2013 Santiago Symposium on Microgrids

Survey of Microgrid R&D in Latin America

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CENTRO DE ENERGÍA

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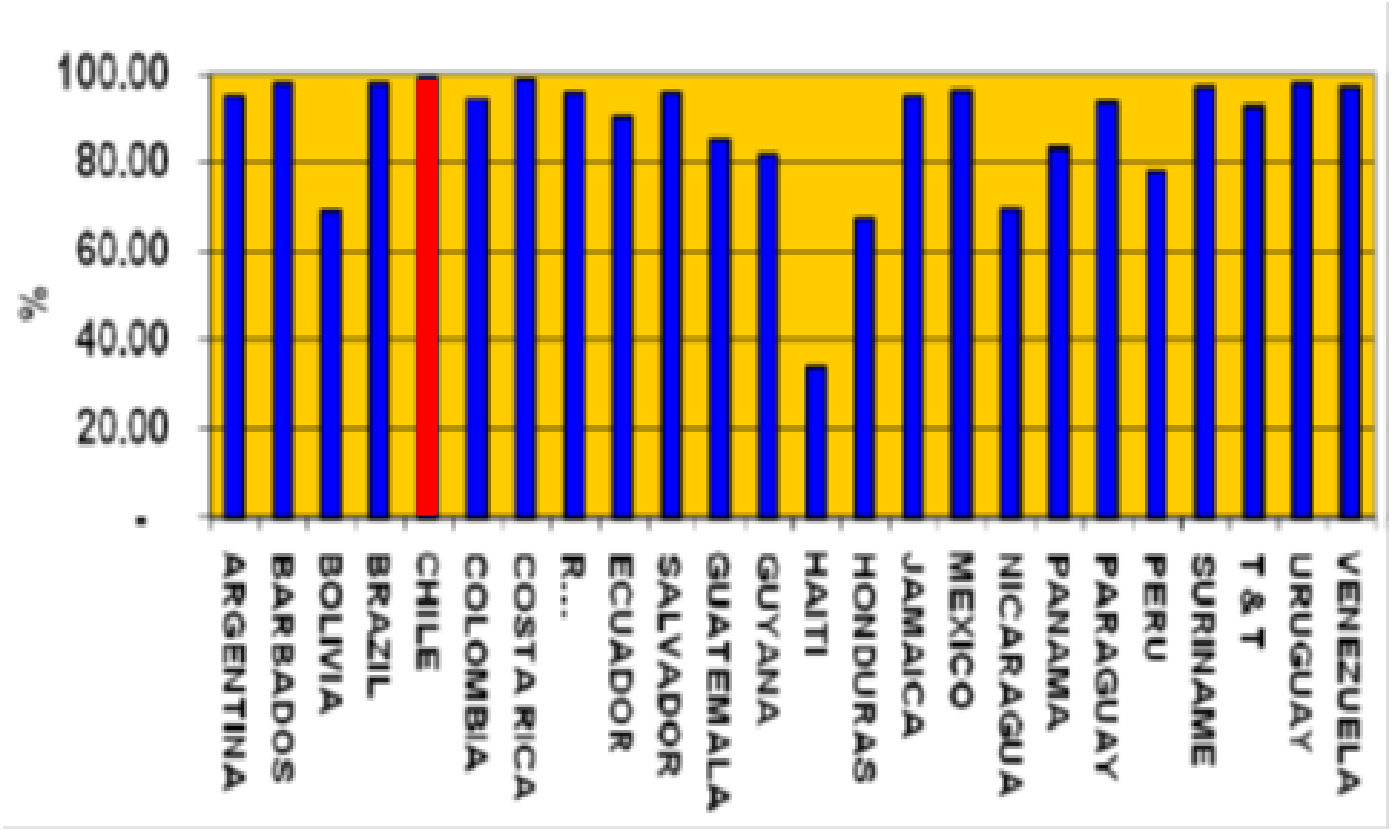
1. Microgrids opportunities and status in the region
2. Social SCADA and resilience
3. V2G in isolated microgrids
4. Conclusions

Microgrids opportunities in the region

Electricity Coverage in Latin America

(34 mill. have no access to electricity in LA)

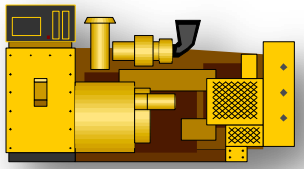
Electricity coverage

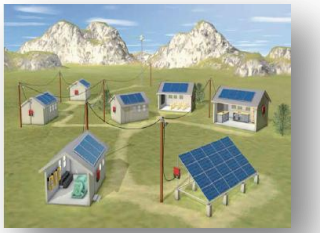


Source: OLADE, 2007

Microgrids opportunities in the region

Development status





RE projects fall down in providing **diesel engines** for power supply and organize the **community** in such way that they are **in charge of covering the operation and maintenance costs** of the solution. Unfortunately in the **long term** is **not possible to cover all these costs** and the **power supply is limited** to few hours per day

MG operating in islanding way

- Must be able to integrate and coordinate several local energy sources with appropriate load-frequency strategies.
- Active participation of the local community

