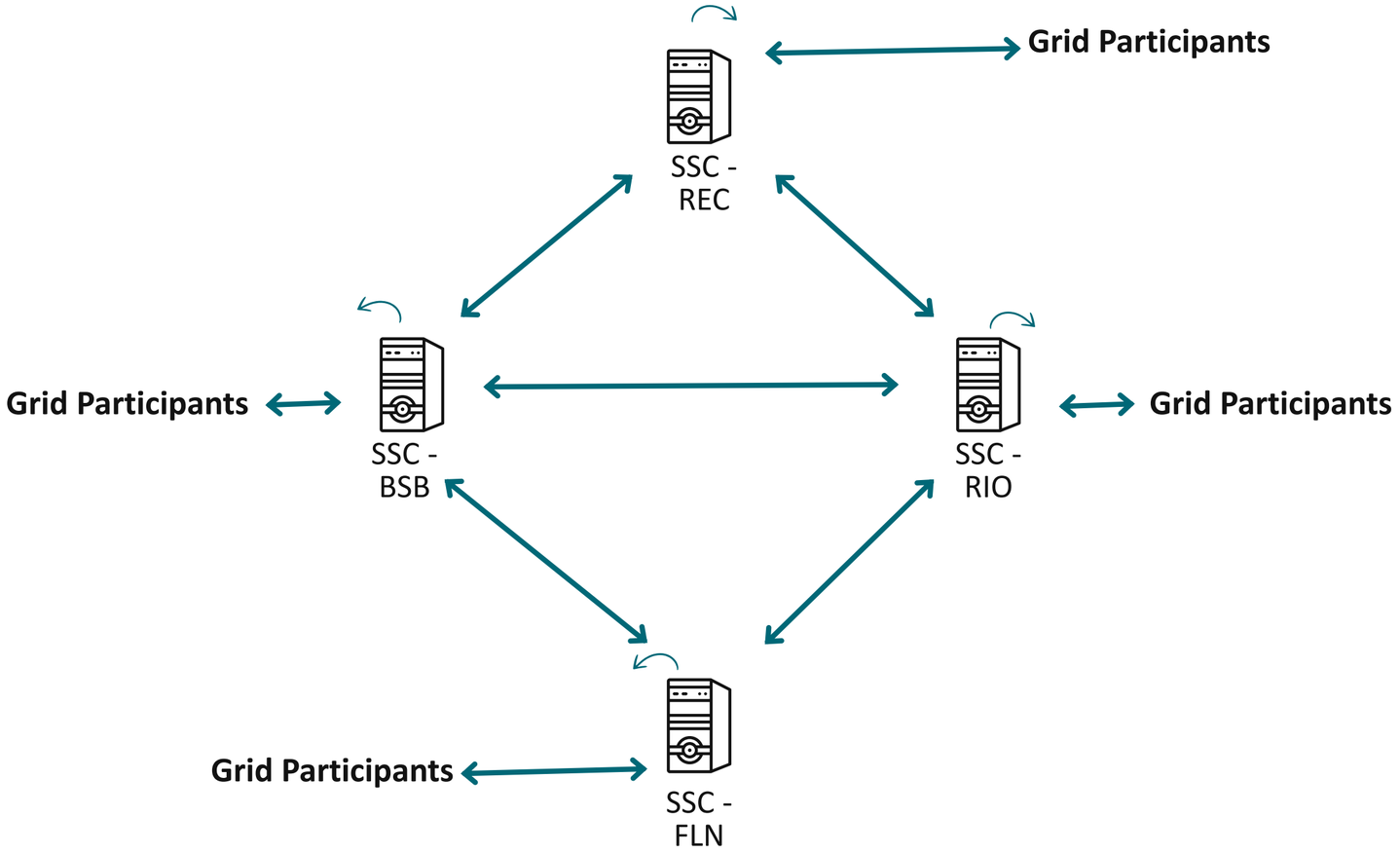
PI System at ONS

Data Archive
15 Million Tags

AVEVA PI Vision
100+ Active Screens

Asset Framework
56 Bases

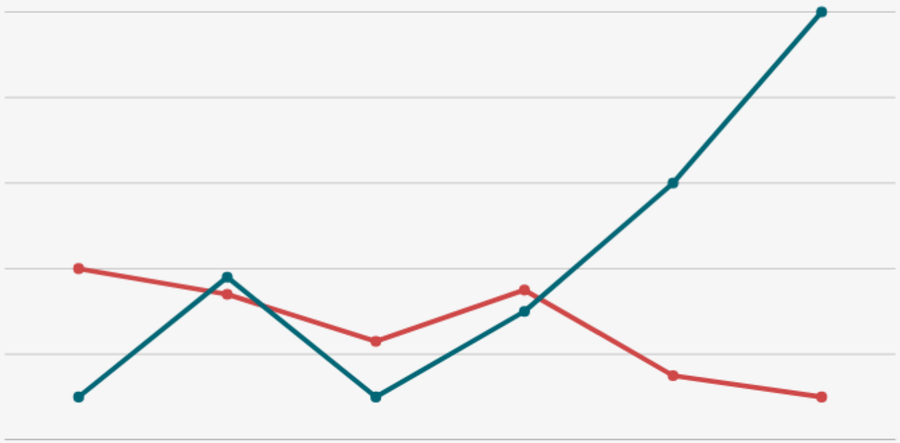
PI Interface
12 Processes



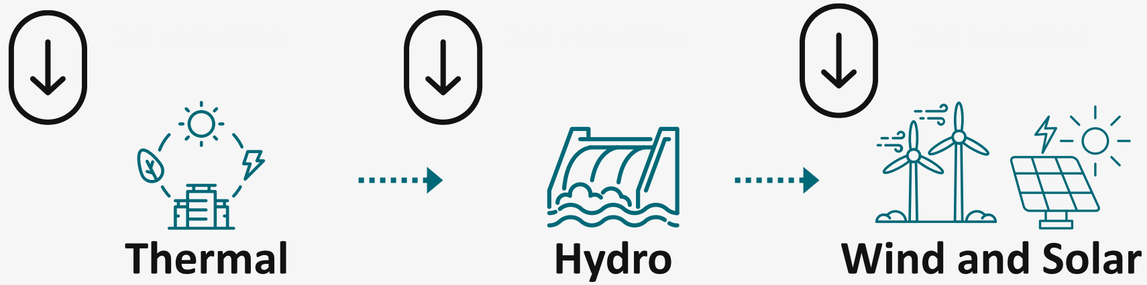
Curtailment

What is Curtailment?

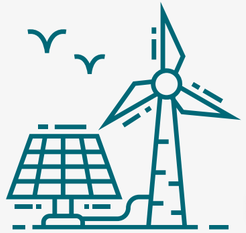
Curtailment occurs when **renewable energy generation is restricted** due to grid limits, oversupply, or coordination issues, leading to wasted clean energy.



