DESIGN OF A PARTICIPATORY-MODEL/MICROGRID/SMART-FARM SYSTEM FOR THE MAPUCHE INDIGENOUS COMMUNITIES

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Project FONDEF IDeA 14I10063

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Contents

Motivation

- Access to electrical energy in rural zones has a strong impact on local development.
- Extending the main electrical grid involves high costs and technical issues.
- The microgrids based on renewable distributed units are presented as an attractive solution for rural zones.

Motivation

- Mapuche people have strongly emigrated from the rural zones → Family disintegration triggered by the migration of young people
- Mapuche means "people of the land" in Mapudungun. The gap between the Mapuche life way and Chilean society has generated loss of their cultural identity.
- The Mapuche culture has a strong respect for the environment and its renewable resources.

Brief Summary

- Design a microgrid/smart-farm system for Mapuche people based on a participatory model.
  - The Mapuche people is the largest ethnic group among the indigenous peoples of Chile (86.4%)
  - For them, the community is above the individual interests.
- The proposed project is designed according to the Mapuche culture.

Project Objetives

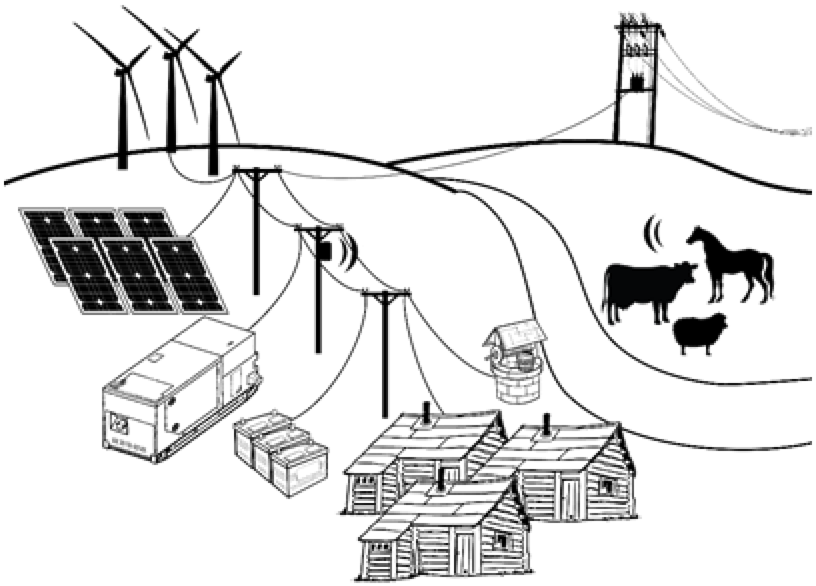
- Design a methodology:
  - To implement microgrids for energy supply in Mapuche communities.
  - To install a smart* farm system considering management of irrigation water and a livestock monitoring system.

- For improving the quality of life for Mapuche rural communities, while strengthening appreciation of their culture and ethnic identity.