Source: Denda, Shimizu Corpotation

Microgrids opportunities in the region

Some Microgrid developments in LA

Puertecitos,
Under execution
Baja Califonia, MX

Puerto Alcatraz, San Juanico
Operative
Baja Califonia, MX

Huatacondo
Operative
Tarapacá, CH

Ollagüe
Under execution
Antofagasta, CH

Juan Fernández
Design stage
J. Fernández, CH

Silice Project
Pilot application
Bogotá, CO

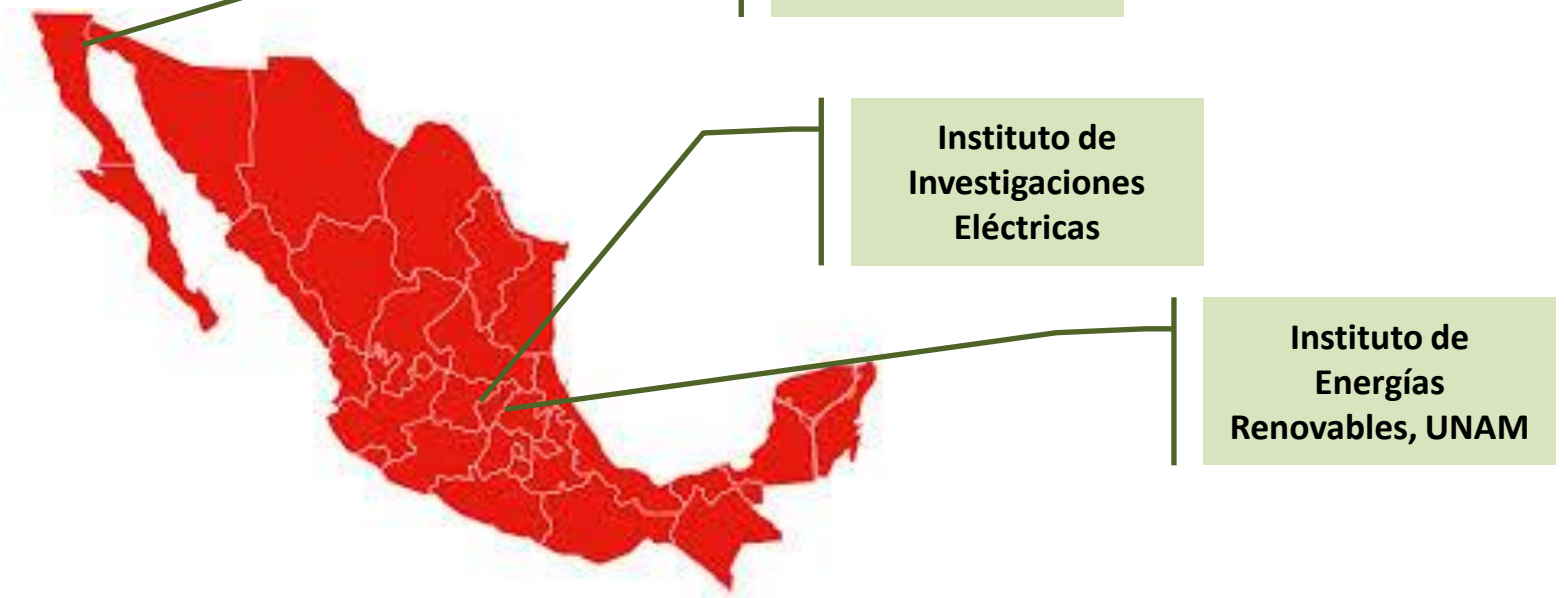
Lencóis island
Operative
Maranhao, BR

Trinidad island
Feasibility
Rio State, BR

Islas Desertores
Under execution
Chiloé, CH

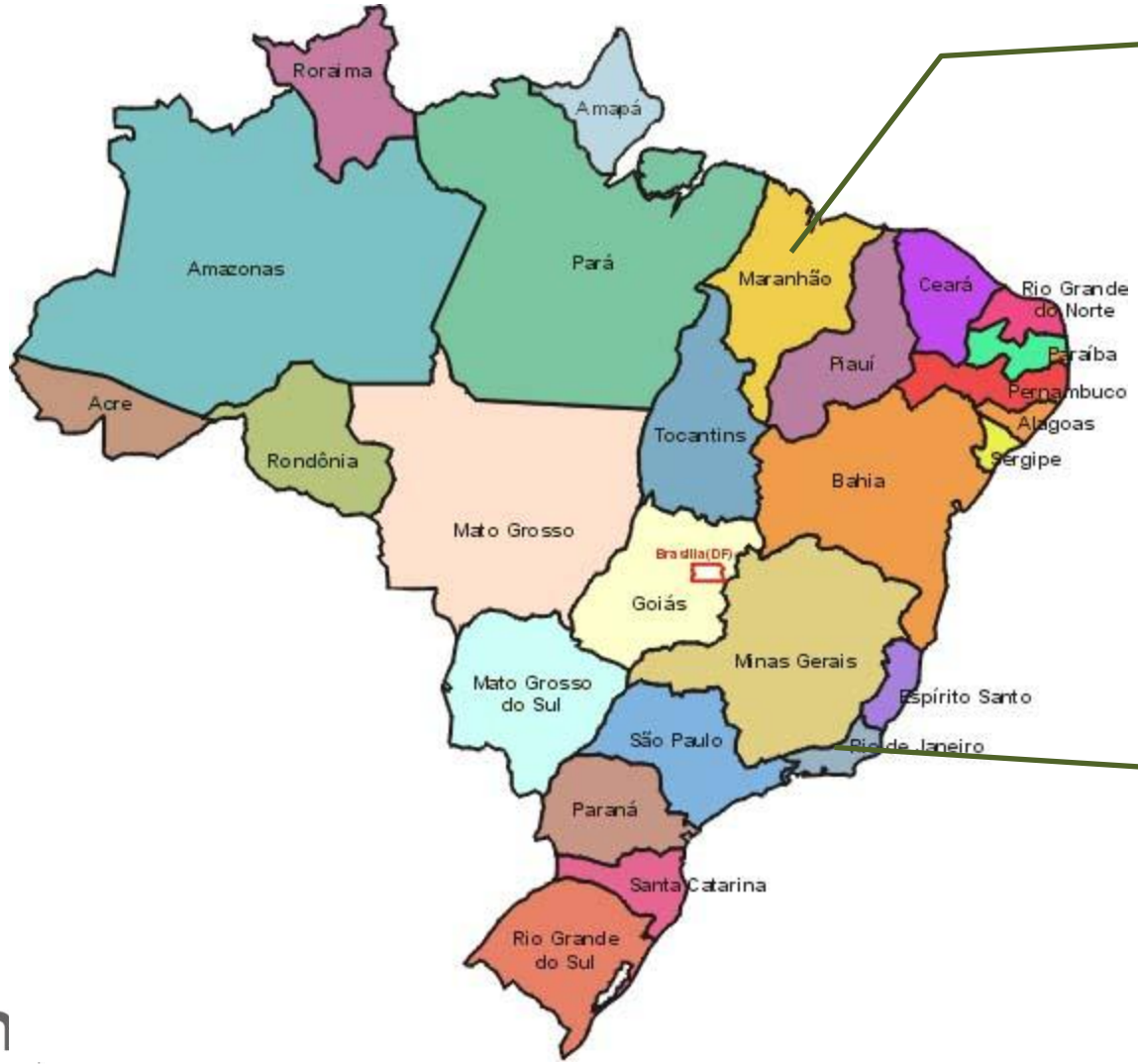
Microgrids opportunities in the region

Research Institutions in LA



Microgrids opportunities in the region

Research Institutions in LA



Federal University of Maranhão

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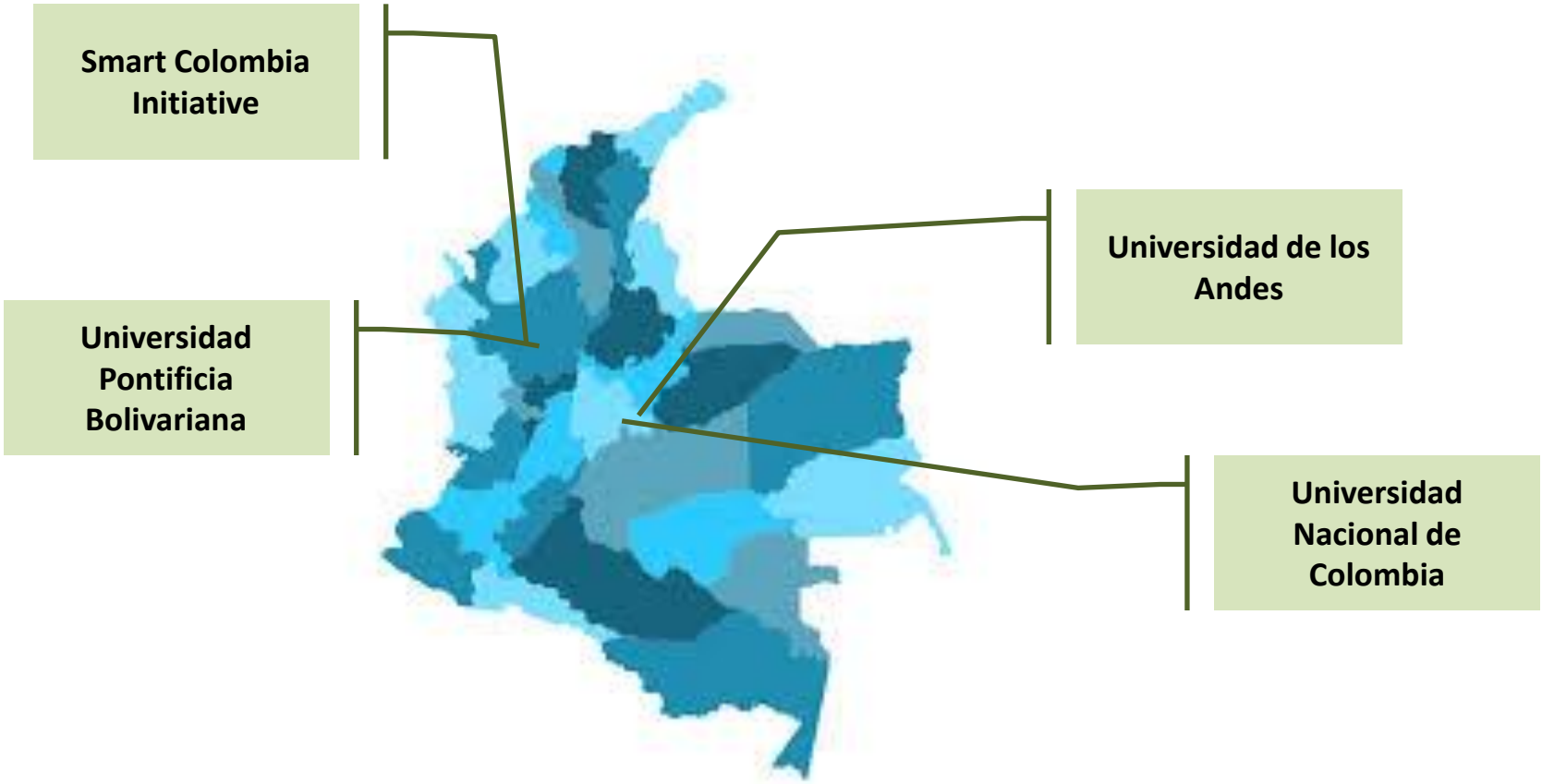
Microgrids opportunities in the region