Generation increasing while **consumption not**



Cycle of Curtailment



- Excess Supply
- Grid Limits Generation
- Lost Clean Energy

- Demand Increases
- Grid Increase Generation
- Renewables back online

How the case addresses this

Our project focuses on optimizing the curtailment process, ensuring faster and smarter renewable energy recovery.

The Problem

Manual Coordination Inefficiencies

The Problem

Manual Coordination Inefficiencies

220+

WIND and **SOLAR** farms

Increased Reliance on Renewables

Wind and solar variability required faster and simultaneos dispatch.

The Problem

Manual Coordination Inefficiencies

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WIND and **SOLAR** farms

Increased Reliance on Renewables

Wind and solar variability required faster and simultaneos dispatch.

Asynchronous Energy Coordination

Phone-based methods limited speed and energy distribution.

The Problem

Manual Coordination Inefficiencies

220+

WIND and **SOLAR** farms

Increased Reliance on Renewables

Wind and solar variability required faster and simultaneos dispatch.

Asynchronous Energy Coordination

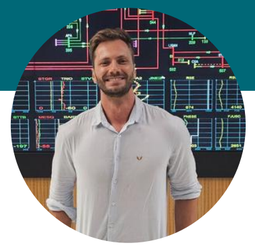
Phone-based methods limited speed and energy distribution.

Delayed Renewable Recovery

Slow coordination after curtailment delays wind and solar restoration, limiting renewable use.

Simulation of operation

Reduction of Wind Generation



COSR-NE
(Kaio)

Engie
(John)

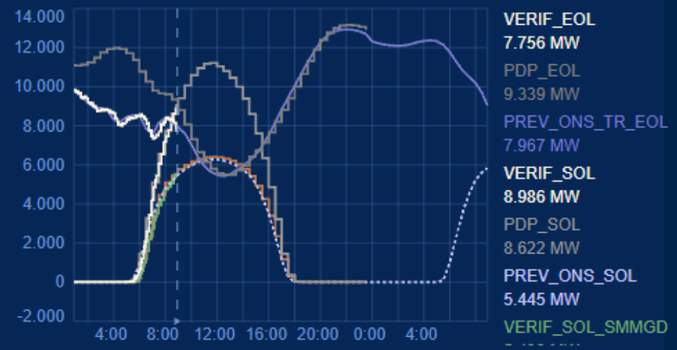
The Start | Real-Time & Forecast: Wind and Solar Across Brazil

Operador Nacional do Sistema Elétrico

NE N SE S

NE N SE S

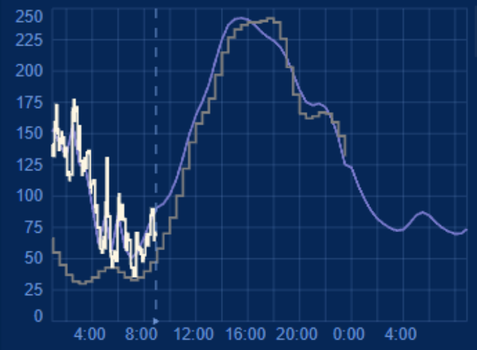
PREVISÃO NORDESTE



VERIF_EOL
7.756 MW
PDP_EOL
9.339 MW
PREV_ONS_TR_EOL
7.967 MW
VERIF_SOL
8.986 MW
PDP_SOL
8.622 MW
PREV_ONS_SOL
5.445 MW
VERIF_SOL_SMMGD

54,9 % ATENDIMENTO CARGA
34,8 % FATOR DE CAPACIDADE
62,9 % ATENDIMENTO CARGA
92,9 % FATOR DE CAPACIDADE

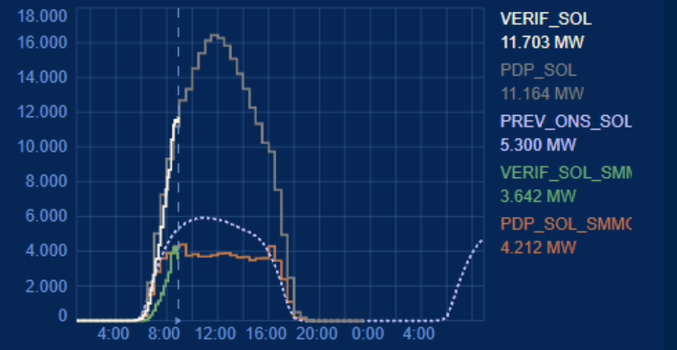
PREVISÃO NORTE



VERIF_EOL
70 MW
PDP_EOL
47 MW
PREV_ONS_TR_EOL
89 MW

0,9 % ATENDIMENTO CARGA
16,0 % FATOR DE CAPACIDADE

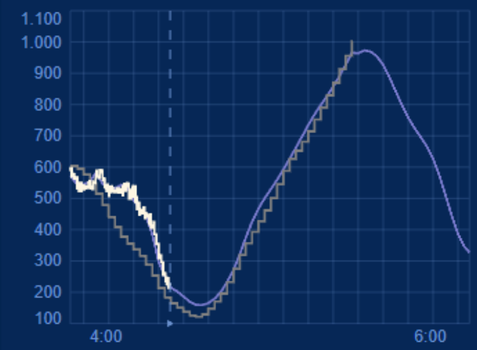
PREVISÃO SUDESTE



VERIF_SOL
11.703 MW
PDP_SOL
11.164 MW
PREV_ONS_SOL
5.300 MW
VERIF_SOL_SMI
3.642 MW
PDP_SOL_SMMC
4.212 MW

23,7 % ATENDIMENTO CARGA
35,9 % FATOR DE CAPACIDADE

PREVISÃO SUL

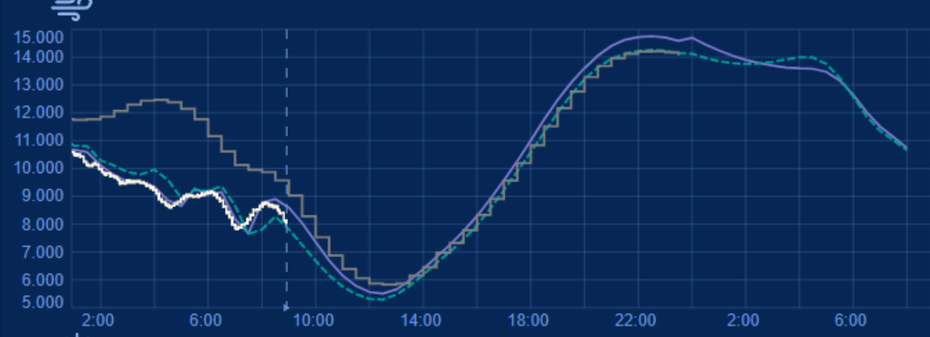


VERIF_EOL
221 MW
PDP_EOL
183 MW
PREV_ONS_TR_EOL
220 MW

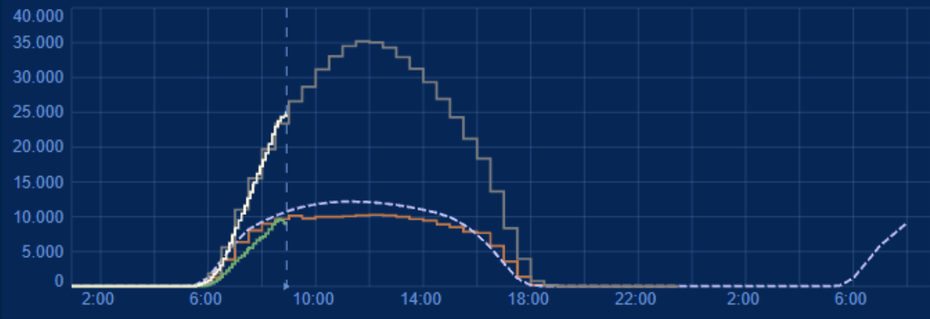
1,4 % ATENDIMENTO CARGA
7,7 % FATOR DE CAPACIDADE