*Smart: Sustainable, Manageable, and Accessible Rural Technologies

Project Stages

Microgrid

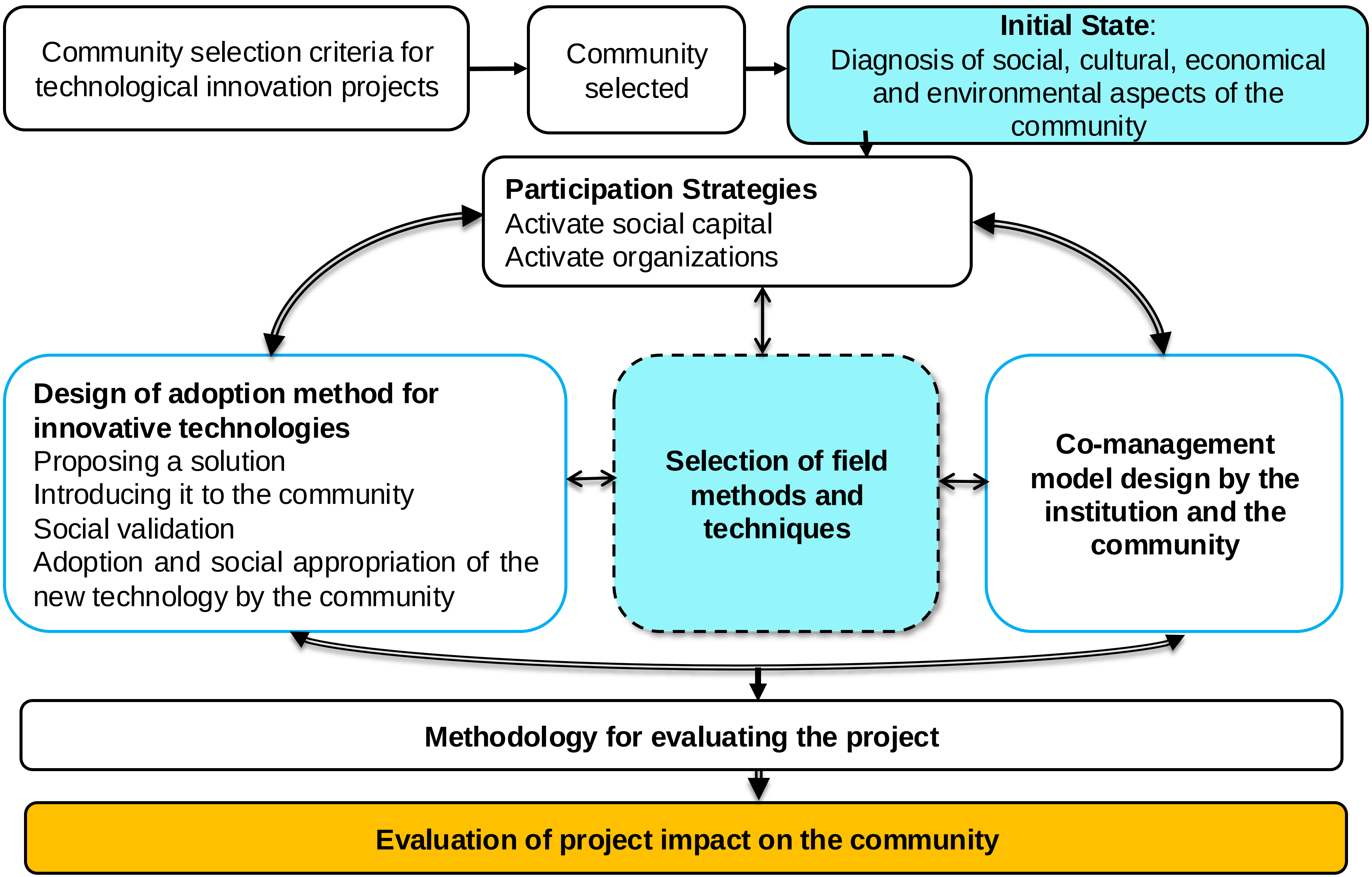


Smart Farm

- Participatory model for technological innovation
  - Technical-social criteria for selecting communities
  - Participatory diagnosis
- Microgrid design
- Smart farm system design
- Integration of microgrid/smart-farm /participatory model