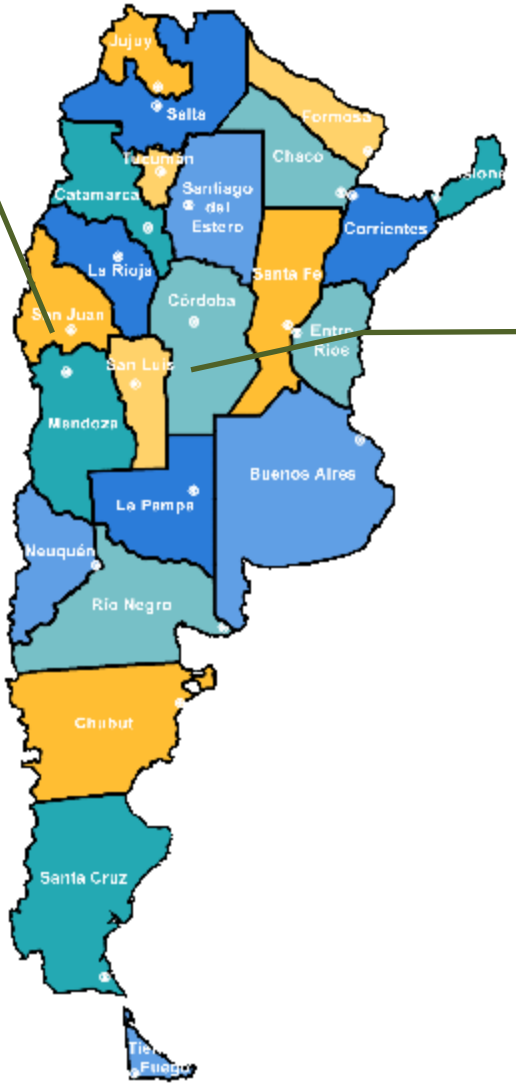
Research Institutions in LA



Microgrids opportunities in the region

Research Institutions in LA

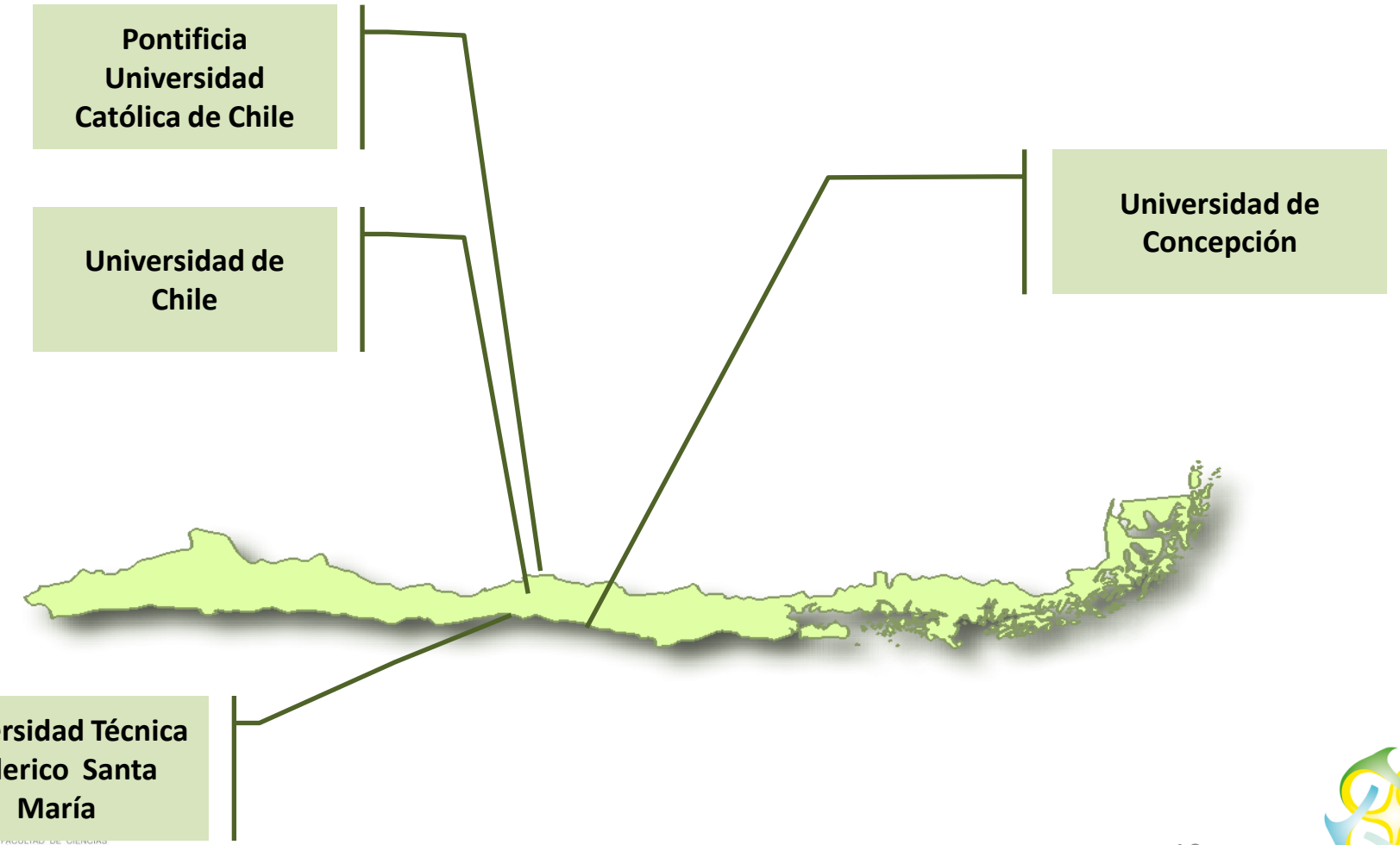
Universidad Nacional de San Juan



Universidad Nacional de Río Cuarto

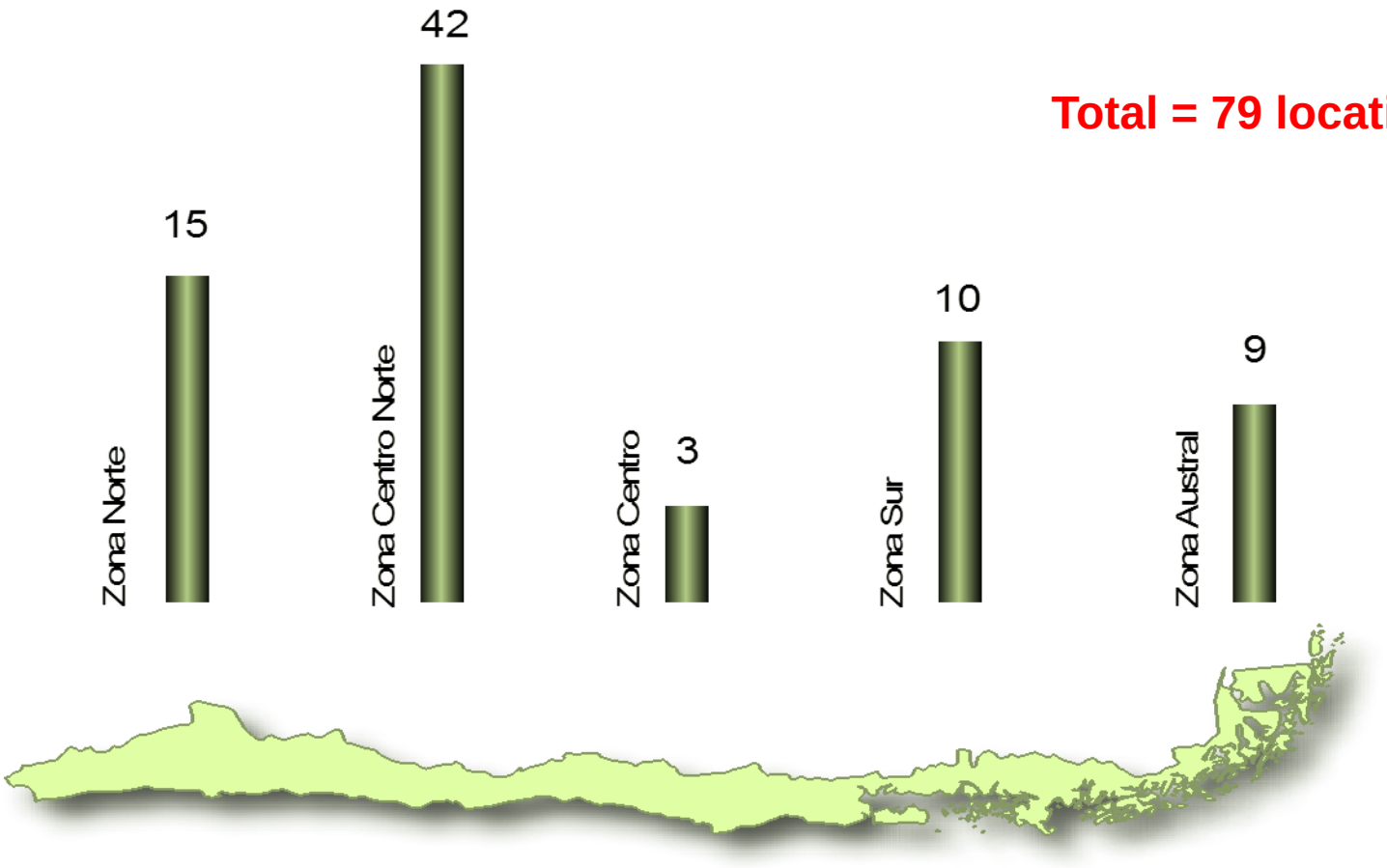
Microgrids opportunities in the region

Research Institutions in LA



Microgrids opportunities in the region

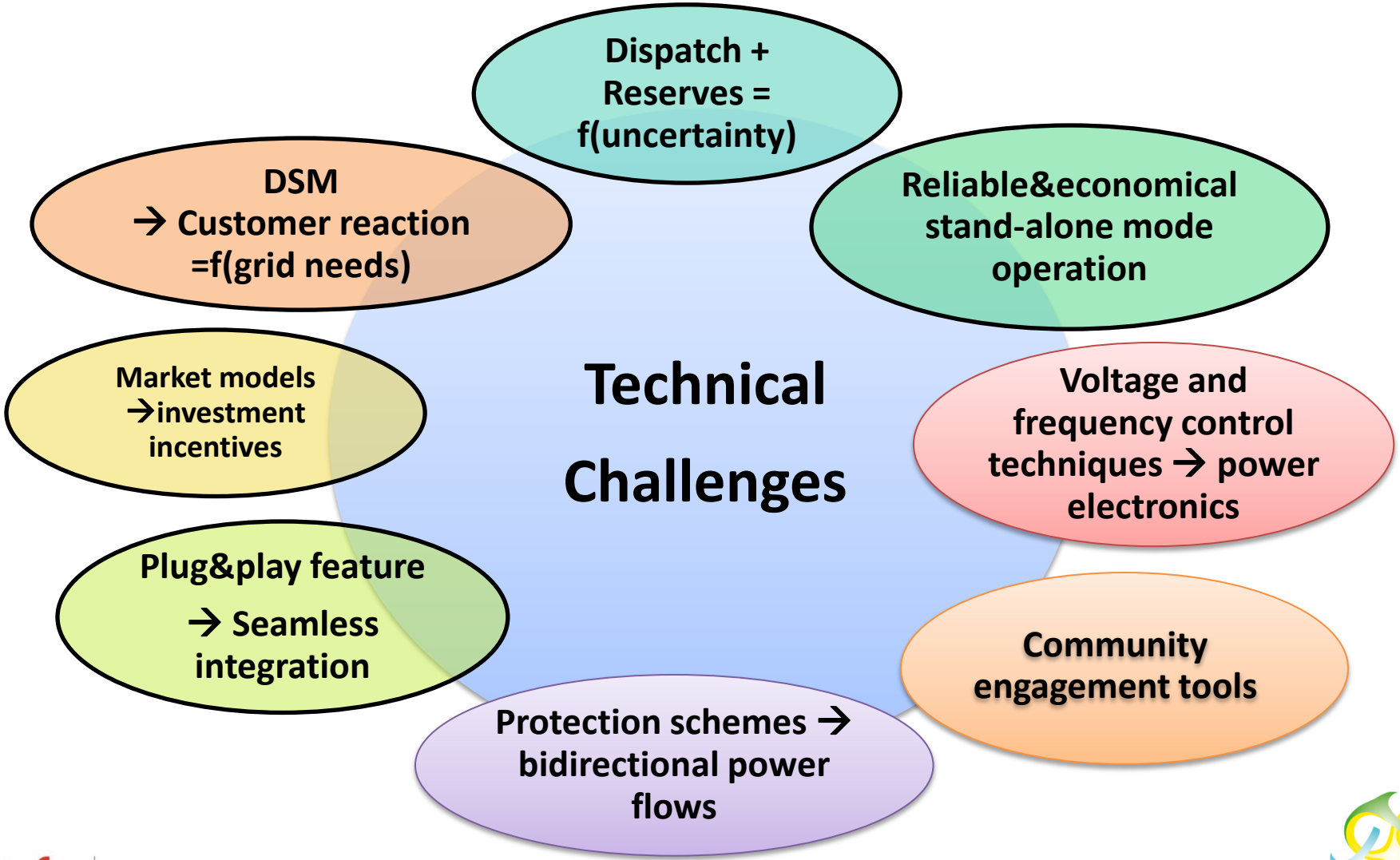
Chile: Number of feasible isolated MG opportunities