PREVISÃO BRASIL

A curva PREV_ONS_EOL é corrigida com o vento
Não considera cortes de geração



VERIF_EOL
8.051 MW
PDP_EOL
9.574 MW
PREV_ONS_EOL
7.895 MW
PREV_ONS_TR_EOL
8.640 MW



VERIF_SOL
24.987 MW
VERIF_SOL_SMMGD
9.089 MW
PDP_SOL
23.400 MW
PREV_ONS_SOL
10.744 MW
PDP_SOL_SMMGD
9.685 MW

GERAÇÃO ATUAL (MW)

		DESVIO ATUAL PDP (MW)
EÓLICA	8.051	-1.527
SOLAR	24.987 S/ MMGD 9.089	1.588
HIDRO	46.056	-1.578
TERMO	7.457	1.138

CARGA (MW)

86.551 C/ MMGD

-471

RECORDE DE GERAÇÃO (MW)

03/11/2024 23:55:56
23.808 RECORDE

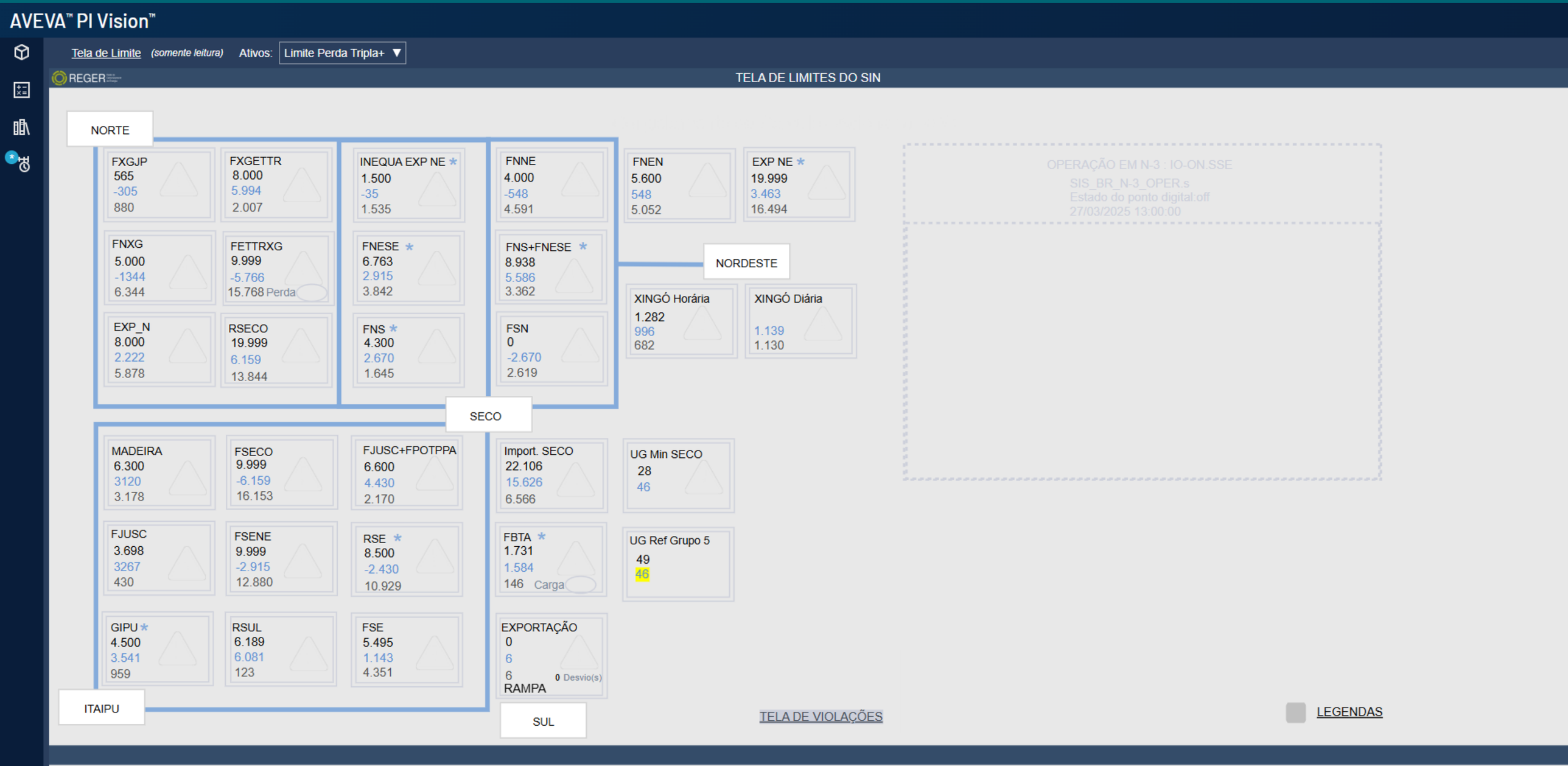
14/03/2025 12:10:36
38.358 RECORDE

ACESSO TELA LIMITES

AJUDA

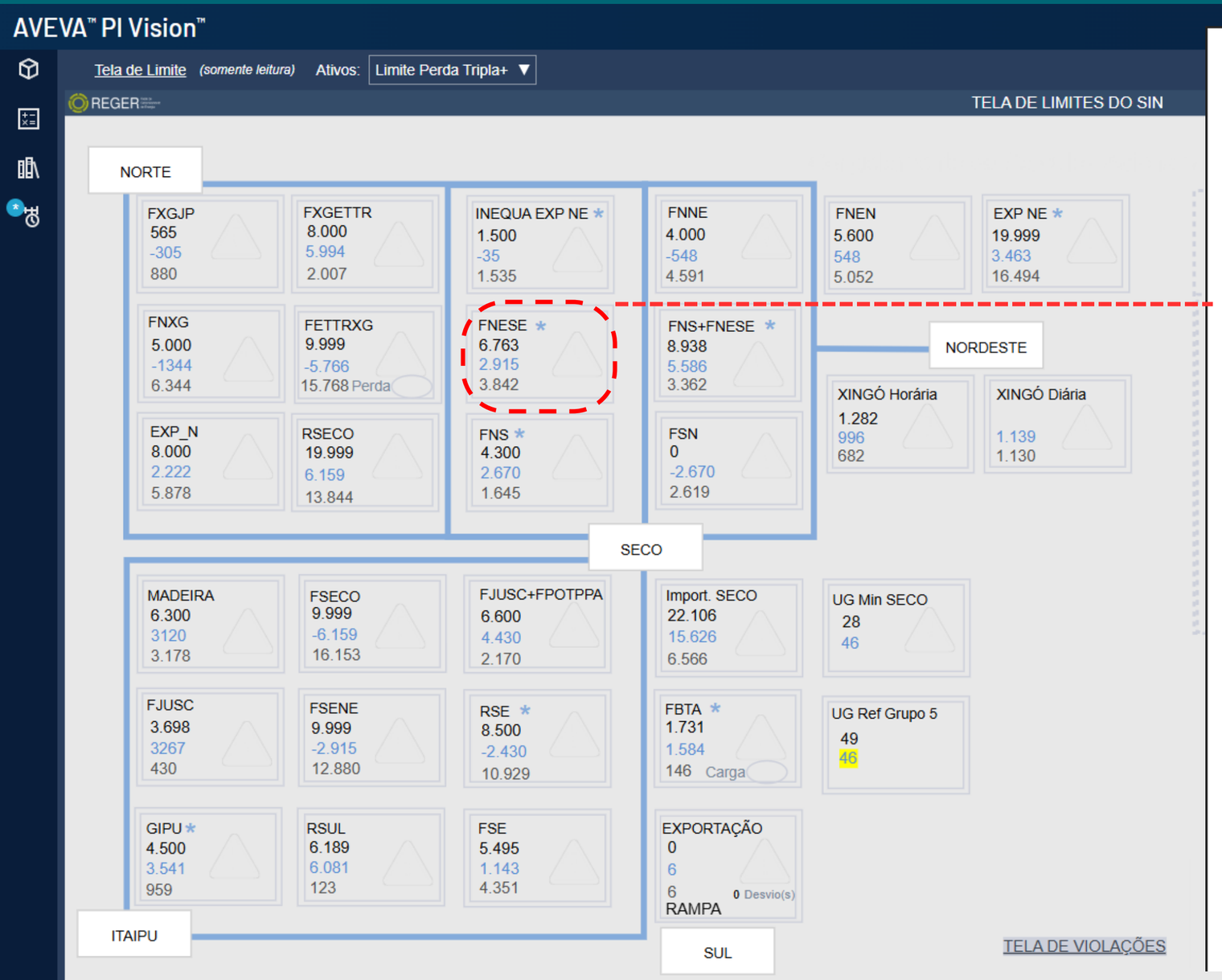
The Start | Power Flow Limits: Regional Constraints and Calculated Conditions

Operador Nacional do Sistema Elétrico



The Start | Power Flow Limits: Regional Constraints and Calculated Conditions

Operador Nacional do Sistema Elétrico



Operador Nacional do Sistema Elétrico

Manual de Procedimentos da Operação - Módulo 5 - Submódulo 5.12

Alterado pela(s) MOP(s): MOP/ONS 580-S/2024; MOP/ONS 119-S/2025; MOP/ONS 124-S/2025;

Instrução de Operação	Código	Revisão	Item	Vigência
Operação Normal da Interligação Sudeste / Nordeste	IO-ON.SENE	75	3.1.1.1.	19/03/2025

5.1.2.1. CONDICIONANTES E REDUÇÕES QUE DEVEM SER APLICADAS AOS VALORES DOS LIMITES DE FNESE DEFINIDOS NA TABELA DO ITEM ANTERIOR:

1. Para operação com uma diferença entre os bipolos igual ou inferior a 1.000 MW

Somatório (FXGET + FXGTR) (MW)	Redução nos limites de FNESE (MW)
≤ 7.000	0,3 (F_{XGTR} - F_{XGET}) + 300
> 7.000	Não há redução

Nota: Considera somente resultado positivo

2. Para operação com uma diferença entre os bipolos superior a 1.000 MW