Participatory Model for Technological Innovation

Participatory Model for Technological Innovation



Participatory Model for Technological Innovation

Design of criteria selection

Fulfillment of essential criteria →

- Isolated and rural communities
- Poverty level
- Energy resources

Fulfillment of Other criteria →

Social cohesion
- Internal & external relationships

Participation
- Social-active organizations

Demographic dimension
- Gender
- Population mobility
- Age-related roles

Participatory Model for Technological Innovation

Participatory Diagnosis

Selection criteria

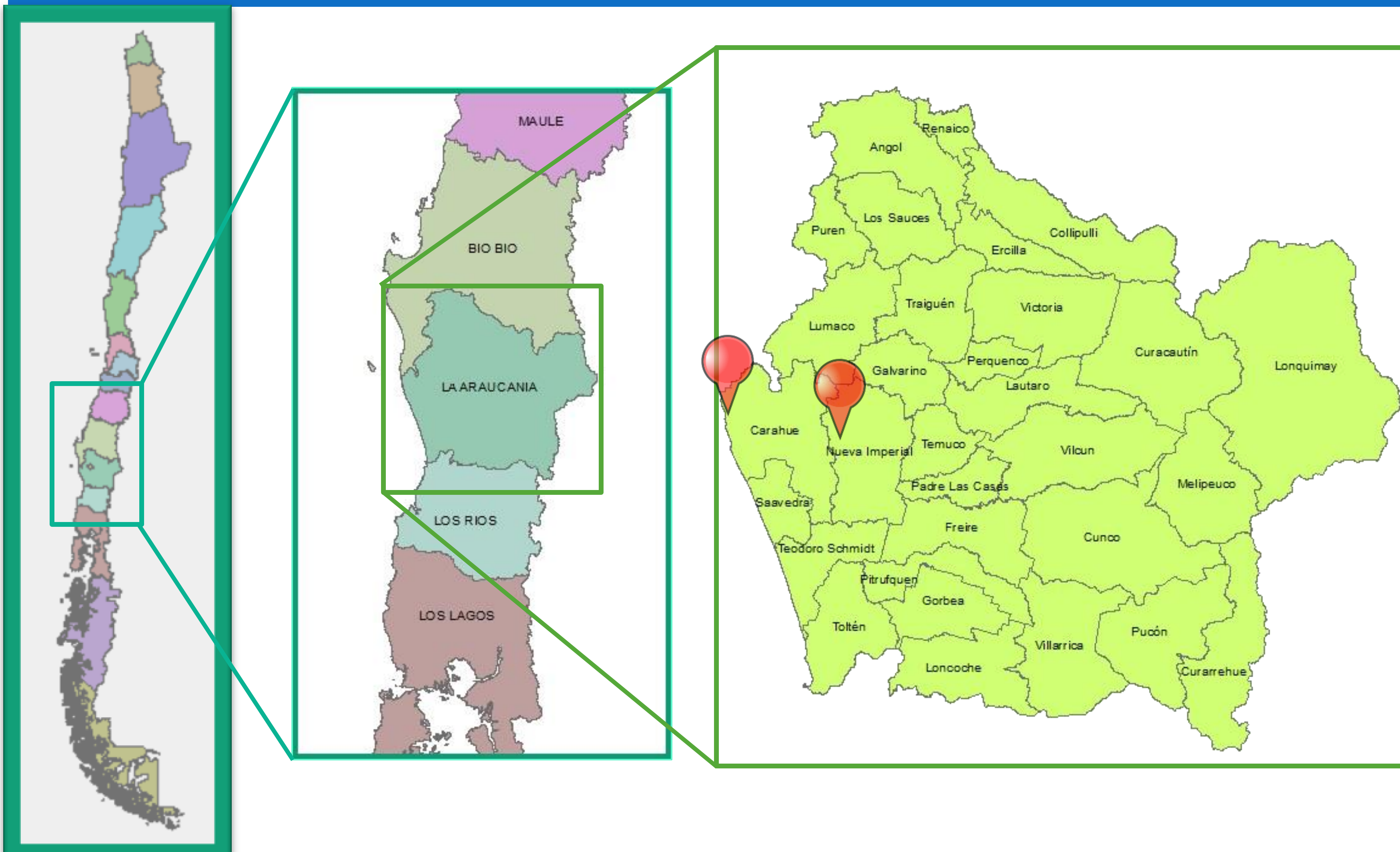
+

- **Environmental aspects**
- **Economical and productive aspects**
- **Socio-cultural aspects**