Total = 79 locations

Microgrids opportunities in the region

Challenges for MG developments



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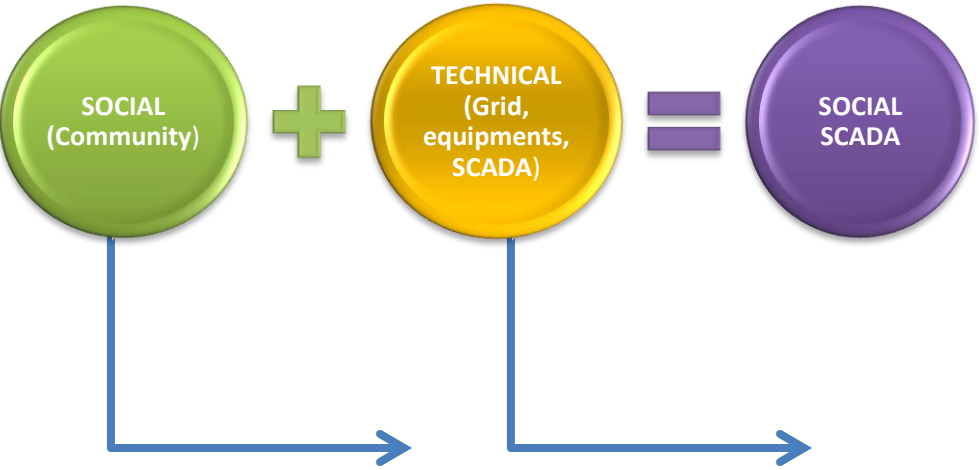
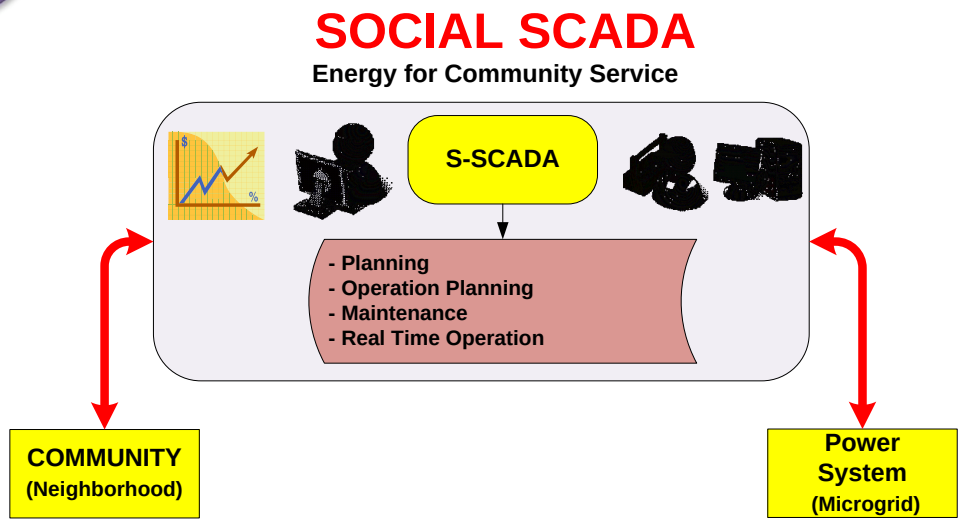
Social SCADA and resilience



Its necessary to take into account the interactions between technology and people, as well as consequences.

The introduction of new energy technologies in a rural setting is a challenge, since it generates changes in patterns of energy use and others.

