La Potencia sin Control no sirve de nada

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Estabilidad y Control de Sistemas Eléctricos de Potencia

Deptos: Sistemas y Control/Potencia
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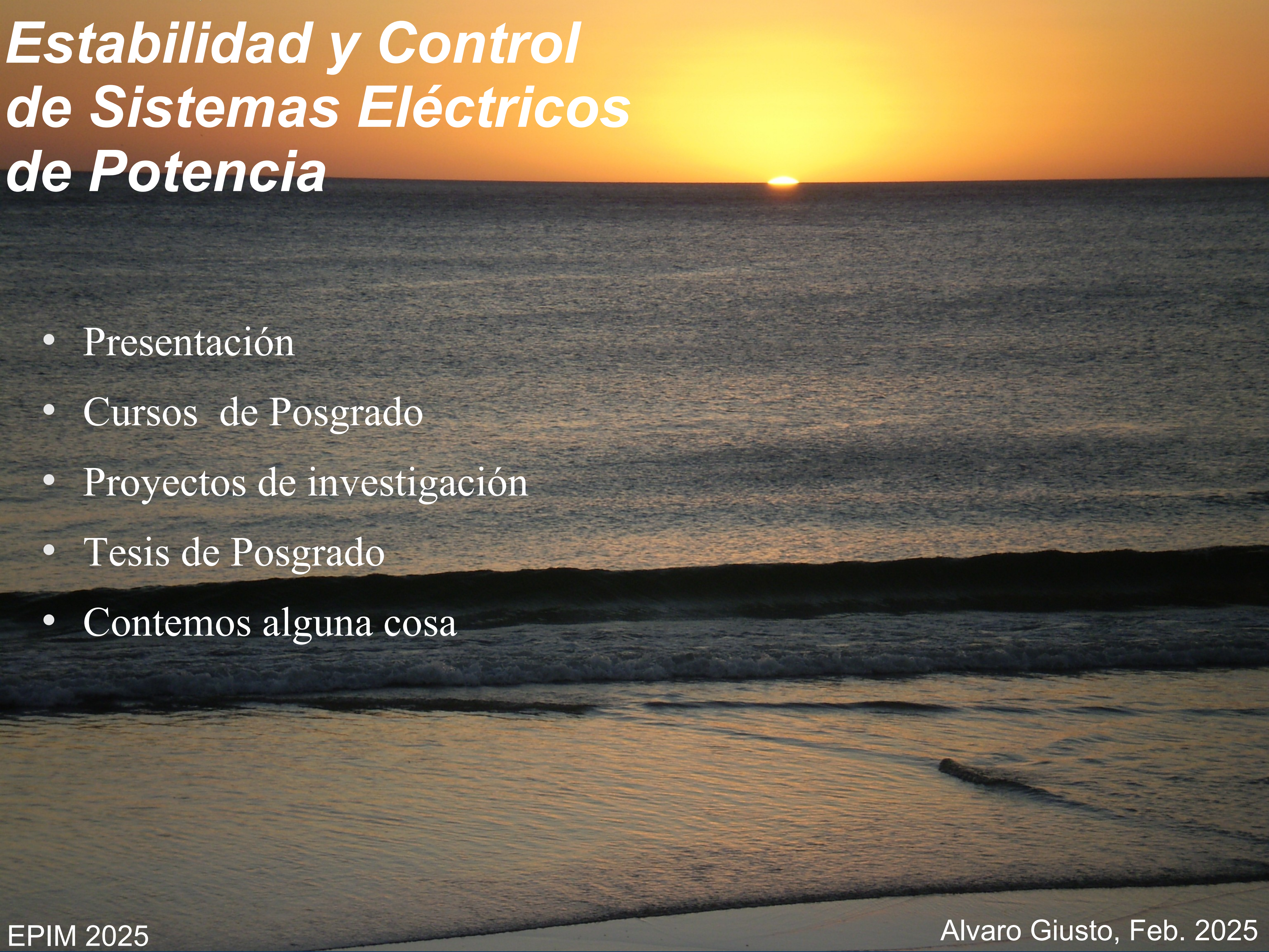
Universidad de la República

EPIM 2025

Alvaro Giusto, Feb. 2025



Estabilidad y Control de Sistemas Eléctricos de Potencia

- Presentación
- Cursos de Posgrado
- Proyectos de investigación
- Tesis de Posgrado
- Contemos alguna cosa

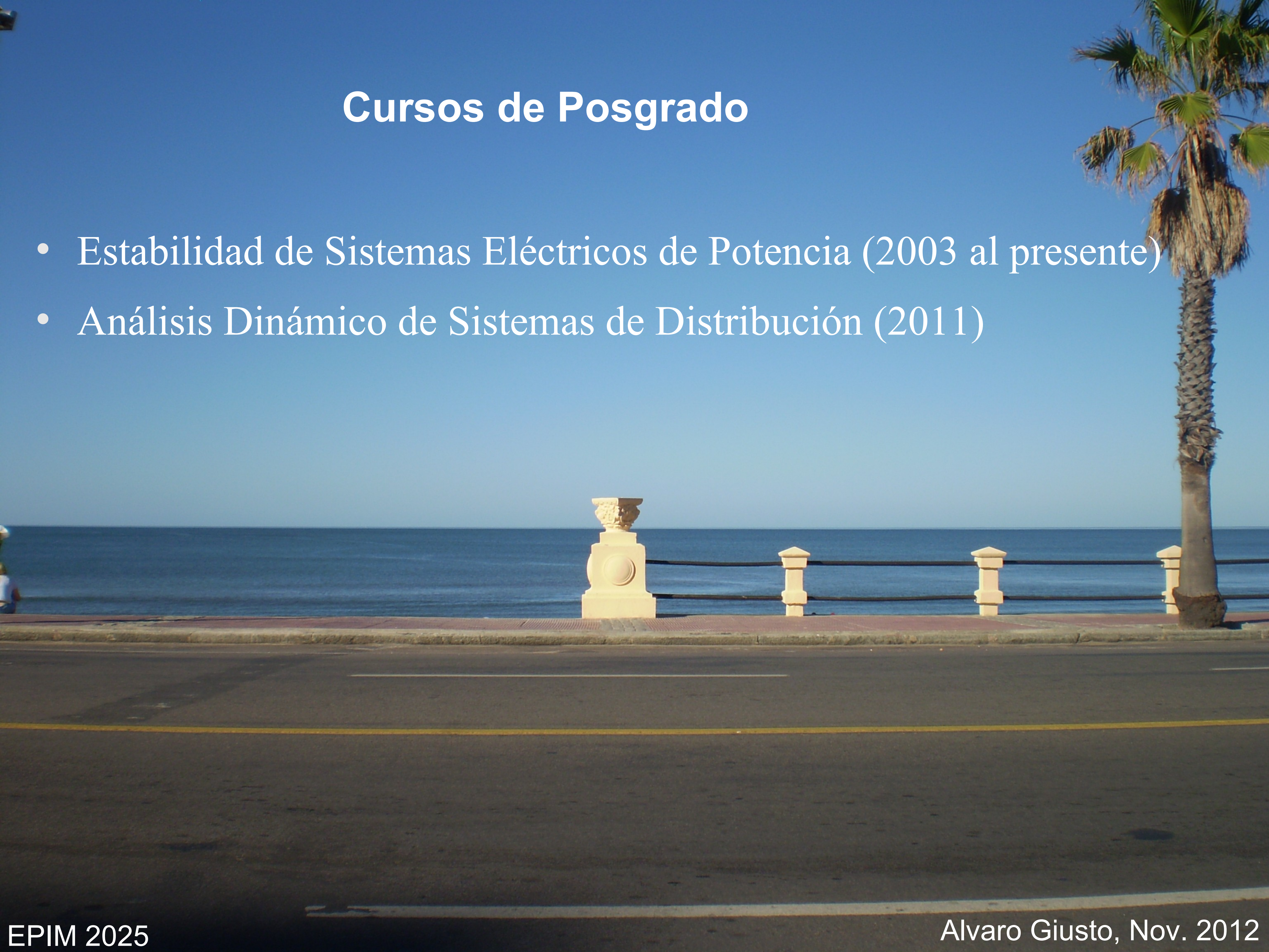
Presentación

- Creado en 1999
- Dos doctores
- Cinco magísters
- + de 100 egresados de curso
  de grado/posgrado/
  actualización profesional
- Más de 20 publicaciones
- Modelado, control,
  máquinas eléctricas,
  protecciones, gen. eólica

Pero,
¿de qué se trata?