Redução nos limites de FNESE (MW)
0,60 [Módulo (F_{XGET} - F_{XGTR})]

3. Condicionantes e reduções nos limites de FNESE, referentes ao Fluxo Juscelino (FJUSC)

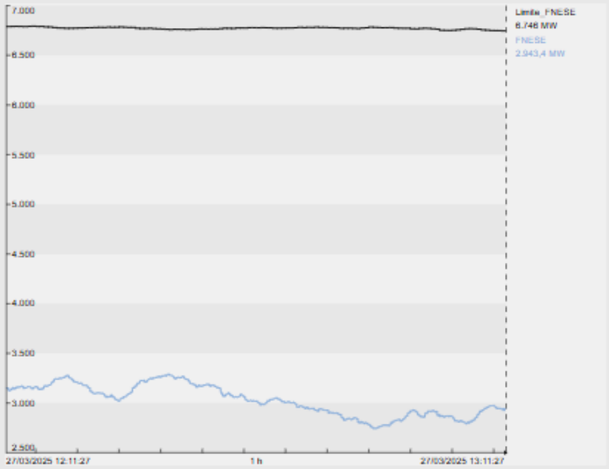
Somatório (F_{XGET} + F_{XGTR}) (MW)	Redução nos limites de FNESE (MW) (1)		
	Carga SIN ≤ 76 GW	76 < Carga SIN ≤ 92 GW	Carga SIN > 92 GW
≤ 2.000	Não há redução	Não há redução	Não há redução
2.000 < F_{XGET} + F_{XGTR} ≤ 6.000	0,25 x (FJUSC – 2.400) (1)	0,25 x (FJUSC – 2.700) (1)	0,25 x (FJUSC – 3.000) (1)
> 6.000	1,61 x (FJUSC – 2.100) (1)	1,61 x (FJUSC – 2.400) (1)	1,61 x (FJUSC – 2.700) (1)

(1) A redução deve ser aplicada apenas para **UFV SIN > 1.000 MW** e quando o resultado for positivo.

3.1. Caso o resultado da inequação da tabela anterior seja positivo, para o controle da folga no limite de FNESE deve-se utilizar a combinação simultânea das sensibilidades das usinas no FNESE e do efeito do condicionante do FJUSC no limite.

The Start | **PI Vision** provides real-time data and insights, forming the foundation for the solution

ONS Operador Nacional do Sistema Elétrico



Limite FNESE
6.746 MW
27/03/2025 13:11:00

FNESE
2.943 MW
27/03/2025 13:11:21

LIMITE
VERIFICADO

Limite FNESE (final)

6.746 MW

Redução SGIs:	0 MW
Limite SGI/MOP Fixo:	19.999 MW

IO-ON.SENE Item 5.1.2.

F_XGET + F_XGTR:	5.994 MW
Tabela 5.1.2.	7.000 MW
Redução - Dif. entre Bipolos < 1000 MW	2 MW
Redução - Dif. entre Bipolos > 1000 MW	0 MW
Redução referente a FJUSC	83 MW
FJUSC 3.333 MW	UFV SIN 11.293 MW
Carga do SIN 92.037 MW	
Redução Tensões (BP XNG>1000MW)(*):	0 MW
SGI Penalização Bipolo Xingu	0 MW
Limite FNESE (após penalização):	6.815 MW

IO-ON.SENE Item 5.1.3.