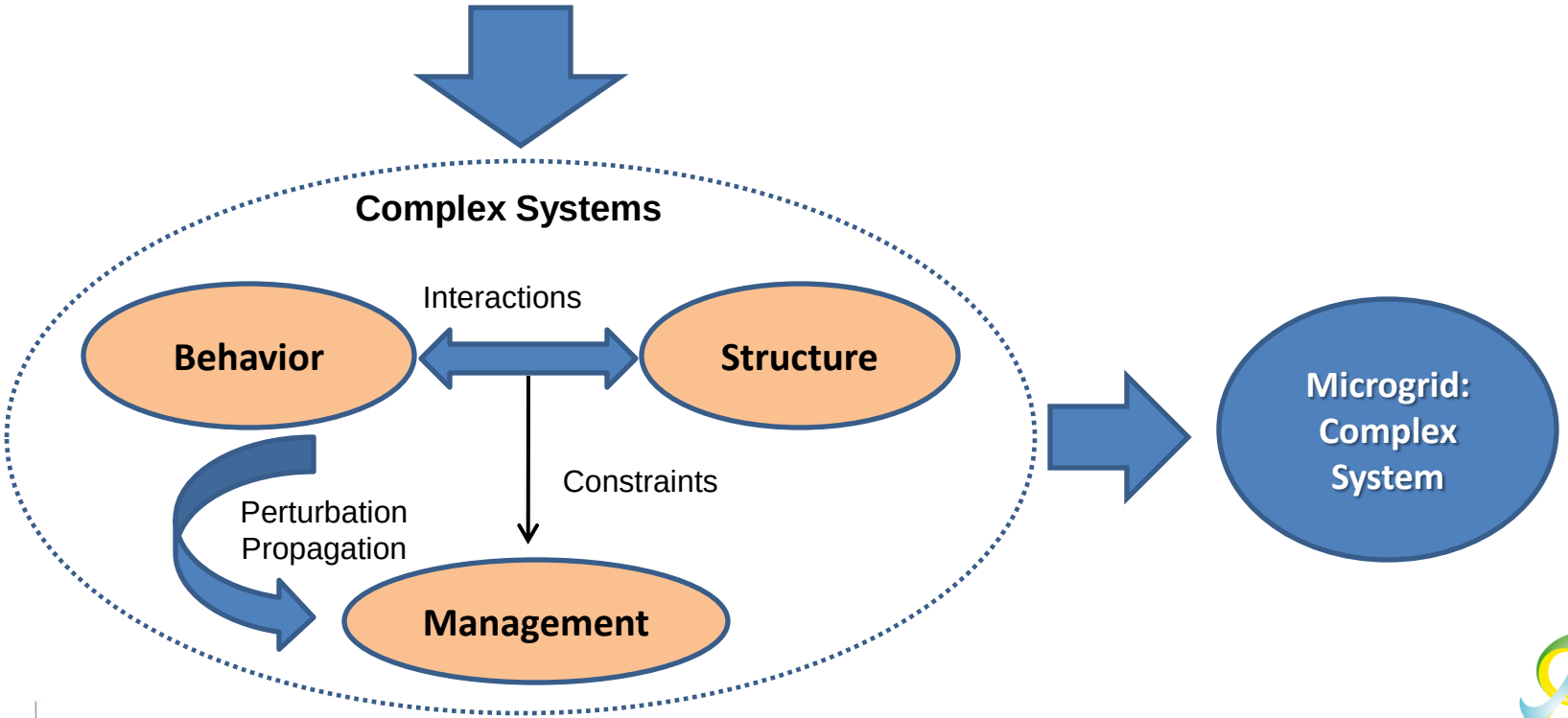


Is S-SCADA an adequate tool to face disruptive events in a isolated microgrid evironment?

S-SCADA + Resilience

Social SCADA and resilience - Objective

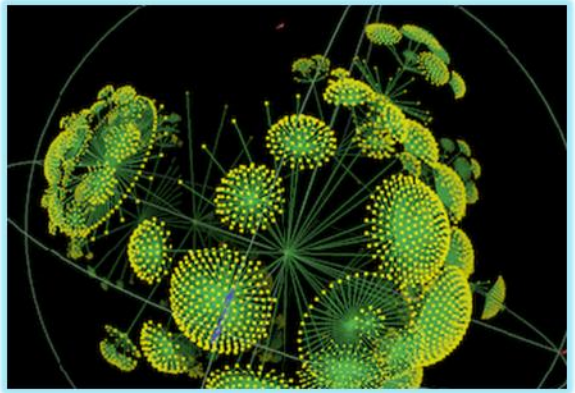
Develop monitoring tools for Microgrids from the perspective of ***Resilience***, focused on the sustainability of the system, based on Complex Systems Theory.



Social SCADA and resilience – Complex Systems

Complex System is a generic term used to describe interconnected parts that as a whole exhibit one or more properties not obvious from the properties of individual parts.

Resilience is the capacity of a system to continually change and adapt yet remain within critical thresholds.



Features:

- Difficult to determine boundaries.
- May be open.
- Multiple dynamic.
- Self-organization.
- May produce emergent properties.
- Relationship are non-linear and contain feedback loops.

Ref: Ryan J. Urbanowicz and Jason H. Moore
Ref: Stockholm Resilience Centre

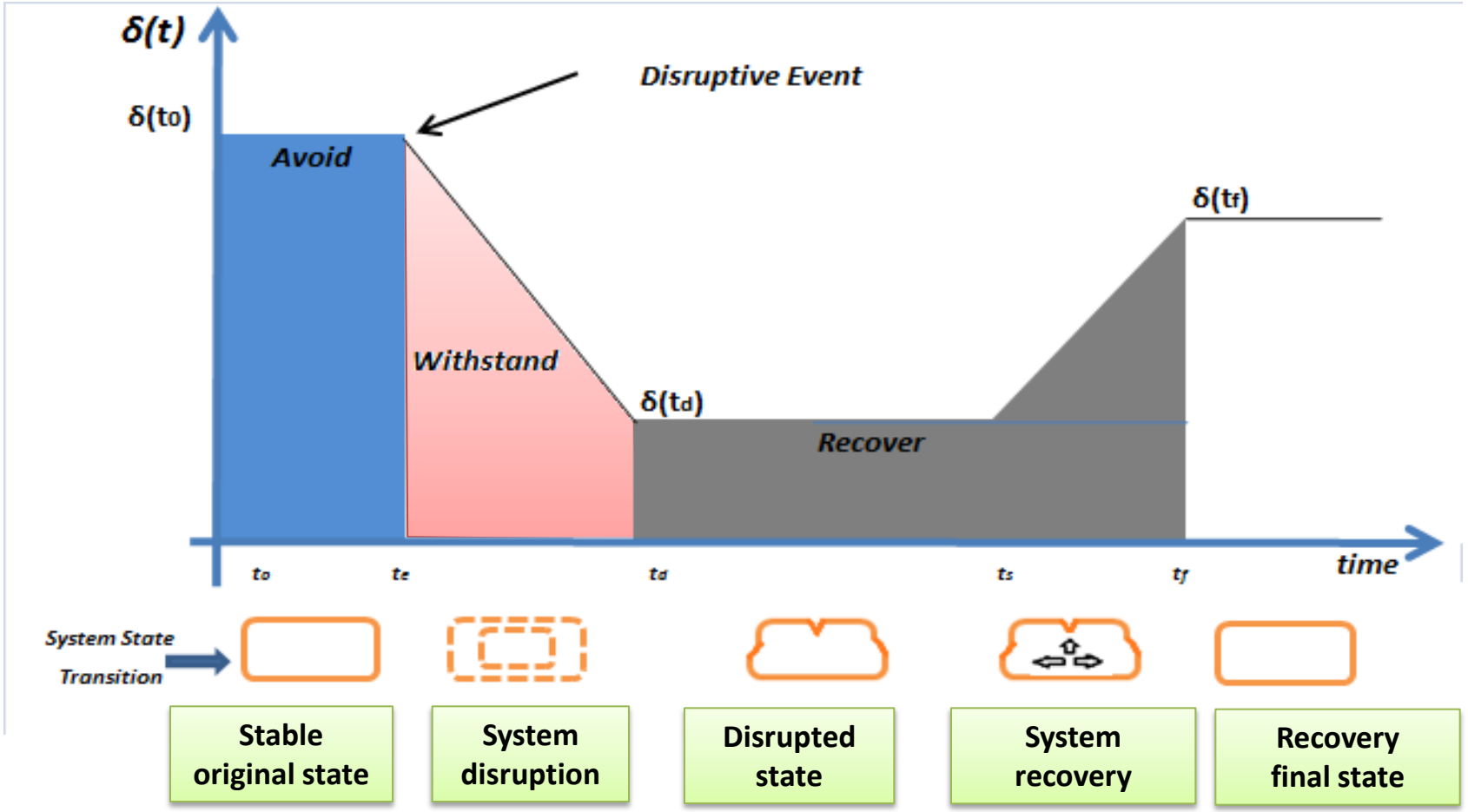
Social SCADA and resilience
Resilience of a Microgrid

In a microgrid framework resilience may be understood as a measure of the sustainability of the system.