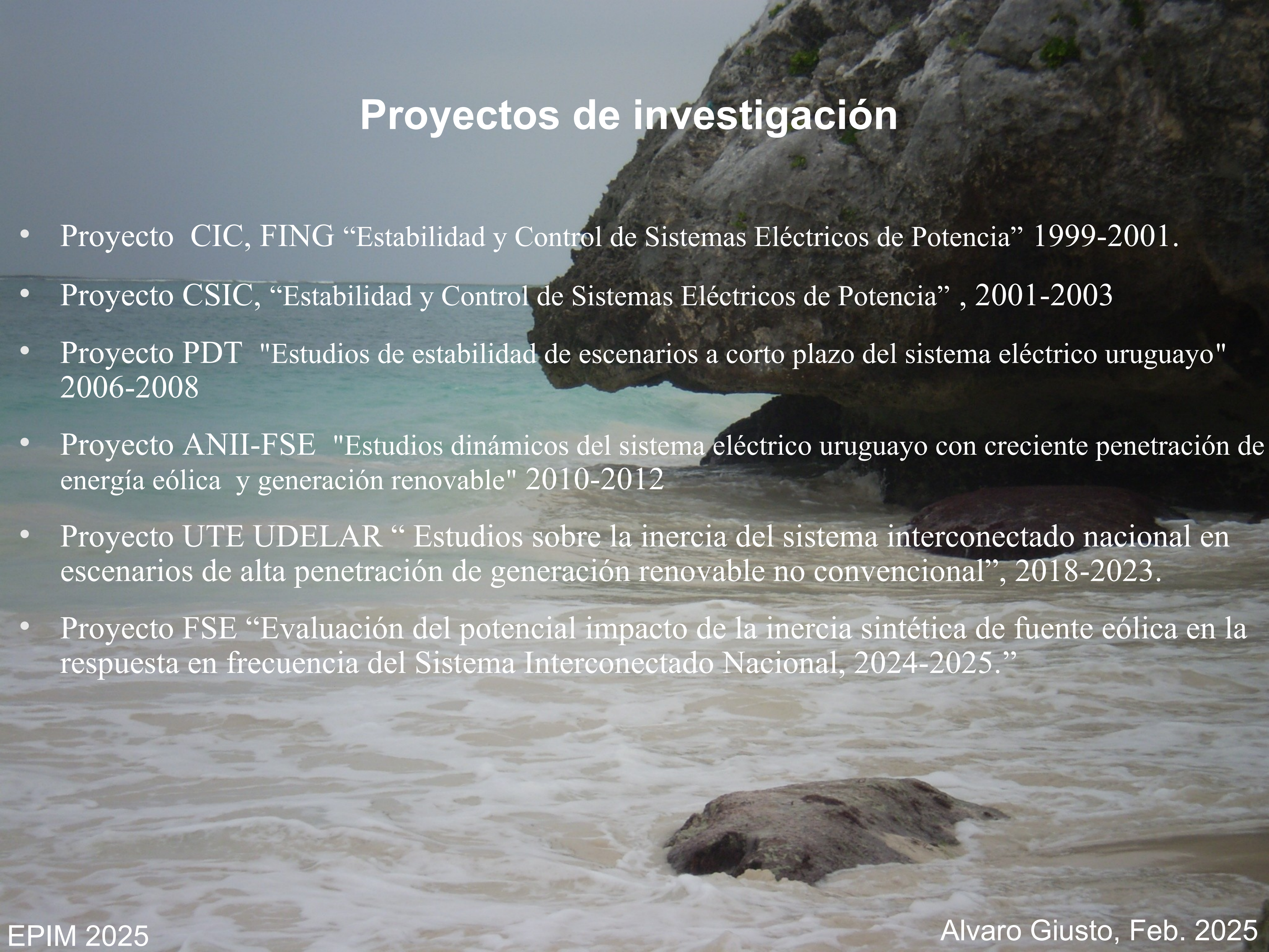
Estabilidad y Control de Sistemas Eléctricos de Potencia

- Análisis de estabilidad, control de oscilaciones,
- Sistemas de protección,
- Análisis dinámico de los próximos escenarios del sistema eléctrico nacional.
- Estimación de inercia, inercia sintética.



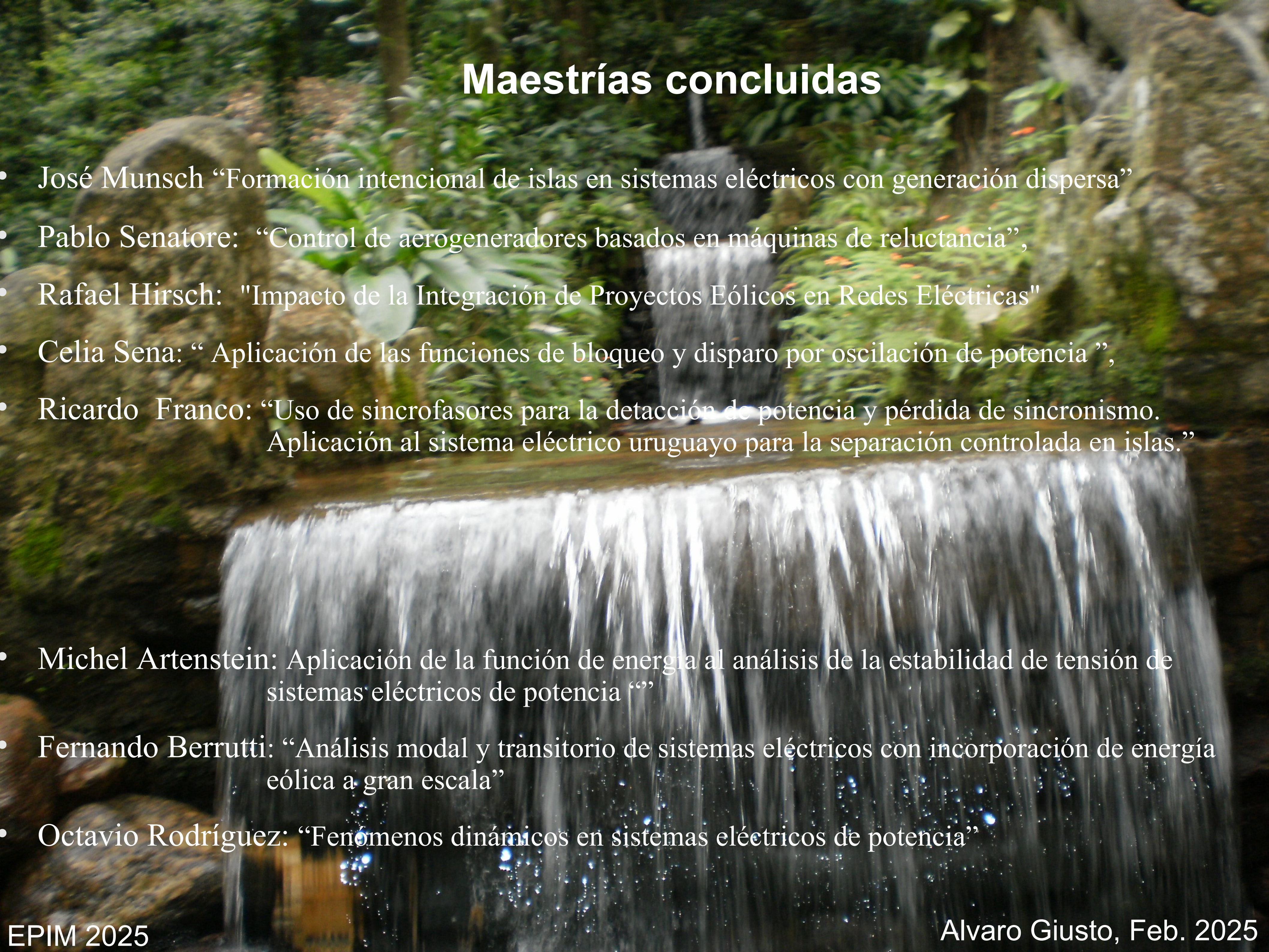
Cursos de Posgrado

- Estabilidad de Sistemas Eléctricos de Potencia (2003 al presente)
- Análisis Dinámico de Sistemas de Distribución (2011)



Proyectos de investigación

- Proyecto CIC, FING “Estabilidad y Control de Sistemas Eléctricos de Potencia” 1999-2001.
- Proyecto CSIC, “Estabilidad y Control de Sistemas Eléctricos de Potencia” , 2001-2003
- Proyecto PDT "Estudios de estabilidad de escenarios a corto plazo del sistema eléctrico uruguayo" 2006-2008
- Proyecto ANII-FSE "Estudios dinámicos del sistema eléctrico uruguayo con creciente penetración de energía eólica y generación renovable" 2010-2012
- Proyecto UTE UDELAR “ Estudios sobre la inercia del sistema interconectado nacional en escenarios de alta penetración de generación renovable no convencional”, 2018-2023.
- Proyecto FSE “Evaluación del potencial impacto de la inercia sintética de fuente eólica en la respuesta en frecuencia del Sistema Interconectado Nacional, 2024-2025.”



Maestrías concluidas

- José Munsch “Formación intencional de islas en sistemas eléctricos con generación dispersa”
- Pablo Senatore: “Control de aerogeneradores basados en máquinas de reluctancia”,
- Rafael Hirsch: "Impacto de la Integración de Proyectos Eólicos en Redes Eléctricas"
- Celia Sena: “ Aplicación de las funciones de bloqueo y disparo por oscilación de potencia ”,
- Ricardo Franco: “Uso de sincrofasores para la detacción de potencia y pérdida de sincronismo. Aplicación al sistema eléctrico uruguayo para la separación controlada en islas.”

- Michel Artenstein: Aplicación de la función de energía al análisis de la estabilidad de tensión de sistemas eléctricos de potencia “”
- Fernando Berrutti: “Análisis modal y transitorio de sistemas eléctricos con incorporación de energía eólica a gran escala”
- Octavio Rodríguez: “Fenómenos dinámicos en sistemas eléctricos de potencia”

Maestrías en marcha

- Aldo Rondoni: “Gestión de la demanda en sistemas de distribución.”
- Marcelo Rey: “Gestión de la demanda en sistemas de distribución. ”
- Alejandro Alvarez: “Estimación del impacto de la inercia sintética de origen eólico en el sistema eléctrico uruguayo”
- Nicolás Yedrzejewski “Regulación de frecuencia de sistemas eléctricos de baja inercia. ”

Contemos alguna cosa...

Análisis modal/ Estabilidad a pequeñas perturbaciones

Tolerancia a huecos

Inercia sintética

Análisis Modal del Sistema Eléctrico Uruguayo

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Universidad de la República - Uruguay

Proyecto PDT 47/05

Encuentro de Potencia, Instrumentación y Medidas, IEEE Uruguay

Oct. 2008

Gracias!

Análisis Modal del Sistema Eléctrico Uruguayo

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Oct. 2008

Esquema

- Introducción
- Descripción del modelo
- Análisis modal
- Validación
- Mitigación de oscilaciones
- Conclusiones

Introducción

Proyecto PDT 47/05 *Estudios de estabilidad de escenarios a corto plazo del sistema eléctrico uruguayo*.