Participatory Model for Technological Innovation

Participatory diagnosis

Mapuche Communities



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Mapuche Communities

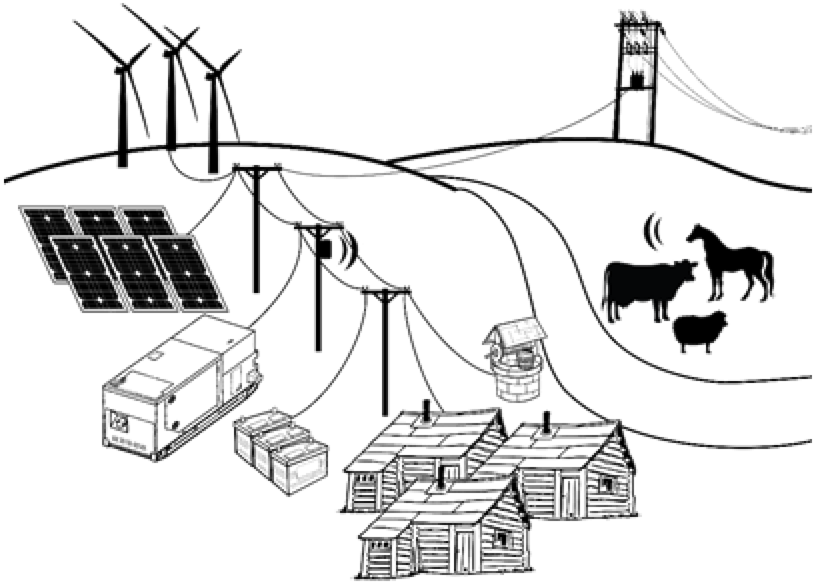
José Painecura

- 100 km from Temuco.
- 573 [Ha] (mountains and streams).
- Lafkenche: People of the sea.
- No mobile phone or internet coverage.
- Productive activities.
  - Agriculture for their own consumption
  - Small livestock.
  - Collecting seaweed and seafood.
- They are connected to the an unreliable grid with a high frequency of faults.

Contents

- Motivation and proposal√
- Project objectives and stages√
- Participatory model√
- Mapuche communities√
- Microgrid design
- Smart farm system
- Integrated system