Fluxo Norte para Xingu	-1.374 MW
Tabela 5.1.3.	19.999 MW
Redução referente a FJUSC	0 MW
Redução Tensões (FNXG>1000MW)(*):	0 MW
SGI Penalização FNXG	0 MW
Limite FNESE (após penalização):	19.899 MW

IO-OC.8XG

Estado XGET	Estado XGTR	UM BIPOLO
2	2	0

Tabela IO-OC.8XG 1 polo fora	3.400 MW
Tabela IO-OC.8XG 1 bipolo fora	3.000 MW
Redução referente a FJUSC	233 MW
Redução (desequilíbrio > 1000 MW)	0 MW
IO-OC.8XG 1 polo fora (após penalização)	19.999 MW
IO-OC.8XG 1 bipolo fora (após penalização)	19.999 MW

IO-ON.N.5N

Item 6.2.2. (Se fluxo de TC p/ XG e XG p/ SPL)

Fluxo Tucuruí-Xingu:	-179 MW
Fluxo Xingu-Serra Pelada	1.182 MW
F_XGET + F_XGTR:	5.994 MW
Limite FNESE:	19.999 MW

IO-ON.SENE Item 5.1.7

Reduções aplicadas aos itens 5.1.2 e 5.1.3 da IO-ON.SENE

Grupo	Equipamento	Estado	MVAr
Redução Grupo 1 0	Xingó Nº CSs Xingó Nº UGs CS 1 Janaúba 3 CS 2 Janaúba 3	1 3 1 1	
Redução Grupo 2 0	CE Padre Paraíso 2 CS 1 Janaúba 3 CS 2 Janaúba 3	1 1 1	-34
Redução Grupo 3 100	Xingó Nº CSs Xingó Nº UGs CS 1 Camaçari II CS 2 Camaçari II CE Luziânia CE Sapeaçu	1 3 1 1 1 1	 -56 -56
Redução Grupo 4 0	CE Bom Jesus da Lapa II CE Morro do Chapéu II CE Gentio do Ouro CE João Neiva 2 CS 1 Camaçari II CS 2 Camaçari II	1 1 1 1 1 1	-72 -27 -9 -38

Subestação		Faixa Inferior
Buritirama	532,2 kV	525
P. Paraíso 2	535,0 kV	530
Luziânia	540,9 kV	525
Arinos 2	539,2 kV	530
Rio das Éguas	539,4 kV	525

* A redução no limite é de 100 MW
(para cada intervalo de 5 kV abaixo
do limite inferior da faixa de tensão)
obs: aplicar a redução APENAS considerando a maior violação

The Solution

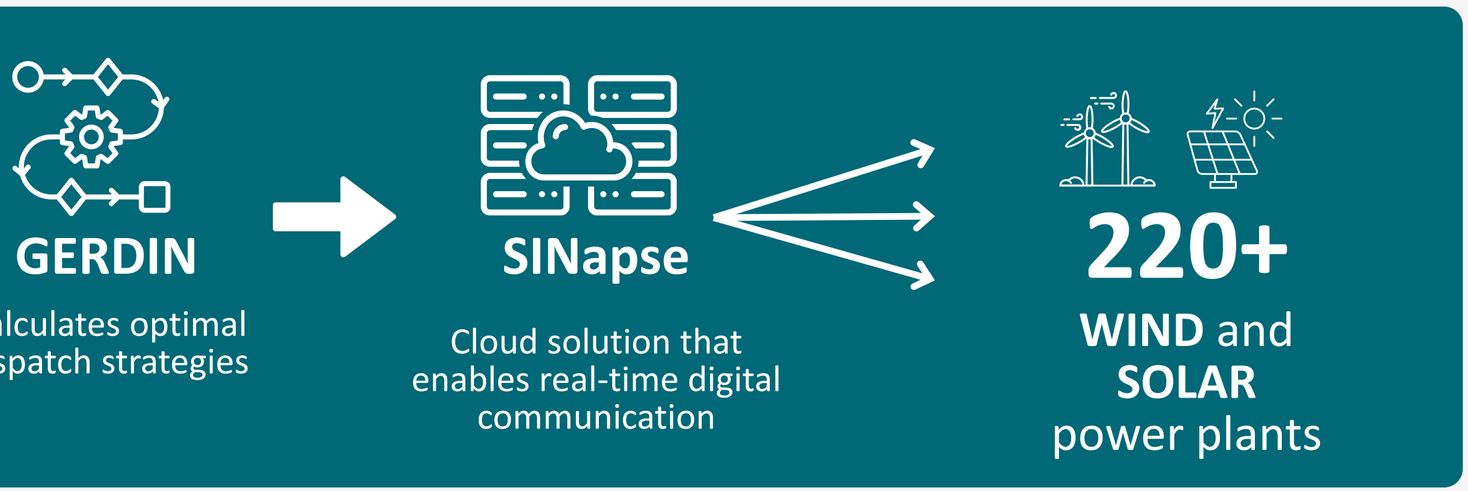
PI System

Provides data-driven decisions

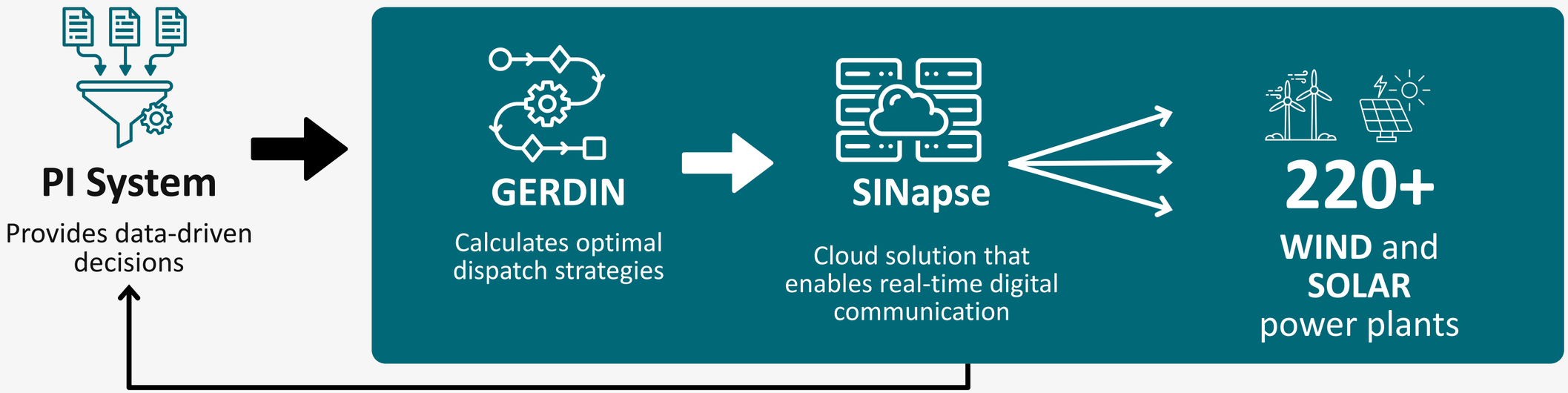
The Solution

PI System

Provides data-driven decisions



The Solution



PI System continuously monitors the performance of **GERDIN, SINapse**, and over **220 wind and solar power plants**

Technologies Used

AVEVA

Firebase Realtime Database

aws

Azure DevOps

mongoDB.