Equipo de trabajo: Michel Artenstein, Ricardo Franco
Alvaro Giusto, Pablo Monzón, Celia Sena

Facultad de Ingeniería

Estrecha cooperación por parte de UTE:

- Planificación de la Explotación y Estudios
- Estudios y Proyectos
- Protecciones de Transmisión

Introducción

Diferentes conceptos de estabilidad:

- transitoria,
- de tensión, de ángulo,
- Estabilidad frente a pequeñas perturbaciones

Capacidad del sistema eléctrico de mantener el sincronismo frente a pequeñas perturbaciones.

Porqué importa?

- Condición necesaria para estabilidad transitoria.
- Calidad de servicio.
- Aporta información dinámica relevante.
- Hay poderosas herramientas de análisis.

Introducción

Modelo del sistema

$$\dot{x} = f(x, y)$$
$$0 = g(x, y)$$

x: variables de estado: δ, ω
y: variables de enlace: V,θ

Linealización:

$$\dot{x} = Ax$$
$$x(0) = x_0$$

Se estudia la respuesta a una condición inicial fuera del equilibrio.

Introducción

Instrumentos

Autovalores $\lambda_i \in C$,
autovectores derechos (*mode shapes*) $\vec{v}_i \in C^n$,
e izquierdos $\vec{u}_i \in C^n$.

$$A\vec{v}_i = \lambda_i \vec{v}_i$$
$$\vec{u}_i A = \lambda_i \vec{u}_i \quad i = 1..\mathrm{n}$$

Introducción

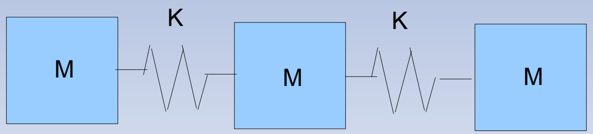
Modo de oscilación

- Par $\lambda_i \in C, \vec{v}_i \in C^n$

El sistema responde frente a una perturbación con una superposición de modos:

$$\vec{x}(t) = \sum_{i=1}^{n} \alpha_i e^{\lambda_i t} \vec{v}_i$$

Ejemplo



Descripción del modelo

Sistema interconectado argentino uruguayo

- Red equivalente sistema argentino: 67 barras, 28 máq.
- Total: 360 barras, aprox. 50 máq
- Máquinas sincrónicas de orden 5 o 6
- Modelo PSS/E de UTE,
  migrado a DSAT (Powertech Labs).

Descripción del modelo

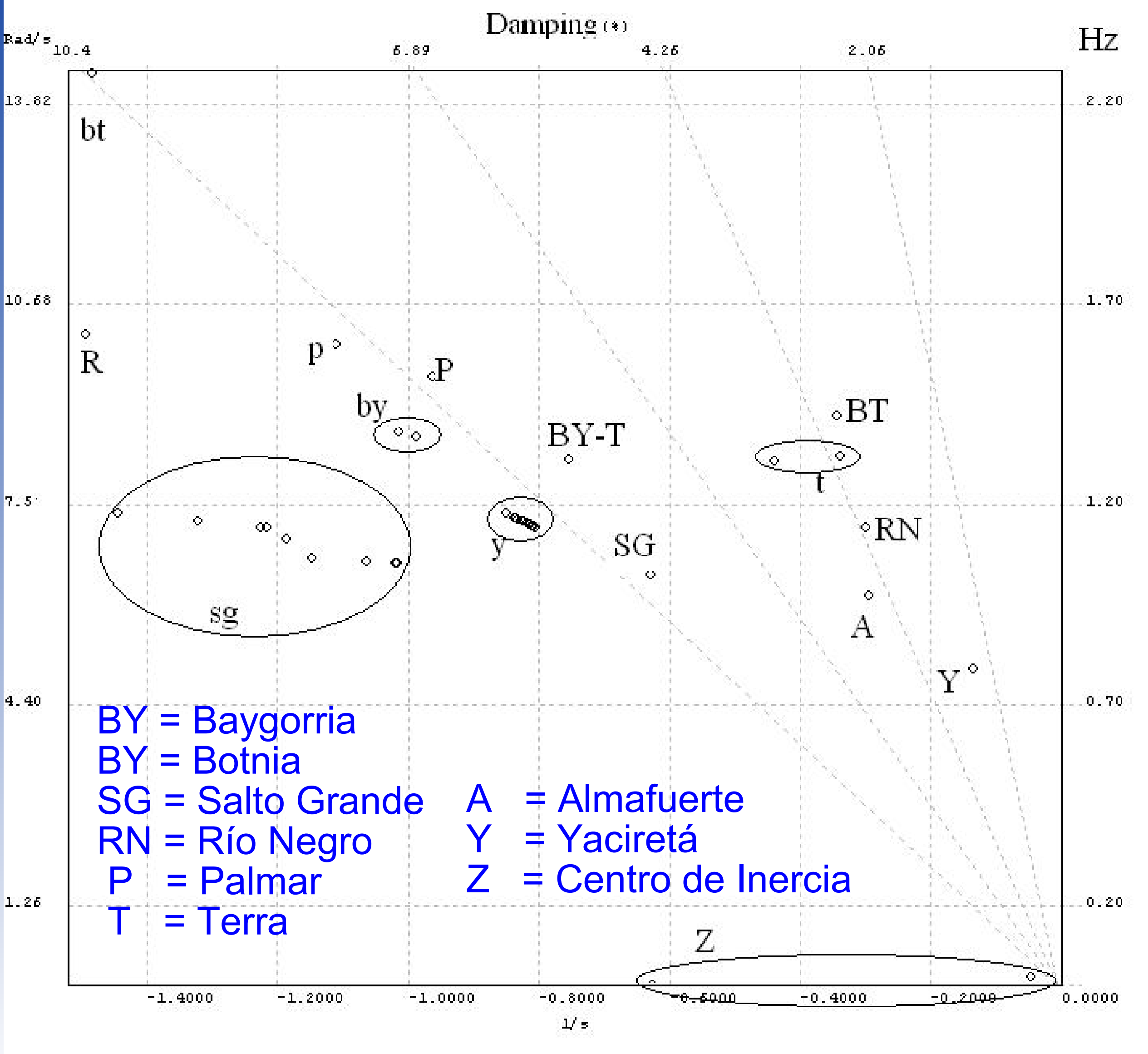
Escenarios estudiados

- Máximo hidráulico 2010
- Máximo térmico 2010
- Máximo 2004, esencialmente hidráulico

Contingencias

- Línea Young-Terra, 150 kV
- Línea San Javier-Fray Bentos, 150 kV
- Barra Trinidad, 150 kV
- Línea San Javier-Salto Grande, 500 kV
- Conexión SG Uruguay-SG Argentina, 500 kV

Análisis modal



BY = Baygorria
BY = Botnia
SG = Salto Grande
RN = Río Negro
P = Palmar
T = Terra

A = Almafuerte
Y = Yaciretá
Z = Centro de Inercia

Modos electromecánicos, escenario hidráulico 2010

Análisis modal

Escenario 2010

Modo Río Negro $\omega \approx 1.1\,Hz\,,\ \zeta \in [3.4, 4.3]$

Modo Botnia $\omega \approx 1.3\,Hz\,,\ \zeta \in [2.4, 4.2]$

Parámetros de referencia (UTE, CAMMESA)