Microgrid Design

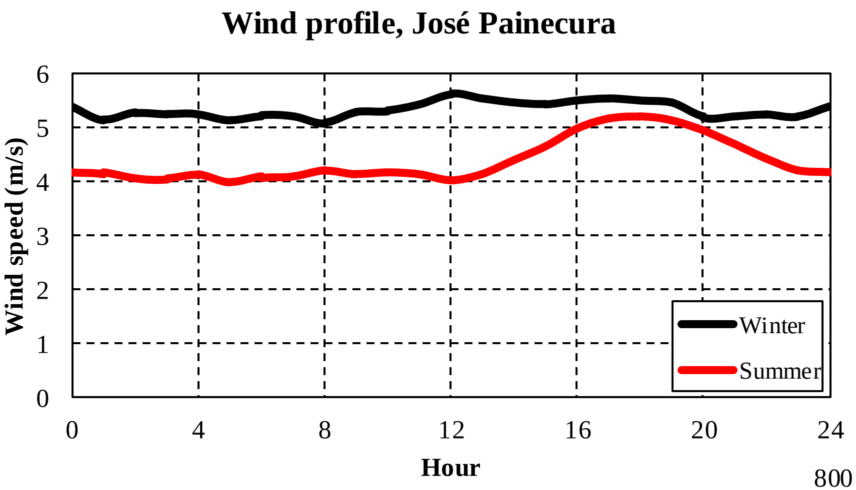


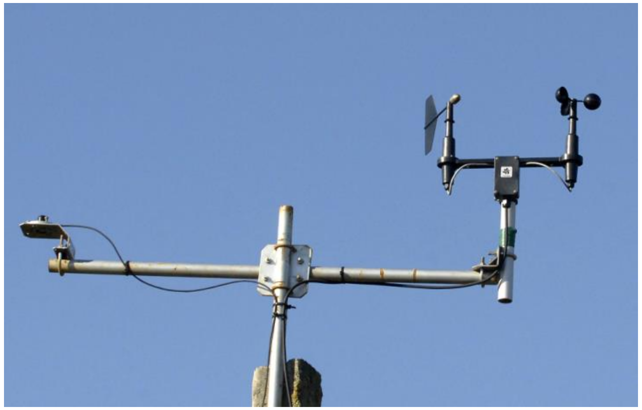
- Wind and solar resources evaluation
- Microgrid planning based on HOMER-PRO Energy software