WAF

OPENSHIFT

kafka

redis

Manual Process

Phone Calls & Calculations

40 Wind/Solar Plants

18 Phone Calls

18 Companies

40 Minutes to Command

VS

Automated Process

PI System + Cloud Solution

220 Wind/Solar Plants

220 Digital Commands

41 Companies

<1 Minute to Command

Results & Impact

98%

Communication Efficiency

Improvement in operational communication efficiency

211 GWH

Energy Maximized

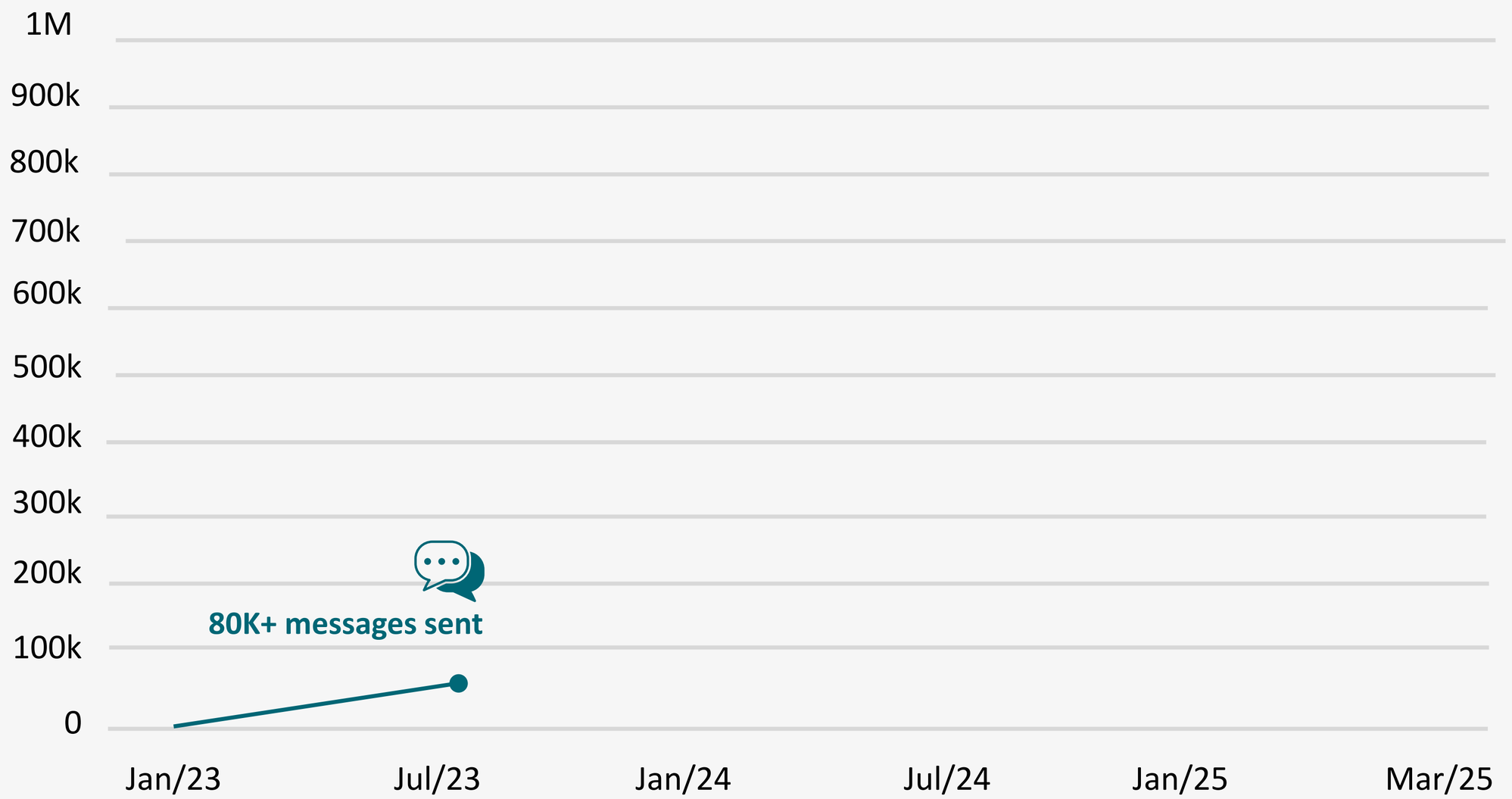
Wind and solar energy faster recovered in 2024