Coeficiente ζ de amortiguación mínimo: 5%,

equivalente a un 73 % de atenuación entre picos consecutivos

Modo Río Negro

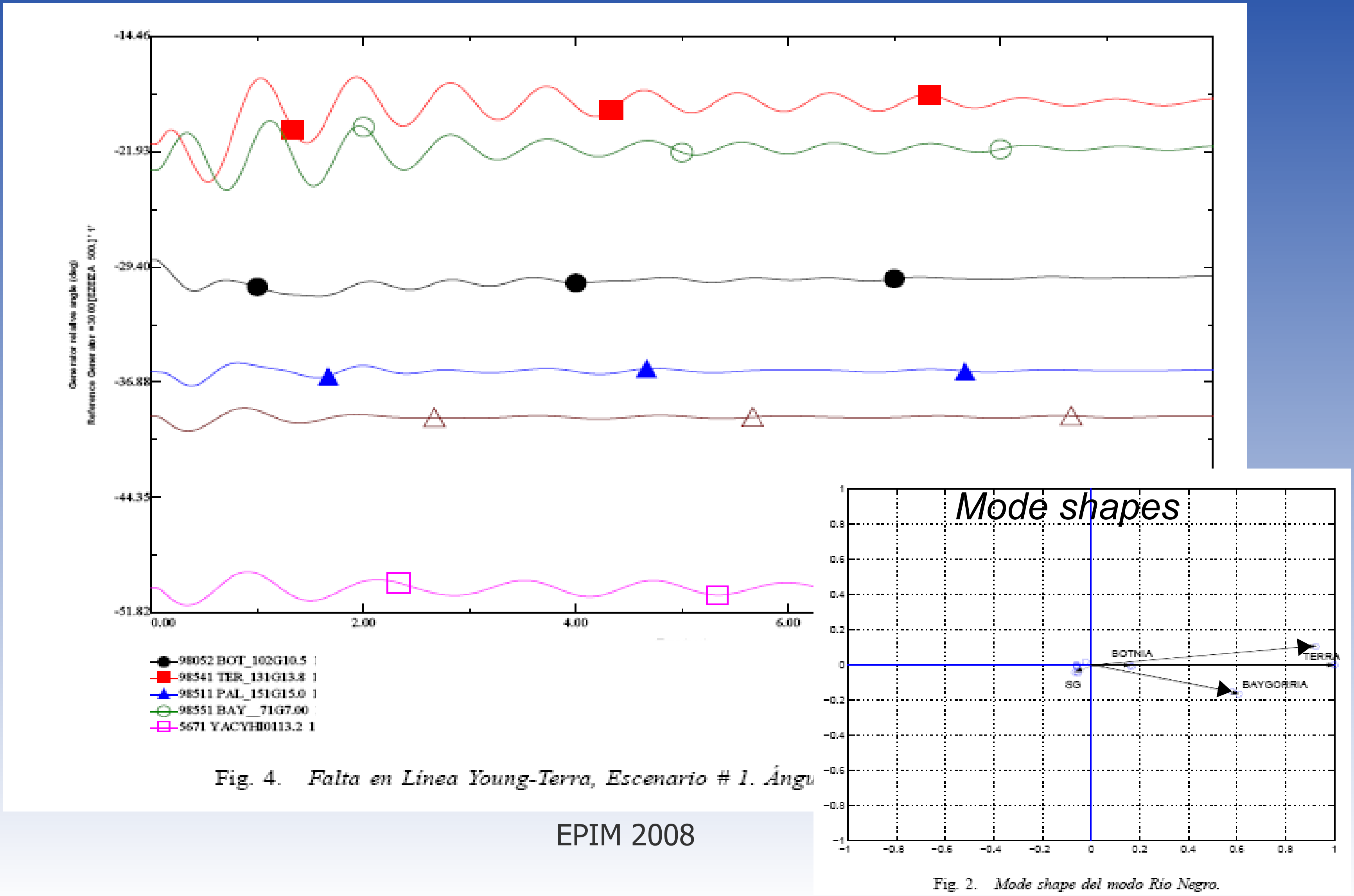


Fig. 4. *Falta en Línea Young-Terra, Escenario # 1. Ángu*

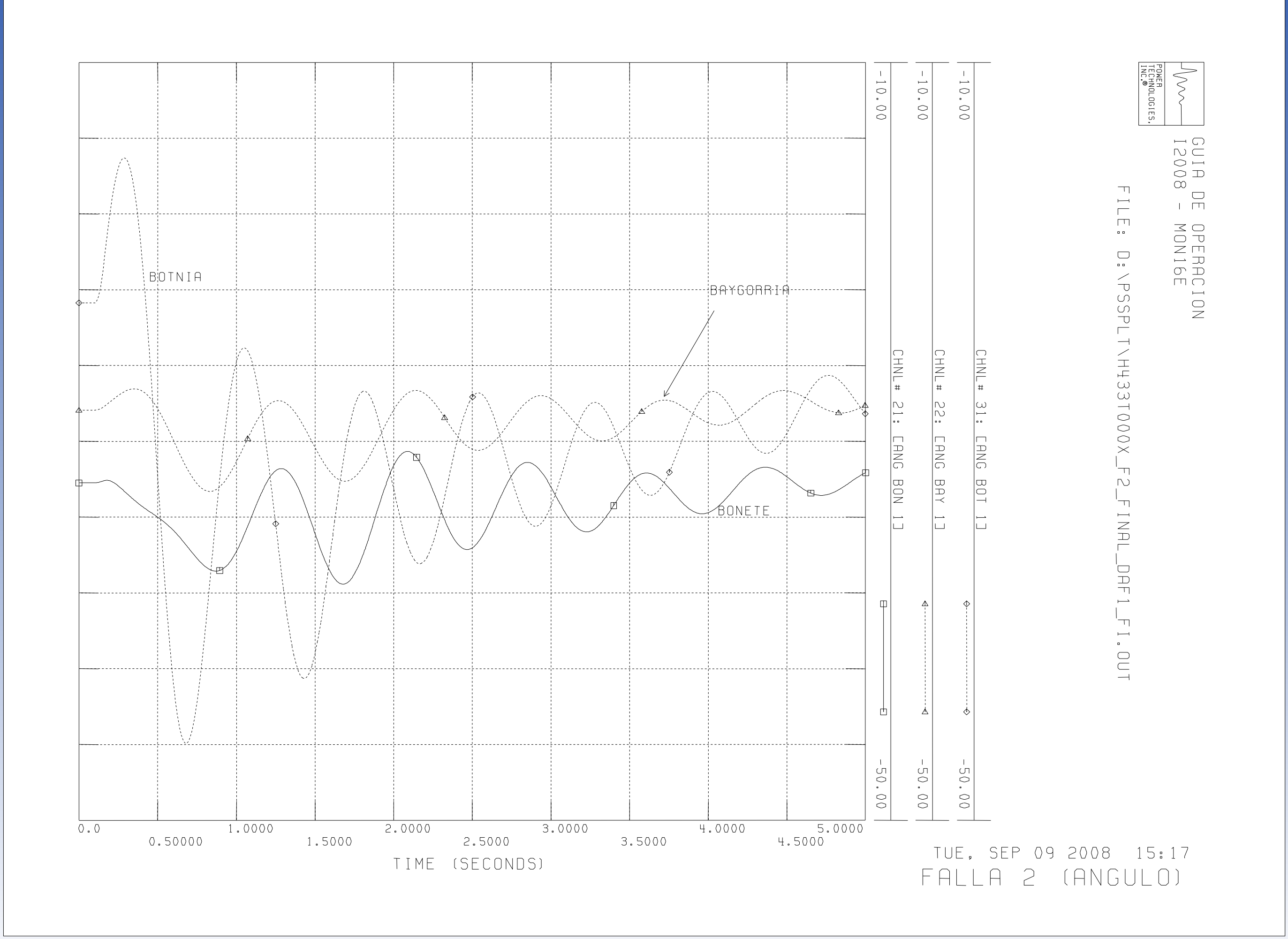
Fig. 2. *Mode shape del modo Río Negro.*

Validación

- Sobre el modelo DSAT: respuesta transitoria
- Sobre el modelo PSS/E: análisis de Prony y respuesta transitoria (Ing. A. Musetti, PEE-UTE).

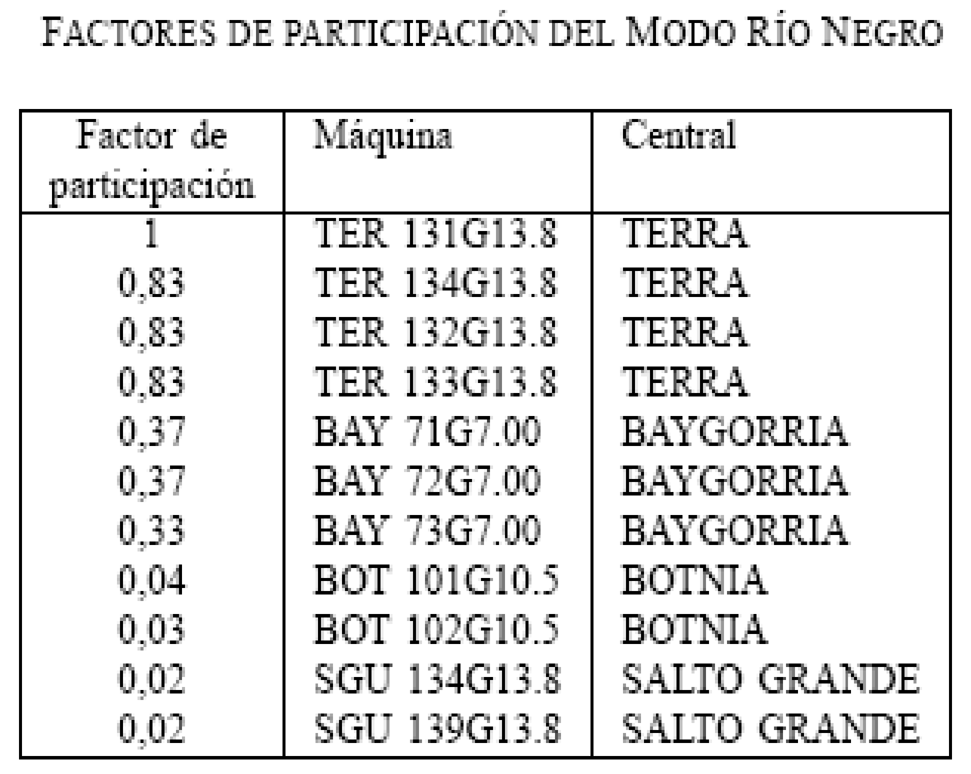
Validación

Falla Fray Bentos-San Javier. Modelo PSS/E con ajustes.



Mitigación de oscilaciones

Vemos que el modo Río Negro puede ser amortiguado eficazmente desde la Central Terra:



FACTORES DE PARTICIPACIÓN DEL MODO RÍO NEGRO

Factor de participación	Máquina	Central
1	TER 131G13.8	TERRA
0,83	TER 134G13.8	TERRA
0,83	TER 132G13.8	TERRA
0,83	TER 133G13.8	TERRA
0,37	BAY 71G7.00	BAYGORRIA
0,37	BAY 72G7.00	BAYGORRIA
0,33	BAY 73G7.00	BAYGORRIA
0,04	BOT 101G10.5	BOTNIA
0,03	BOT 102G10.5	BOTNIA
0,02	SGU 134G13.8	SALTO GRANDE
0,02	SGU 139G13.8	SALTO GRANDE

Mitigación de oscilaciones

Se sintonizó un controlador PSS (*Power System Stabilizer*) para la central Terra