→ Capacity to absorb social, environmental, technical, and economical changes originated by low probability disruptive events with high impact, while quality of service is maintained.

Social SCADA and resilience

Application of Resilience in Microgrids



→ **Indicators are key for each state**

Ref: K. Barker, J. Ramirez, C. Rocco, "Resilience-based network component important measures", 2013.

Social SCADA and resilience

Properties of Resilience in Microgrids

I. Avoid

- Key issue at design stage:
  - Robustness / flexibility
  - Technical standards
  - Training program
- Preventive maintenance
- Condition monitoring
- Community feedback

II. Withstand

Provide the system to respond to disturbance without making changes to it:

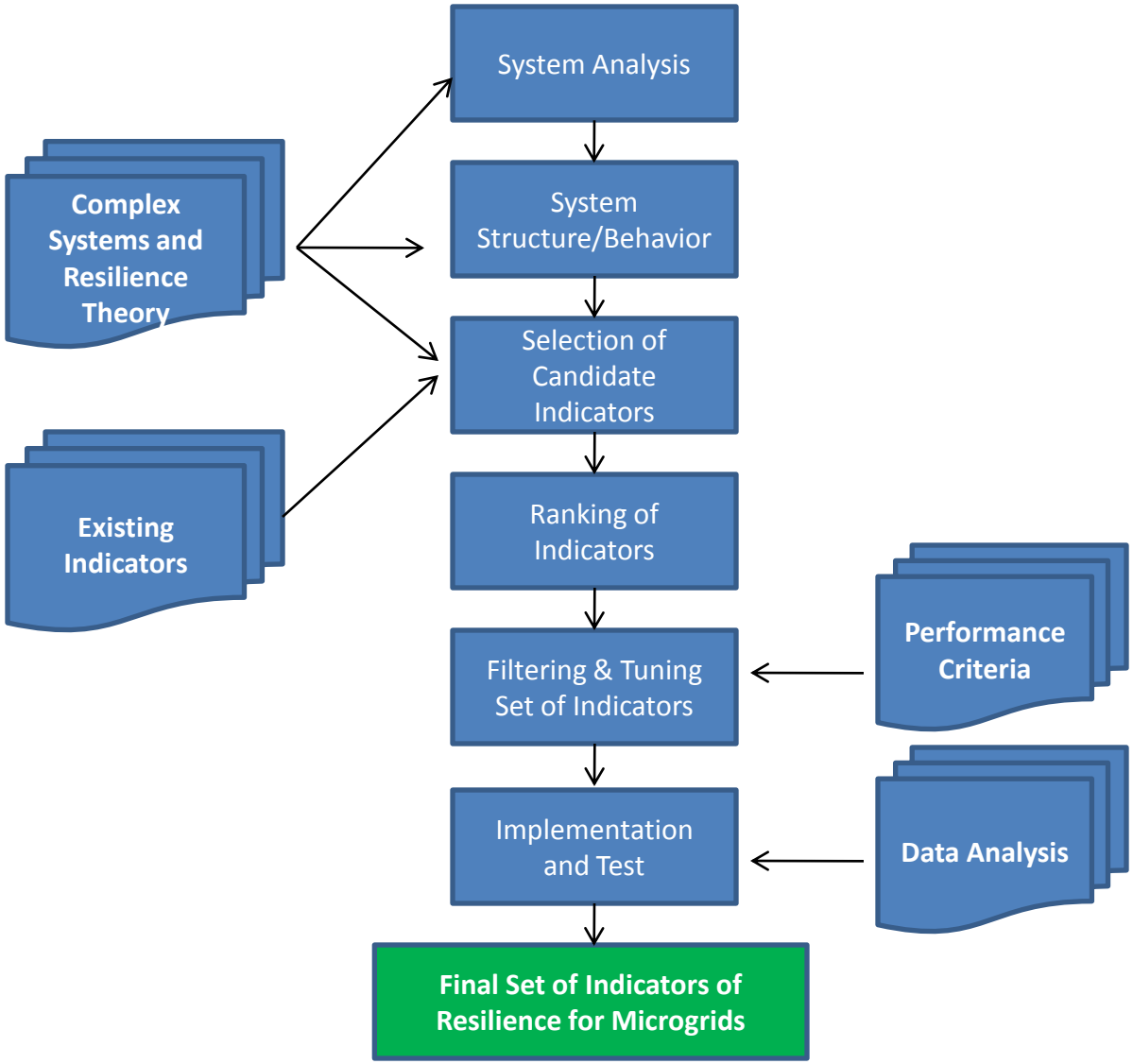
- Protective / SPSs
- Reserve margins
- EMS emergency procedures
- Community contingency plans

III. Recover

Elimination of disturbance sources:

- Corrective maintenance
- Community recovery contingency plans
- Repairing
- Spare parts management
- Coordination with stakeholders

Development of New Indicators



Study Case: PV Panel Failure

System State Transition

Stable original state	System disruption	Disrupted state	System recovery	Recovery final state

• BESS SOH = 0.5
• Fuel consumption factor = 0.7
• Only diesel risk:
  • BESS failure
  • Full PV failure
• Maintenance C= OFF, P= OFF
• Workplan delays:
  • Server update
  • Wind generator service date
		• BESS SOH = 0.5
		• Fuel consumption factor = 1.0
		• Emergency situation reported by the community
		• Maintenance C= ON, P=OFF
				• BESS SOH = 0.4
				• Fuel consumption factor = 0.75
				• Only diesel risk:
				  • BESS failure
				  • Full PV failure
				• Maintenance C= ON, P=ON
				• Workplan delays:
				  • Wind generator service date

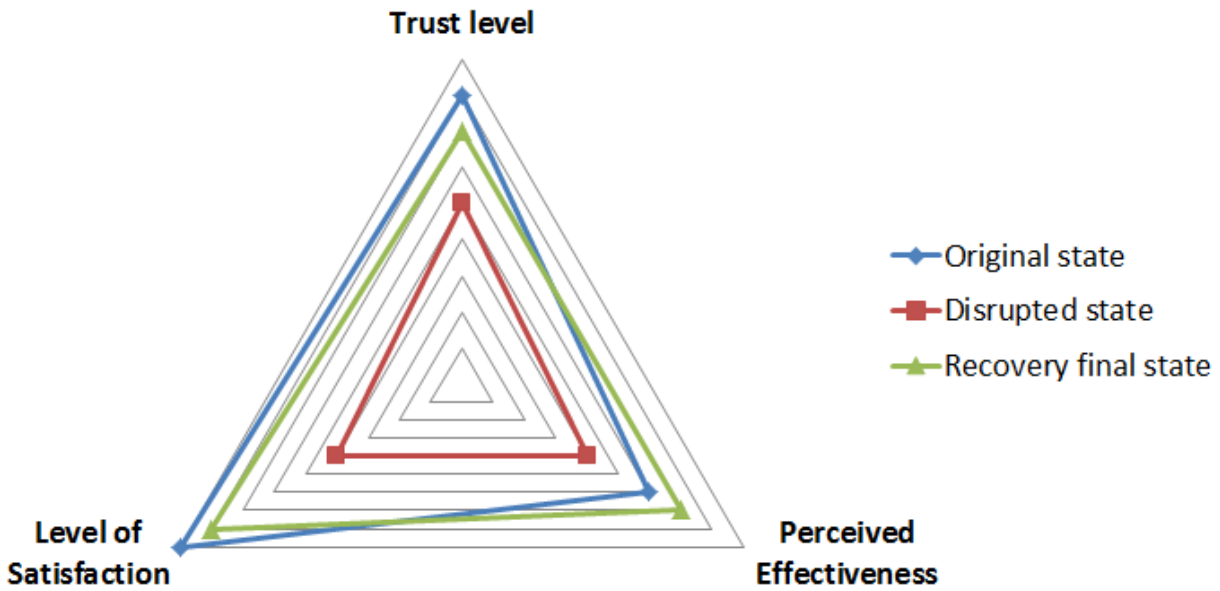
• System reliability decreases • Increase of community concern	• Severe damage in 1/6 PV array	• Back to full diesel based operation • Urgent coordination activities among stakeholders		• Coordination activities among stakeholders • Community concern