$11.4M

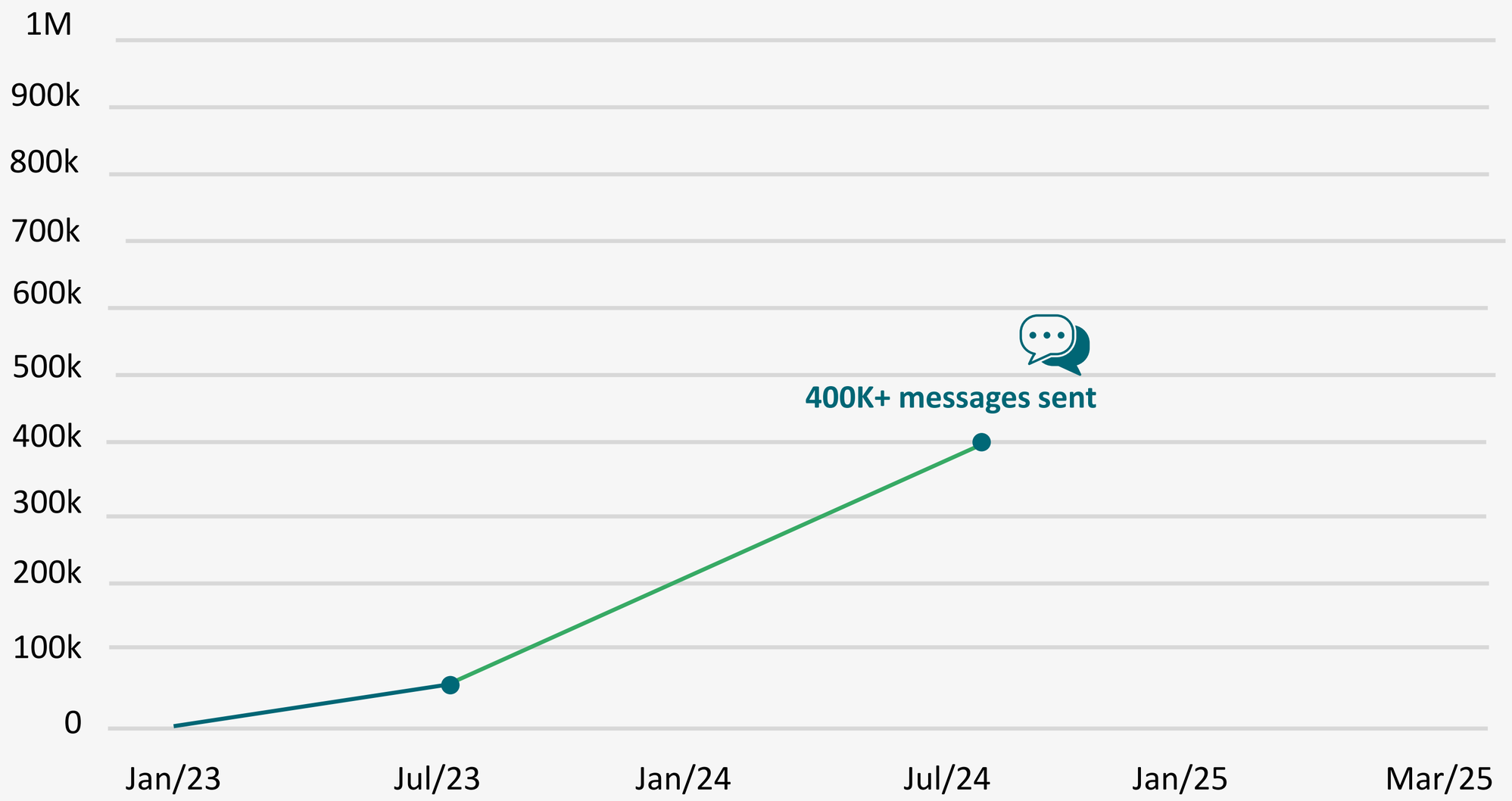
Cost Savings

Savings by maximizing renewable energy

Total Request Sent via SINapse
(Cumulative 2023 - 2025)



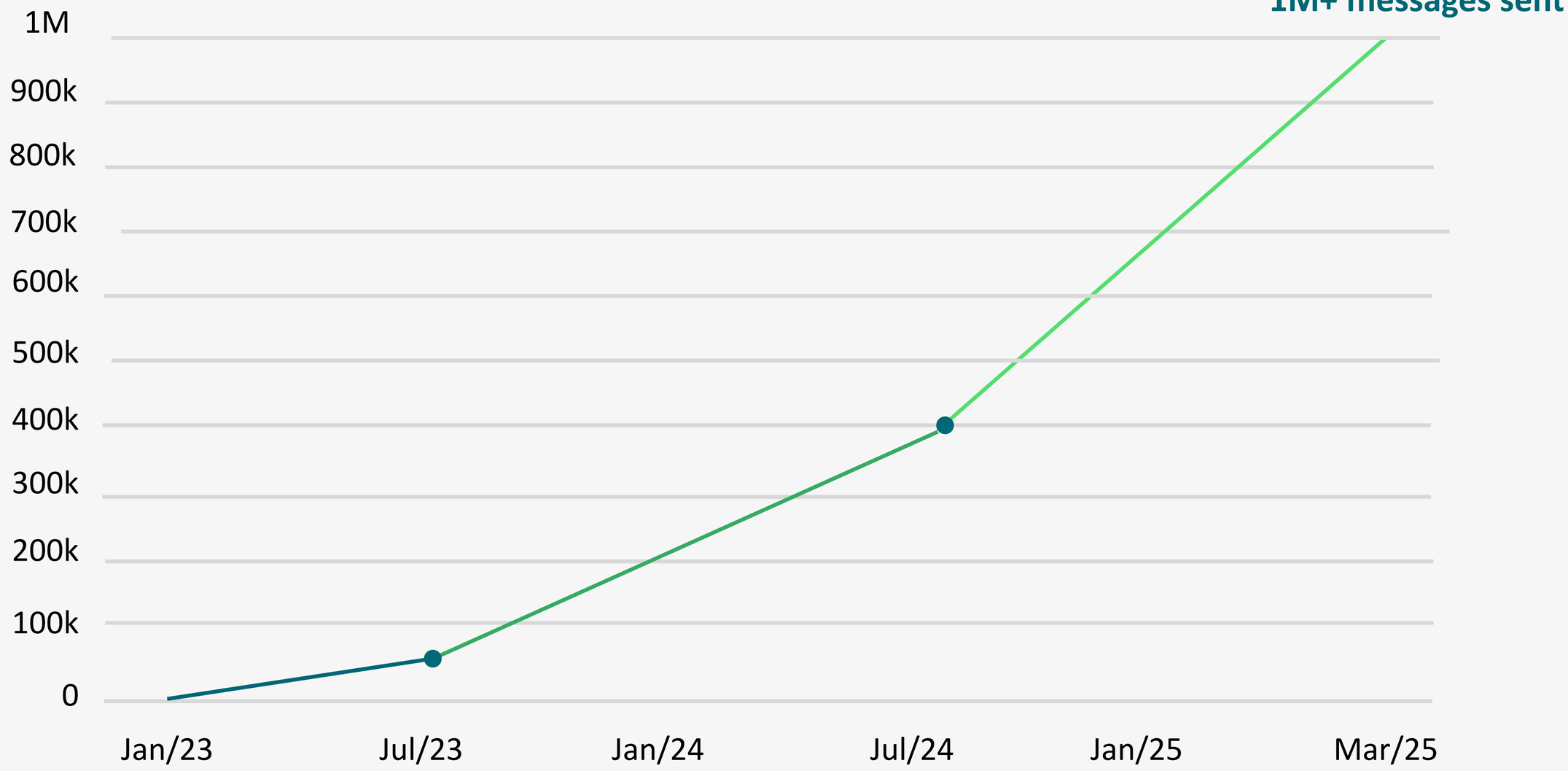
Total Request Sent via SINapse
(Cumulative 2023 - 2025)



Total Request Sent via SINapse
(Cumulative 2023 - 2025)