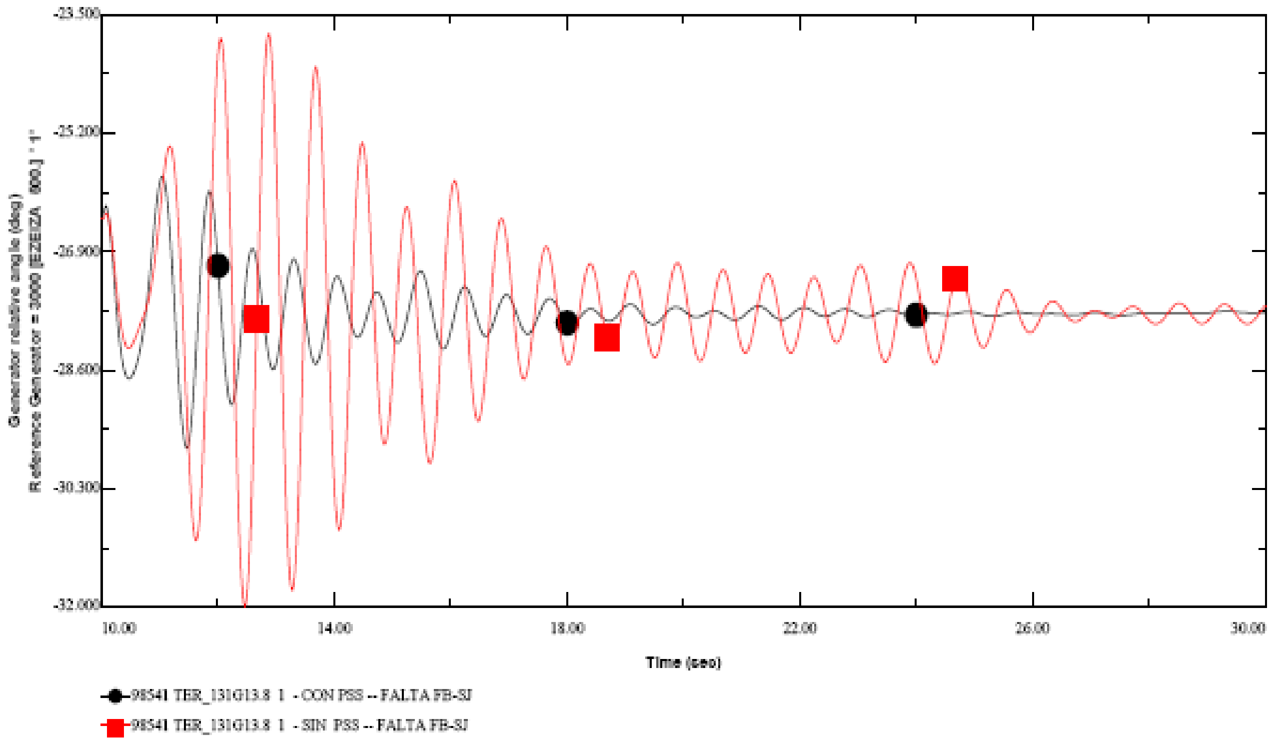


Figure 2.8: *Falta en línea FB-SJ. Ángulos de rotor con y sin PSS.*

Conclusiones

- Análisis modal del sistema uruguayo
  - frecuencias, coef. de amortiguamiento
  - *mode shapes*, fact. participación
- Validación sobre modelos no lineales,
- Validación sobre modelos PSS/E y DSAT
- Mitigación de oscilaciones mediante PSS
- Capacidad local de hacer estos estudios
- Formación de recursos humanos

Gracias por su atención!

Validación

Los dos modos de interés, de manifiesto en la respuesta transitoria

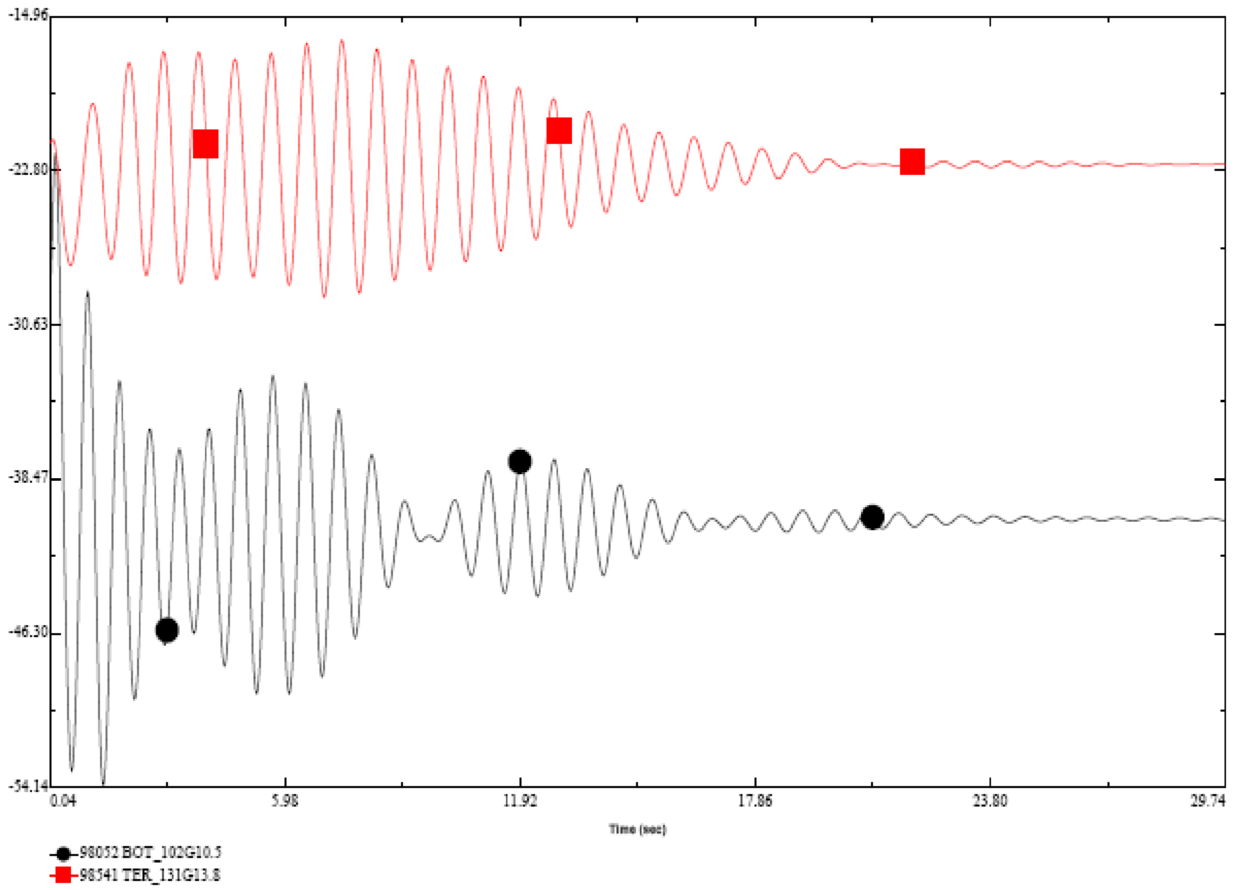


Fig. 5. *Falta en Línea Fray Bentos-San Javier, Escenario # 1. Ángulos relativos a EZEIZA*

Descripción del modelo

Porqué no usar, directamente, el modelo PSS/E?

- Objetivos de la actividad universitaria (docencia, investigación, extensión)
- Condiciones de la licencia académica del paquete.
- Objetivos concretos del trabajo
  - Investigación académica
  - No es un estudio de planificación de la red
- El modelo usado tiene el nivel de detalle necesario para los objetivos del estudio.

Modo Río Negro

Coef. de amortiguación: 4.1%,

Frecuencia: 1.1 Hz

Mode shape :

Terra y Baygorria en fase,

contra el resto.

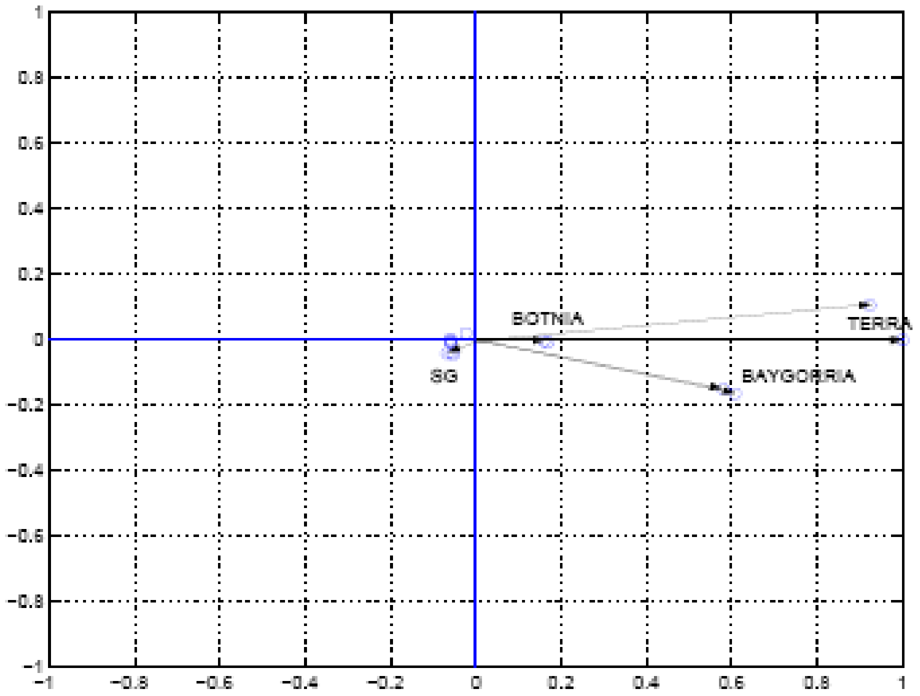
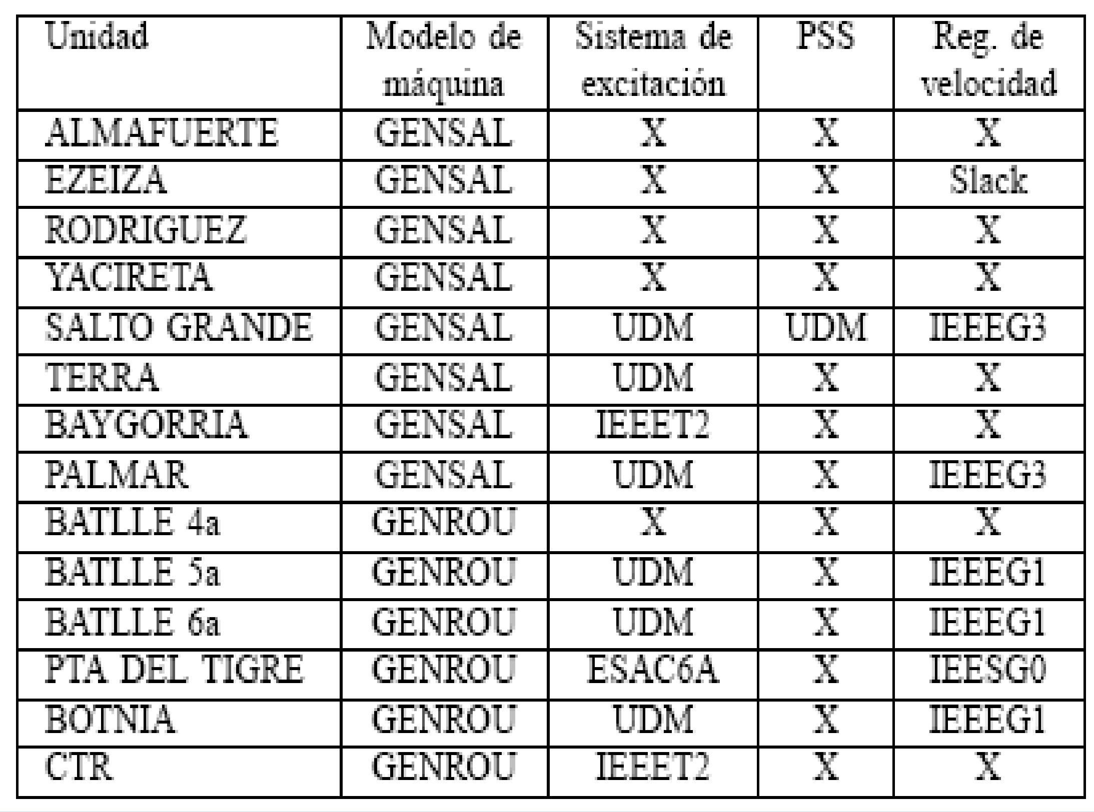