Social SCADA and resilience

Social oriented indicators

The Causal-Chain analysis in Community Trust establishes the need to monitor it, in three dimensions: Trust level, Perceived Effectiveness, and Level of Satisfaction

Trust level	Perceived Effectiveness	Level of Satisfaction
Low	Low	Low
Medium	Medium	Medium
High	High	High



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V2G in isolated microgrids

Development opportunities

V2G opportunities in Chile

Field \ Driver	Green-house gases	Local pollution	Fuel price	Relia-bility	Noise
Santiago downtown 	✓	✓	✓	✓	✓
Mining area 	✓	✓	✓	✓	✓
Rural microgrids	✓	✓	✓	✓	✓

Huatacondo transportation needs

GARBAGE COLLECTION →

L = 1.8[km]
Max slip = 21.5°
Max load = 200[kg]

FARM WORK →

L = 3.4[km]
Max slip = 21.9°
Max load = 200[kg]

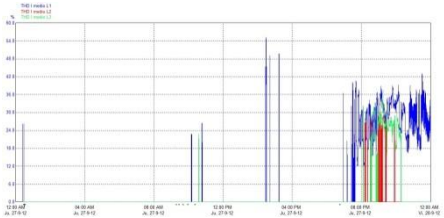
INTERNAL LOAD TRANSPORTATION →

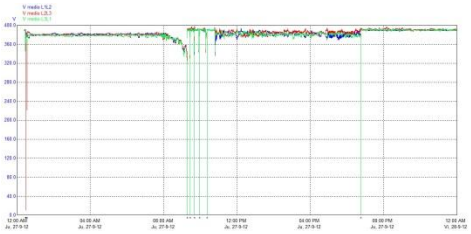
L = 1.2[km]
Max slip = 20.2°
Max load = 200[kg]

V2G in isolated microgrids

Service cost/quality

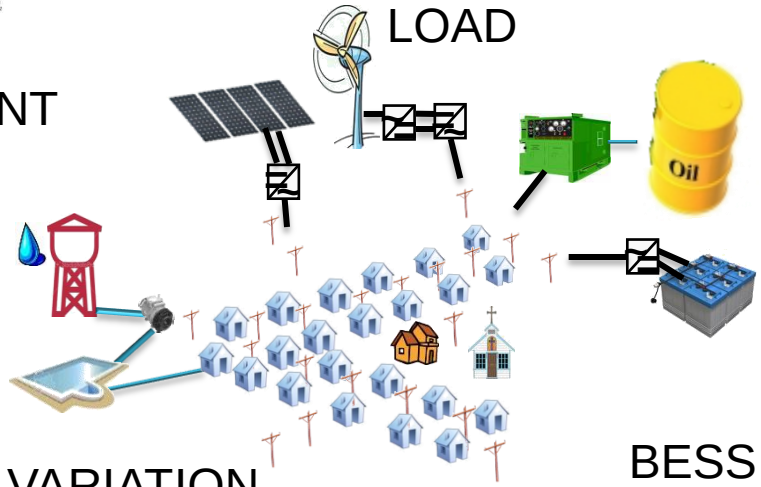
CURRENT THD





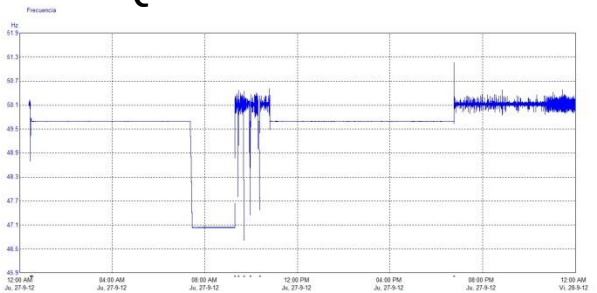
SUDDEN CONNECTION AND DISCONNECTION OF PV PLANT AND LOAD

UNBALANCED LOAD

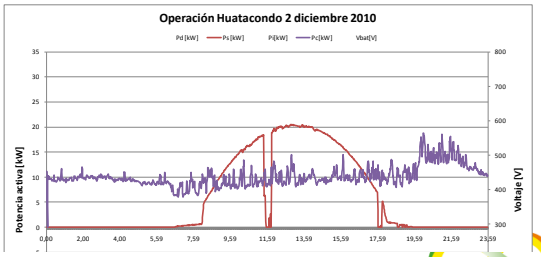


DIESEL COST

FREQUENCY VARIATION



BESS BACK-UP

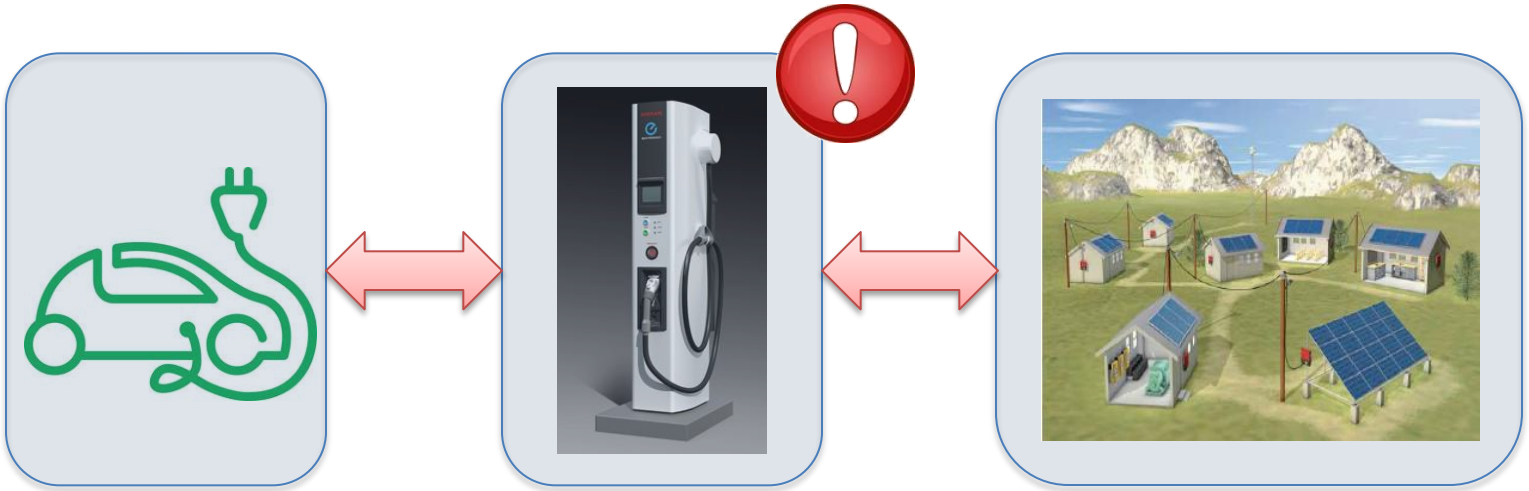


V2G in isolated microgrids

Project Stages

DESIGN AND BUILD OF A FOUR-WIRE THREE-PHASE INVERTER CAPABLE TO:

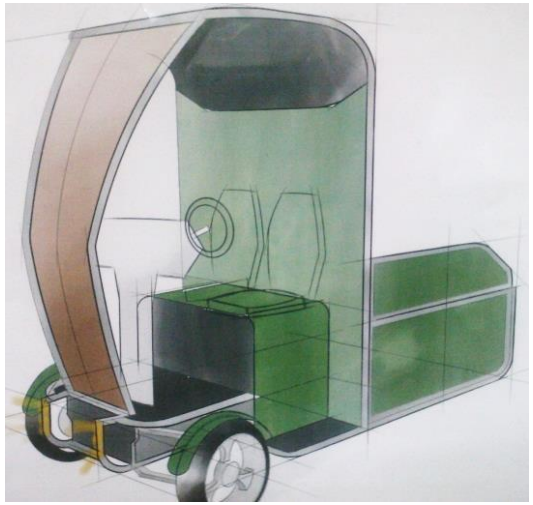
- Allow power conditioning
- Drive a three phase induction machine and supply 3ph loads
- Connected to a three phase grid
- Allow bidirectional power flow
- BESS back-up capability