ONS Operador Nacional do Sistema Elétrico

1M+ messages sent

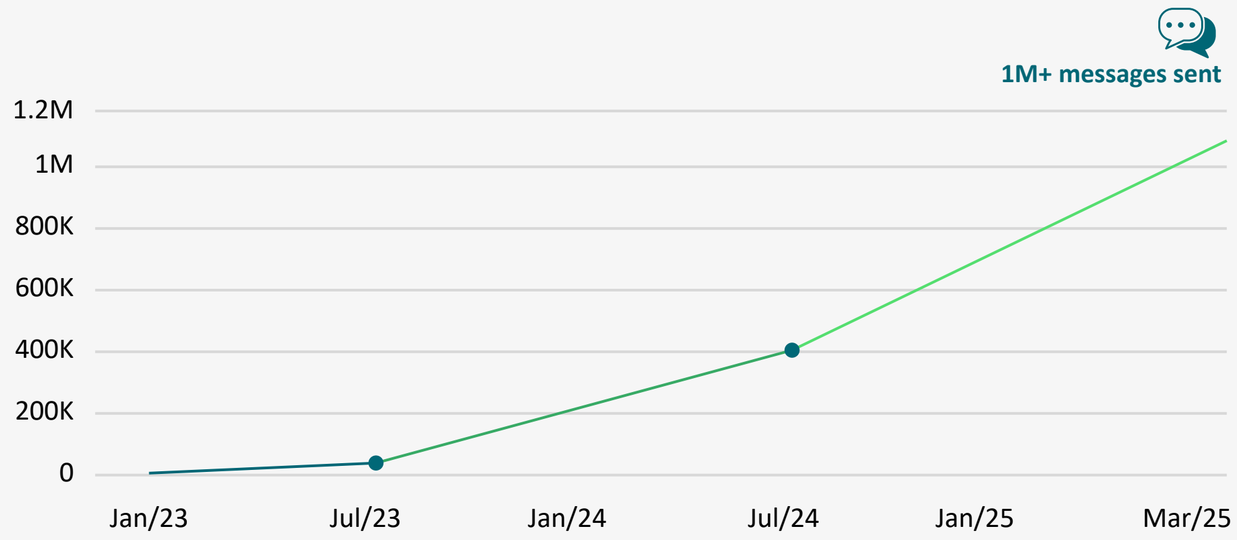


Scaling Renewable Energy Coordination

1 million accumulated messages sent via SINapse by March 2025.

83% of requests were for wind and solar generation, automated through PI System + Solution.

Total Request Sent via SINapse
(Cumulative 2023 - 2025)



Next Steps

From ONS to the Entire Sector – A scalable model transforming how renewable energy is managed.

SINapse API
Current Expansion

- **SINapse API is Scaling Now**
  Companies are already integrating it into their own solutions

CONNECT
Integrator for Business Analytics
Under Evaluation

- **CONNECT and Integrator Under Evaluation**
  Potential future tool for real-time critical data exchange

POWER AND UTILITIES | BRAZIL

ONS Brazil maximizes renewable energy utilization and grid efficiency with AVEVA

Challenge

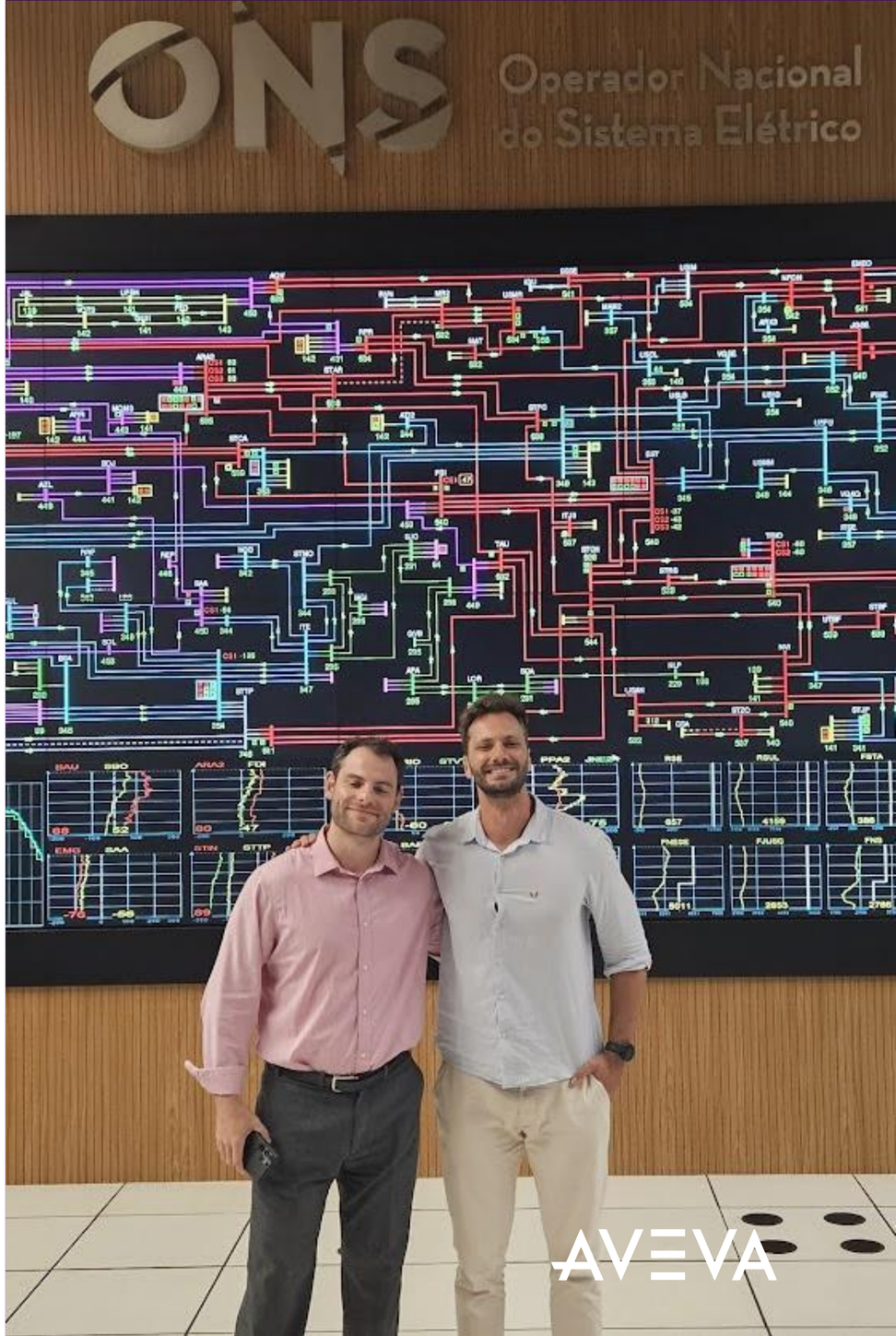
- To manage real-time dispatch of renewable energy while maintaining grid stability
- Reduce reliance on manual phone-based coordination of remote assets, which is time consuming and delaying dispatch decisions
- Avoid curtailments and ensure fair distribution of wind and solar energy across regions

Solution

- Deployed AVEVA™ PI System™, and proprietary tools GERDIN and SINapse, to automate energy dispatch and optimize real-time grid management.

Results

- **98% improvement in operational communication efficiency, allowing real-time digital dispatch**
- **211,000 MWh of renewable energy saved by minimizing curtailments and prioritizing clean energy**
- **$11.4 million USD in cost savings in 2024 due to improved energy efficiency and reduced reliance on fossil fuels**



Q&A

Join the Q&A and get your questions answered now!

Speaker
Kaio Kopko
Engineering Product Manager
kaio.kopko@ons.org.br

Speaker
Leonardo Bezerra
Senior Business & Systems Analyst
lbezerra@ons.org.br

ONS Operador Nacional do Sistema Elétrico

Thank You!

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