Fig. 2. *Mode shape del modo Río Negro.*

Descripción del modelo

Modelos dinámicos



Unidad	Modelo de máquina	Sistema de excitación	PSS	Reg. de velocidad
ALMAFUERTE	GENSAL	X	X	X
EZEIZA	GENSAL	X	X	Slack
RODRIGUEZ	GENSAL	X	X	X
YACIRETA	GENSAL	X	X	X
SALTO GRANDE	GENSAL	UDM	UDM	IEEEG3
TERRA	GENSAL	UDM	X	X
BAYGORRIA	GENSAL	IEEET2	X	X
PALMAR	GENSAL	UDM	X	IEEEG3
BATLLE 4a	GENROU	X	X	X
BATLLE 5a	GENROU	UDM	X	IEEEG1
BATLLE 6a	GENROU	UDM	X	IEEEG1
PTA DEL TIGRE	GENROU	ESAC6A	X	IEESG0
BOTNIA	GENROU	UDM	X	IEEEG1
CTR	GENROU	IEEET2	X	X

Potential impact of wind-based Synthetic Inertia on the Frequency Response of the Argentine-Uruguayan Interconnected Power Systems

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***Abstract*—The high penetration of renewable energy sources has motivated a growing interest on the frequency response of the electrical power systems in scenarios with reduced inertia and on control strategies to cope with them. Among other technically feasible solutions, synthetic inertia strategies has proven to be a valuable solution that take advantage of the installed wind power. This paper describes the implementation of a PSS/E (Power System Simulator for Engineering) model of synthetic inertia for wind generators and its use for the assessment of the impact that this control strategy, implemented on the Uruguayan wind generators, may achieve for the Argentine-Uruguayan interconnected power system.**

***Index Terms*—renewable sources, frequency control, synthetic inertia**

I. INTRODUCTION

The object of study of this paper is the frequency response of the electric power system in scenarios with high wind energy penetration. In the first few seconds after a sudden active power deficit –due, e.g. to a generator tripping– the frequency drops quickly, only limited by the inertia of the synchronous generation in service. During operational states with small amount of synchronous generation, the frequency drop compromises the system stability. A possible solution is to employ so-called synthetic inertia, i.e. a temporary contribution of active power from the wind power generation during this frequency drop. It has been shown in many references [1] that synthetic inertia is able to limit the initial frequency drop after the generation loss and keep the system stable until the primary frequency control takes over. Technically, the amount of energy provided by the synthetic inertia was previously stored as the kinetic energy at the wind turbine which eventually will decelerate. A recovery period is needed during which the wind turbines are accelerated again back to their pre-fault speed.

Different control actions were reported recently in the literature as synthetic inertia (SI). Some authors proposed, essentially, a continuous active power injection proportional to the rate of change of frequency (RoCoF), see [2]. In this paper we follow the lines of references [3], [4] that propose a fix amount of active power injection. This control law acts with some points of contact with the classical load shedding strategy, hence its role is easier to communicate. However, the inherent structural constraints associated to the mechanical stress, and the effect of the recovery period are topics that deserves close attention.

This article describes the exploration of the feasibility of SI control law as in [3] to diminish the frequency deviations in the Argentine-Uruguayan interconnected system (also known as SIN, by its Spanish acronym) when the SI is implemented on the Uruguayan wind farms.

Uruguay is one of the countries with higher penetration of renewable energy sources [5], which is also true for photovoltaic and wind sources that provide respectively 33 % and 5% of the total installed power. The remainder capacity is based on synchronous machines and it is composed by hydro (33%), biomass (5%) and thermal generation (24%). This capacity results in a very high share of renewable energy along the year and the availability of energy surplus to be exported to the neighbor systems. The interconnection with Argentine is done by a set of AC power links which creates a strongly coupled system.

A PSS/E model was built on a standard wind farm model. The turbine parameters and the control law coefficients were chosen to respect physical limitations and industry recommendations. The model was validated with a set of simulations on a well known three machine benchmark suitably modified to include a wind generator. After that, the model was used to study the frequency response of the SIN against different power imbalances with two alternative SI strategies implemented on the Uruguayan Wind Power Plants, WPPs.

Section II describes the SI control strategy and the role to be played by its main parameters. The model is later implemented on PSS/E and validated. The effect of two SI strategies on the SIN frequency response are studied in Section III. Section IV wraps up the paper with some concluding remarks.

II. SYNTHETIC INERTIA CONTROL STRATEGY

A wind generator model was built with an active power control system with the ability to temporarily produce greater

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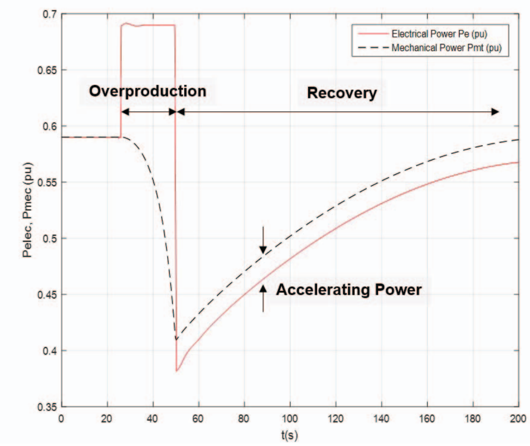

Fig. 1: Behavior of the Synthetic Inertia strategy.

electrical power than the mechanical power extracted from the wind. This has the cost of the turbine deceleration, so this overproduction can only be maintained for a certain time, several seconds. Since this increase in power can be achieved very quickly, it can be a very beneficial contribution in the system frequency regulation when disturbances occur in the network that cause frequency drops. The design adopted follows the approach presented in [3]. Figure 1 shows the expected behavior of the wind generator when a drop frequency disturbance occur in the power system.

As soon as the generator starts operating in the overproduction mode, the turbine speed decreases and the wind generator drifts from its optimum operating point. Therefore the mechanical power available also begins to decrease. The speed of the turbine can be reduced to a certain minimum value, and once that limit is reached the control mode must change its strategy in order to increase the speed and return to the optimal operating point. This new operation mode will be referred to as recovery mode. To increase the speed of the turbine, the control will reduce the generation below the extracted power from the wind. This accelerating power margin is shown in Figure 1. The negative step in the electrical power at the beginning of the recovery period is the price that must be paid for the previous benefit. By the time this period begins, it is expected that the primary frequency regulation of the synchronous generators is compensating for the generation deficit in the system.

A. Turbine model

Figure 2 shows the block diagram of the active power model developed. Based on [7], equation (1) was used to model the relation between the wind speed and the mechanical power extracted:

$$P_m = \frac{1}{2}\rho A_r C_p(\lambda,\theta) V_w^3. \tag{1}$$

The characteristic for $Cp(\lambda,\theta)$ was modeled according to equations (2) and (3):

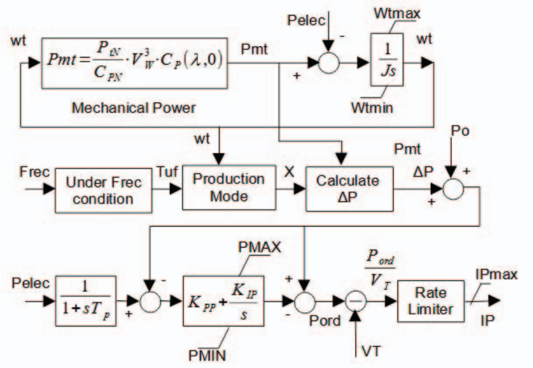

Fig. 2: SI control diagram.

$$C_p(\lambda,\theta) = 0.73\left(\frac{151}{\lambda_i} - 0.58\theta - 0.002\theta^{2.14} - 13.2\right)e^{-18.4/\lambda_i}, \tag{2}$$

$$\lambda_i = \frac{1}{\frac{1}{\lambda-0.02\theta} - \frac{0.003}{\theta^3+1}} \tag{3}$$

B. Under-frequency detection

The purpose of the block is to detect the system condition for which the wind turbine is required to start operating in over production mode. The logic implemented will activate T_{UF} flag when the frequency of the power system remains at a value lower than F_1 for a time greater than T_1. For the variable T_{UF} to be reset, the recovery must remain at a value greater than F_2 for at least a time T_2.