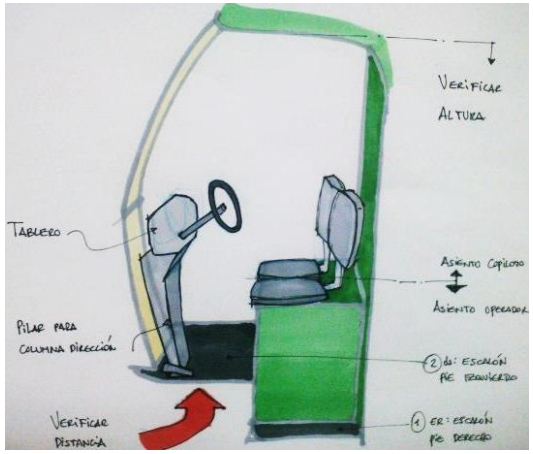


V2G in isolated microgrids

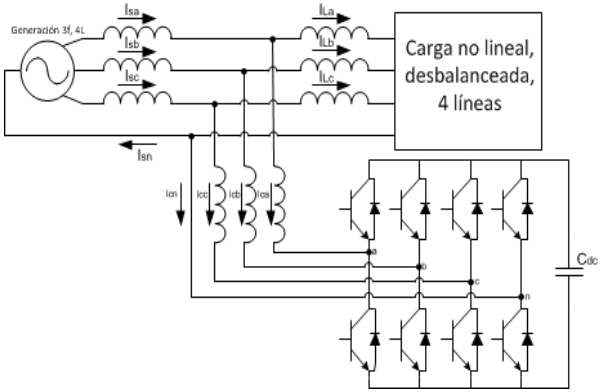
Some results

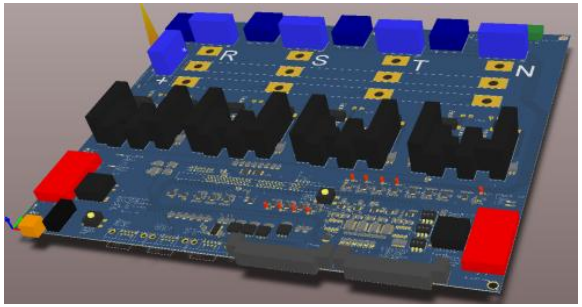
UTILITARY AND COMMUNITY ELECTRIC VEHICLE



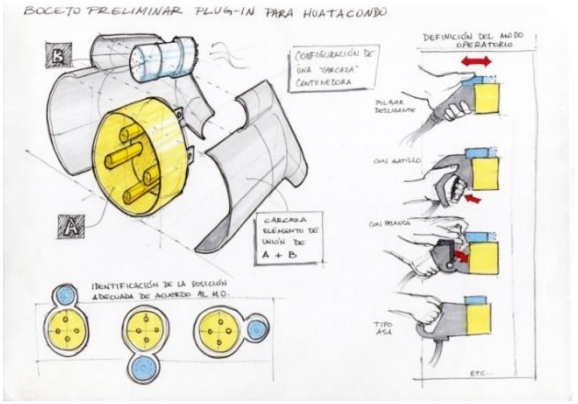


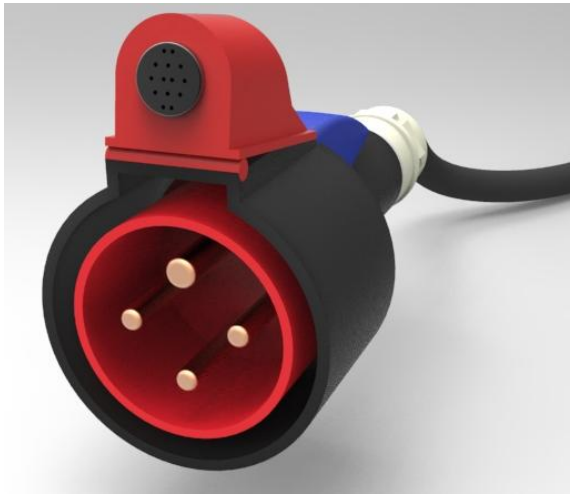
V2G POWER CONVERTER

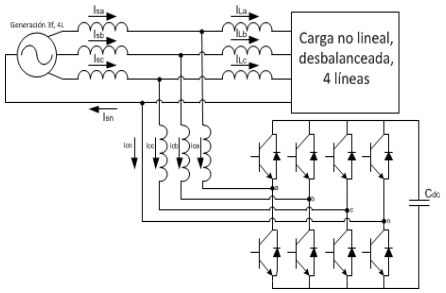




MICROGRID INTEGRATION

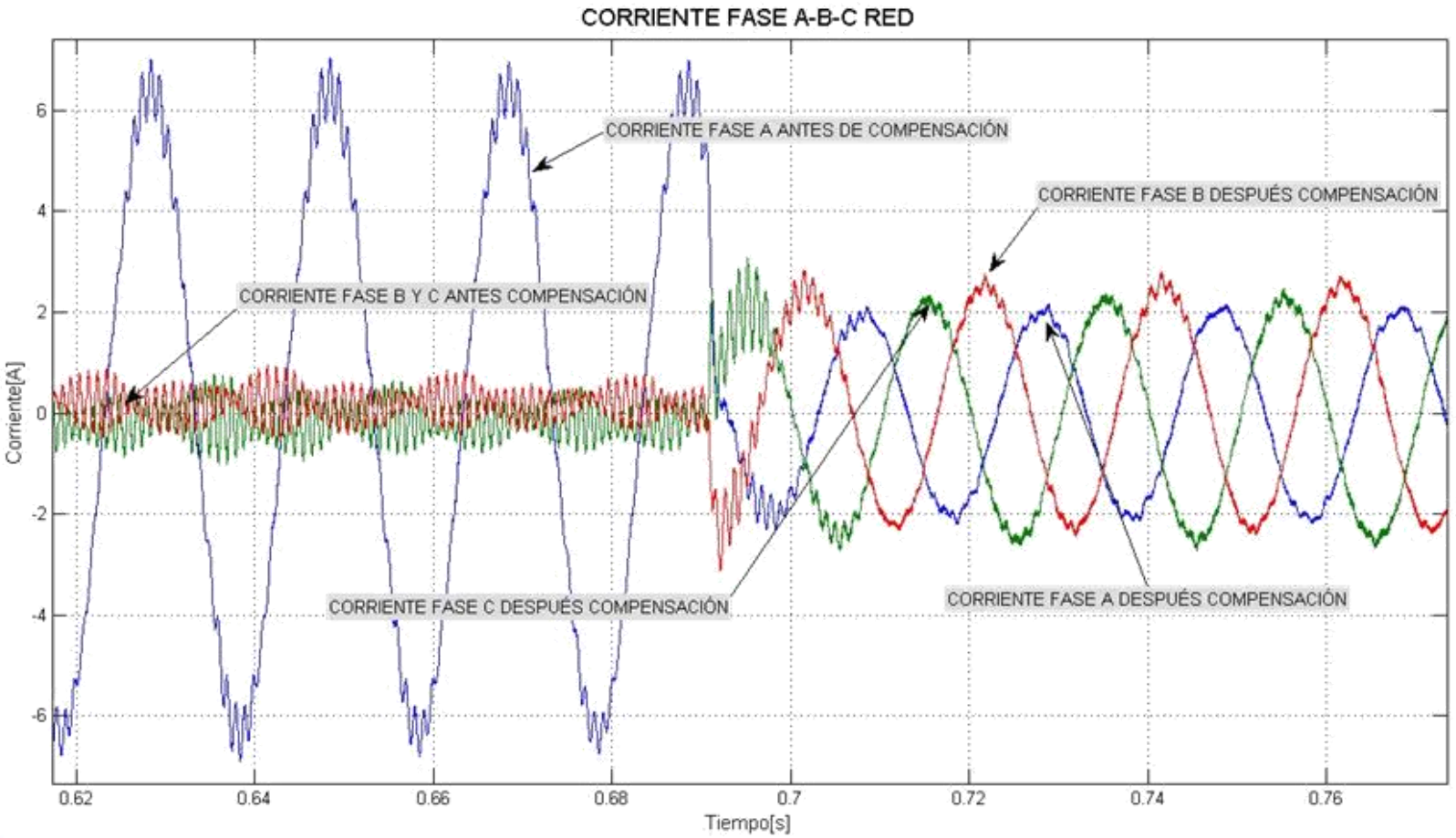






V2G in isolated microgrids

Some results



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Conclusions

- Microgrids appear as a sustainable solution for rural electrification challenges in LA:
  - To maximize lifetime of equipment
  - Low operation costs
  - Low maintenance cost
- Solutions should be faced from two main approaches: technical and social.
- Resilience indicators should improve the performance of microgrids in rural areas.
- Rural microgrids offer a development opportinity for V2G solutions.

2013 Santiago Symposium on Microgrids

Survey of Microgrid R&D in Latin America

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