C. Production mode

The state diagram presented in Fig. 3 shows the logic implemented in the active power controller for the transition between the three operation modes. In normal operation, that is, when the frequency of the system is close to the nominal value respecting the margins established by regulation, the state variable X is set to 0. When an underfrequency event occurs and T_{UF} goes to 1, X also change to 1 and the generator increases its production to a value greater than the mechanical power extracted from the wind. When the speed of the turbine reach a certain minimum threshold w_{tmin}, variable X takes the value 2 and the generator decreases the power production to a value lower than the mechanical power available in the turbine. The turbine begins to recover speed and when it reaches the optimum value again, variable X returns to 0 and the generator recovers its normal operating mode, maximizing production.

D. Rate limiter

To alleviate mechanical stress in the drive train of wind turbines and extend their lifetime, the rate of change of electrical power must be kept limited to a maximum value of 0.45 p.u./s [1]. A block to ensure this condition was implemented at the output of the active power controller.

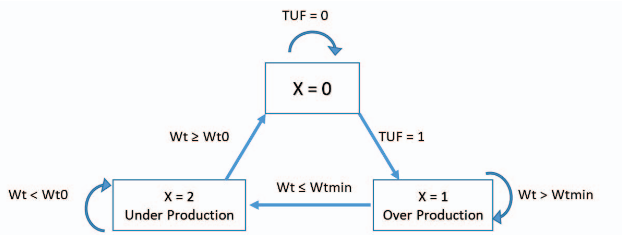

Fig. 3: Mode of production.

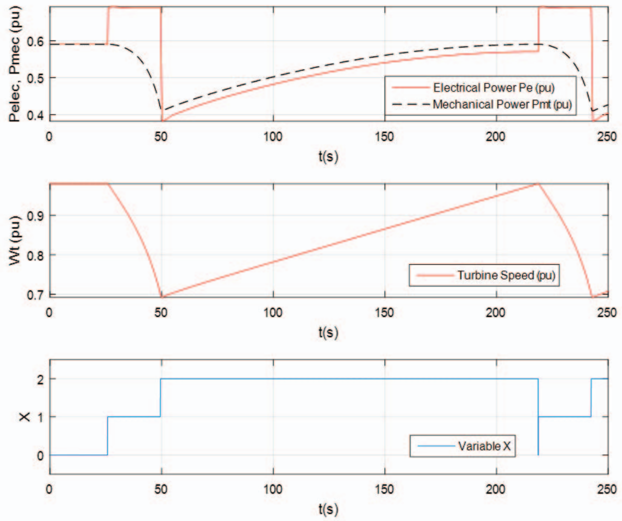

Fig. 4: Model validation: power, turbine speed and mode of production.

E. Model validation

For validation, the model was integrated in a three machine benchmark system [6] adapted to incorporate the connection of a WPP. A set of simulations were run in order to reproduce the behavior presented in [3]. A value of 6 seconds was used for the inertia constant. Figure 4 shows the active and mechanical power of the wind turbine, the speed and variable X during a typical underfrequency event. Figure 5 shows the evolution of the frequency for the case with SI versus the case without SI. Figure 6 shows the power balance for the synchronous machines computed as the sum of the respective accelerating powers. When the WPP starts operating in overproduction mode, the imbalance is reduced and explains why the frequency drop is reduced by the action of the SI at the beginning of the disturbance.

III. Synthetic Inertia performance on the SIN

This Section presents the simulations carried out in PSSE on the interconnected power system of Uruguay and Argentina. The model usually employed by the utility UTE for the largest wind farms on Uruguayan system was employed for all the WPPs in service. This group has 24 WPPs with a total installed power of 1292 MW. According to references [7] and [1] the constant H associated with the inertia of the model is modified to the value 3.5 s. The base case corresponds with a demand of 15.8 GW, where 1.8GW are from Uruguay and 14GW from Argentina. In Figure 7 the evolution of the frequency for 6 simulations is superimposed. Three simulations are carried out causing a disturbance of 800 MW generation loss and another three with 1300 MW. In each group, one simulation uses a standard PSSE model without SI for the WPPs. Another simulation uses the model with SI developed with all WPPs starting overproduction when the frequency drops below 49.9 Hz, which will be referred to as a *flat setting*. And a last simulation, to be referred to as *stepped setting*, where different WPPs start the overproduction at different frequencies shown in Table I. Table II summarizes the main characteristics of the cases and simulations.

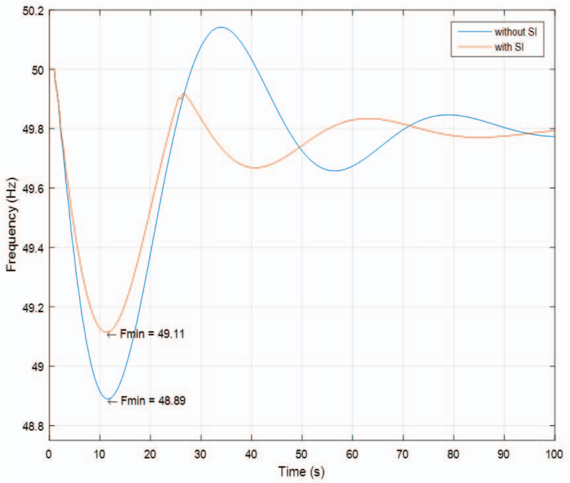

Fig. 5: Model validation: frequency response.

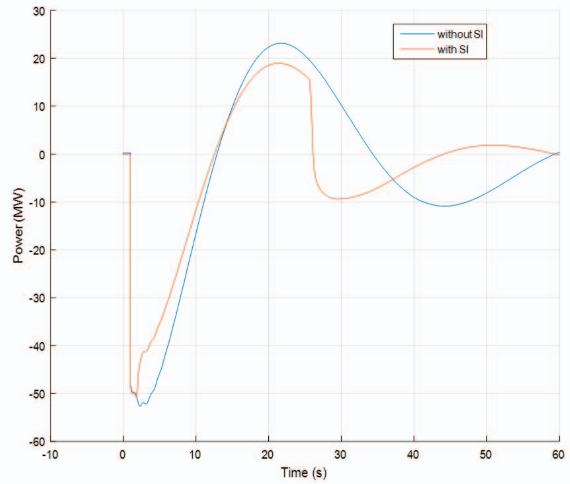

Fig. 6: Total synchronous accelerating power.

What can be seen from the curves in Fig. 7 is that WPPs with SI always reduce the frequency drop. The reduction

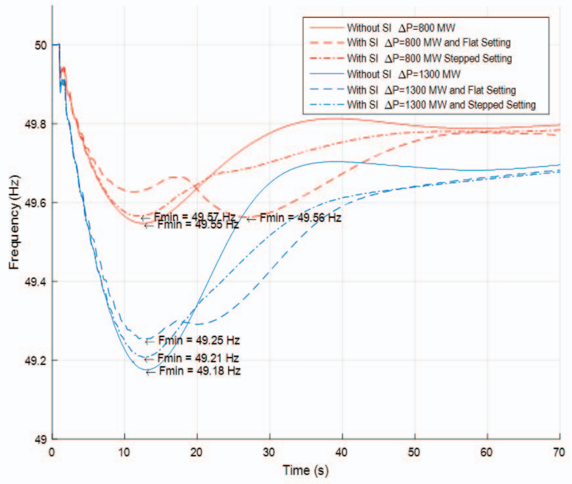

Fig. 7: Frequency response for a WPP inertia H = 3.5 s.

Power (MW)	Freq. setting (Hz)	Power (MW)	Freq setting (Hz)
18	49.8	50	49.4
20	49.8	50	49.4
42	49.8	50	49.4
48	49.8	50	49.4
49	49.8	50	49.4
50	49.8	50	49.4
50	49.6	50	49.2
50	49.6	65	49.2
50	49.6	70	49.2
50	49.6	70	49.2
50	49.6	70	49.2
50	49.6	150	49.2

TABLE I: Stepped frequency setting.

Case	Total Load	Wind Pwr. installed	Wind Pwr. in service	SI Setting	Generation Loss
1	15.8 GW	1.29 GW	774 MW	No SI	800 MW
2	15.8 GW	1.29 GW	774 MW	Flat	800 MW
3	15.8 GW	1.29 GW	774 MW	Stepped	800 MW
4	15.8 GW	1.29 GW	774 MW	No SI	1300 MW
5	15.8 GW	1.29 GW	774 MW	Flat	1300 MW
6	15.8 GW	1.29 GW	774 MW	Stepped	1300 MW

TABLE II: Cases description.

is greater in the case of flat setting, when all WPPs enter simultaneously into overproduction mode. The magnitude by which the gap is reduced will depend on the additional power that can be injected by each WPP. A stepped setting can help to dose the SI resource, involving new WPPs in overproduction mode as the frequency decreases. The setting should ensure that all WPPs have entered overproduction mode before the frequency reaches the first stage of the underfrequency load shedding scheme.

When WPPs enter in recovery mode, there is a frequency dip that is more pronounced the more WPPs performed SI. Only in the case of flat setting and for a deficit of 800 MW the frequency drop is deeper at the beginning of the recovery period than the first frequency drop caused by the disturbance. But even in this case, the drop in frequency is less than that corresponding to the simulation without SI. In the stepped setting, the last WPPs that goes into overproduction mode counteract the deficit of production of the first WPPs that goes into overproduction mode. The transient period will be extended but will also allow more synchronous generators to contribute in the primary frequency regulation.

The tests carried out on the interconnected system show that providing the WPPs with a control system with SI is an effective tool for frequency regulation during disturbances that cause significant generation deficits since it reduces the frequency drop in the power system. It is also shown that entering recovery mode produces smaller frequency drops than in the case without SI. The WPP model developed respects the physical constraints of turbines, so the results in the simulations do not overestimate their performance. The stepped strategy demonstrates that by using a suitable distribution of the frequency thresholds, it is possible to achieve specific objectives in terms of frequency deviation, nadir and transient width. The specific stepped settings in our simulations were chosen without a systematic procedure. However, the tuning of the thresholds is an important topic of research to find the best configuration adapted to each system needs.

Figure 8 shows the generation of WPPs with flat and stepped SI setting for the 800 MW generation loss. In the case with flat setting all WPPs go into overproduction mode while in the case with stepped setting the WPPs of the last stage do not.

Figure 9 shows the total wind power with both SI settings. The plot is almost the same for the 800 MW or the 1300 MW disturbance. In the overproduction period, they contribute approximately 132 MW. Then at the beginning of the recovery mode, the deficit in generation is approximately 288.8 MW. Therefore, the frequency drop produced at the beginning of the recovery mode is limited and will be less significant the greater the deficit of the original disturbance. Figure 9 shows the same information for the stepped SI setting where the effort during over production and the deficit of production at the beginning of the recovery mode are smaller than flat setting.

IV. CONCLUSION

The study described in this paper is intended to assess the potential impact that wind based synthetic inertia strategies may achieve on the frequency response on the interconnected Argentine-Uruguayan system. A suitable PSS/E model was built, with a set of parameters that allow us to study its performance while the physical turbine constraints are respected. The model was tested on a benchmark and validated with respect to recent literature. Two different strategies were tested on a complete model of the interconnected power system. The basic parameters of the model and the different triggering strategies provide us a set of valuable tools for further improving the performance. The results of the study are very encouraging. It was proven that these control strategies, implemented on the Uruguayan wind power plants, are able to significantly improve the frequency response of the interconnected system by decreasing the maximum frequency deviation. Currently

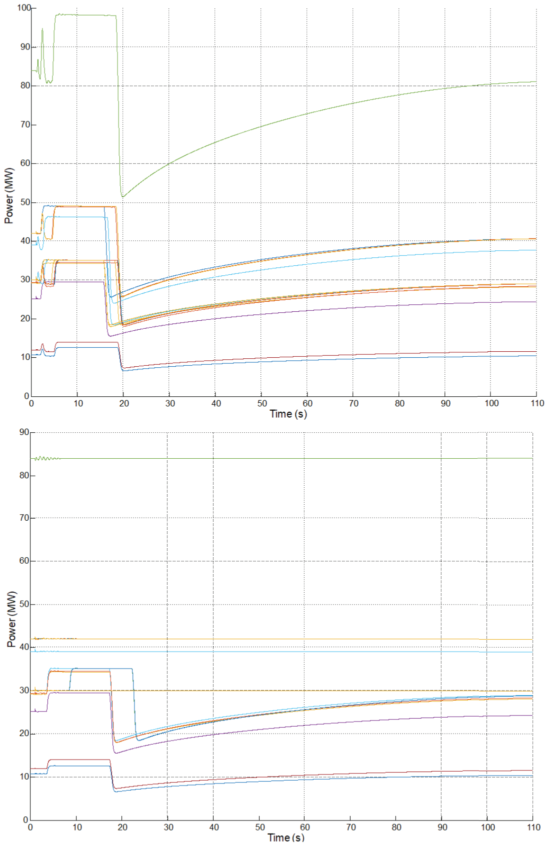

Fig. 8: Active power generation for WPPs. Flat (top), stepped (bottom) SI setting.

research efforts are being directed to the optimization of the set of parameters with respect to performance objectives and operational constraints.

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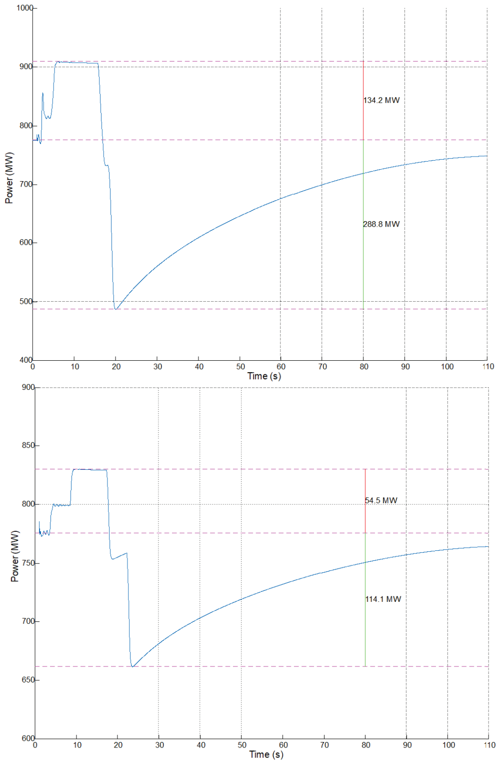

Fig. 9: Total wind active power generation. Flat (top) and stepped (bottom) SI setting.

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Generación eólica: qué puede salir mal?

Ing. Alvaro Giusto

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La generación eólica vino para aportar

Algo puede salir mal?

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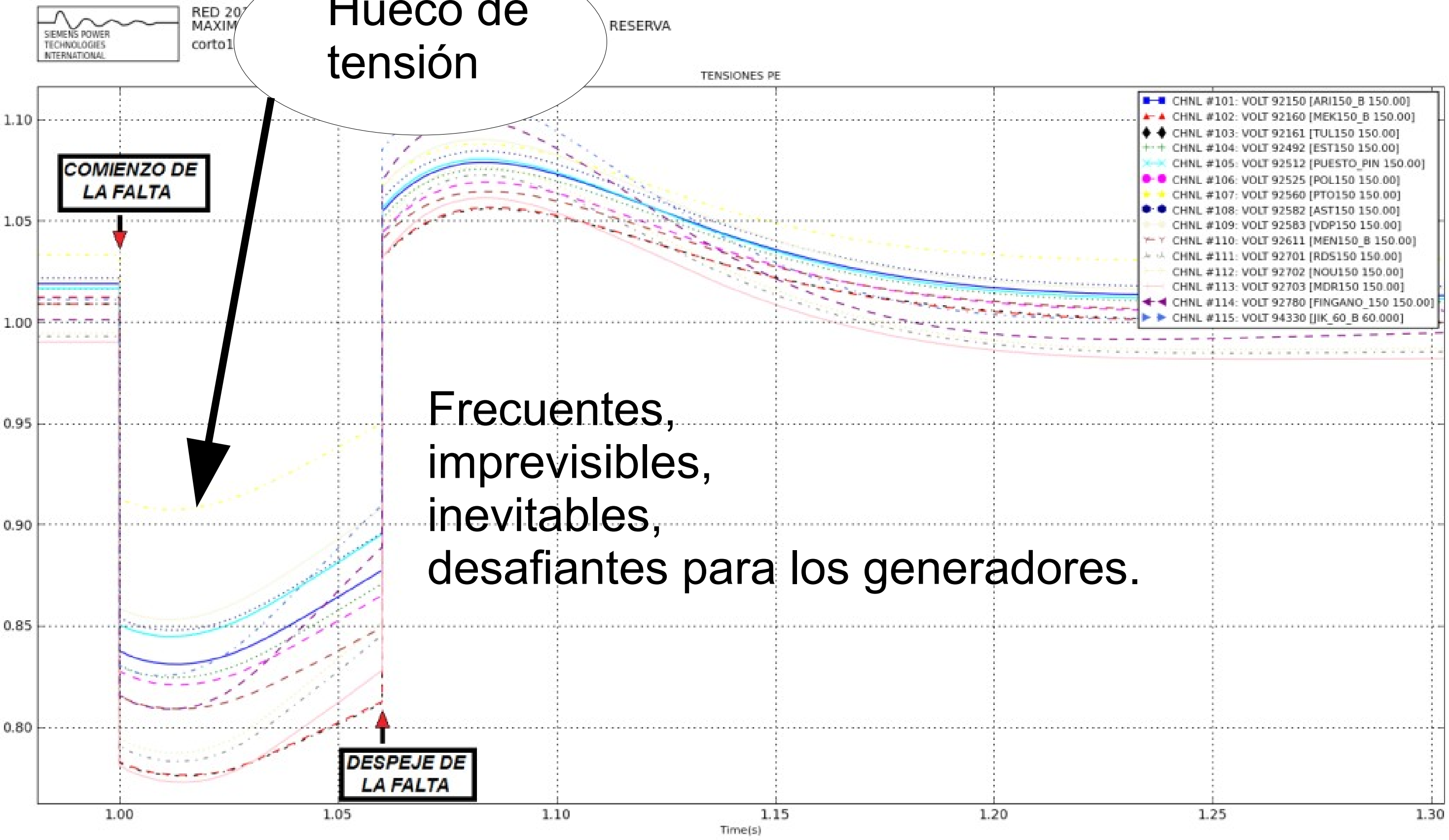
Que pasa cuando ocurre un cortocircuito?



Hueco de tensión

Frecuentes,
imprevisibles,
inevitables,
desafiantes para los generadores.

Qué deberían hacer los parques eólicos frente a los huecos de tensión ?


Should I stay
or should I go?

Principales resultados

De mantenerse la laxitud inicial de la primera compra de energía renovable (60MW, 2006-2007) tendríamos 40 eventos anuales con la salida de todos los parques eólicos.
40 apagones masivos por año.

Los requisitos exigidos en las licitaciones posteriores aseguran que no saldrán de servicio parques eólicos conectados en diferentes nodos.
No habrá, no hay, apagones por esta causa.

Desarrollamos una metodología mixta cálculo/simulación para realizar este análisis.

Gracias!