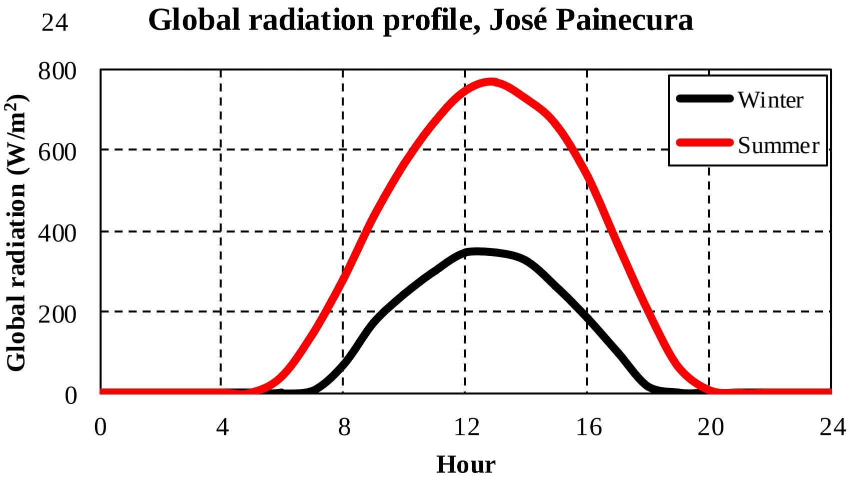
Microgrid Design

Evaluation of wind and solar resources

- Daily Profiles

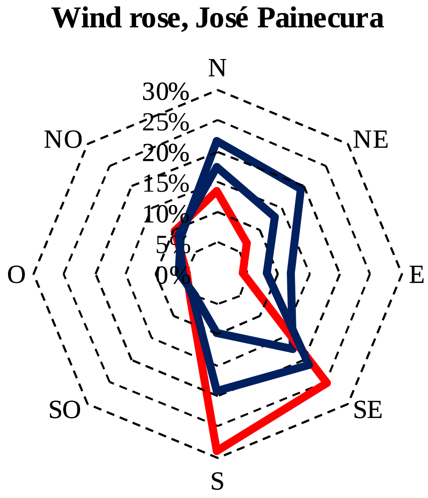


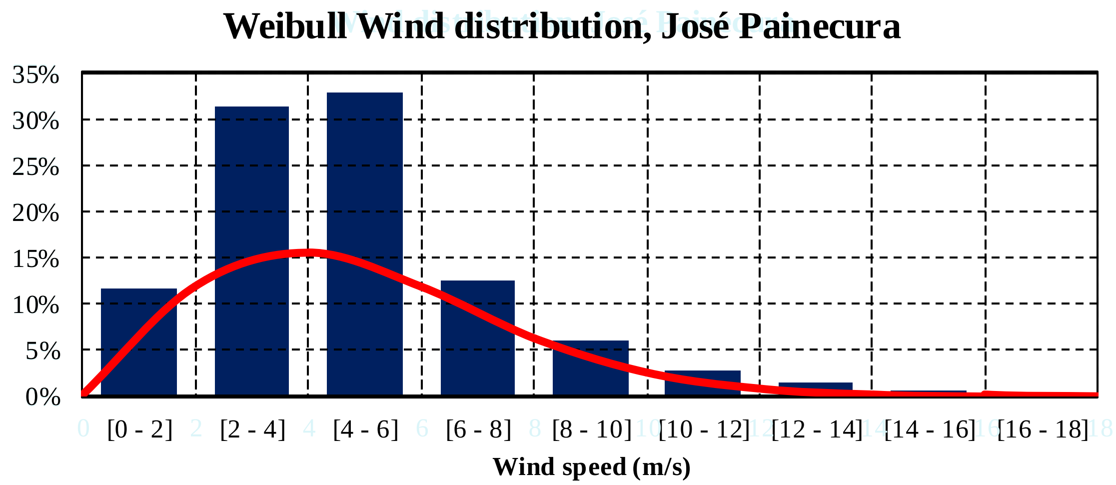




Microgrid Design

Wind resource evaluation

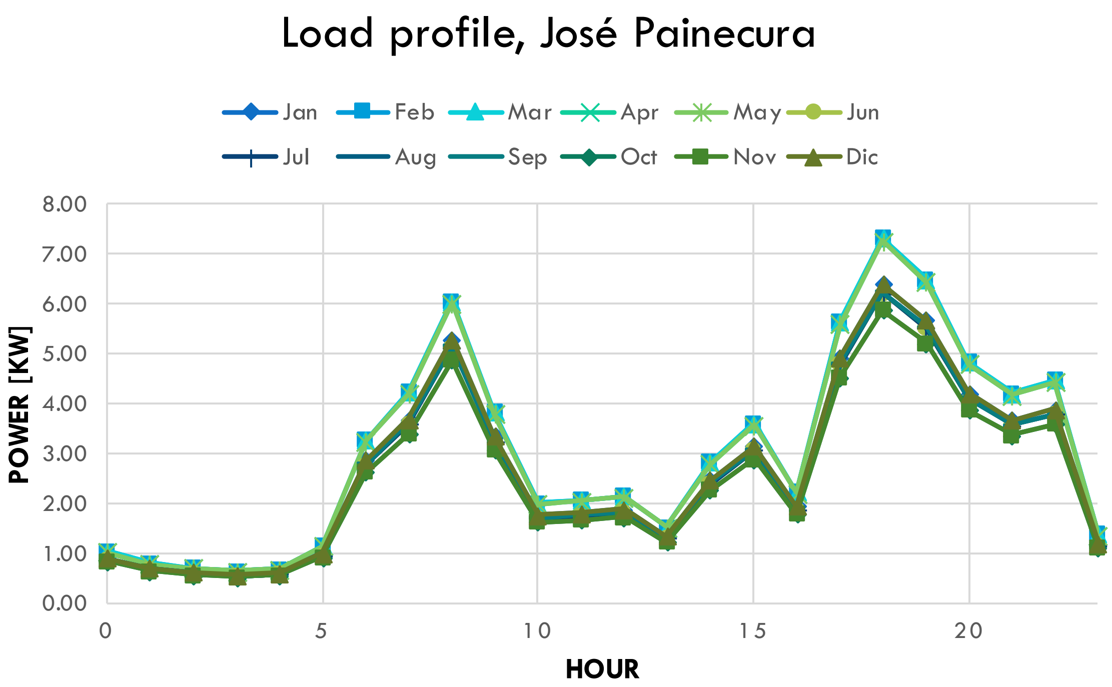




75% over wind of 3(m/s)

Microgrid Design

Demand Estimation



Period	Consumption [kWh]
Dec. – Jan.	3.835
Feb – March	4.391
April – May	4.352
June – July	3.722
August – Sep.	3.736
Oct – Nov.	3.524

Energy Average	65,4 [kWh/day]
Power Average	2,72 [kW]
Power Peak	9,45 [kW]
Load Factor	0,29

Microgrid Design

Technical and economical data

Field conditions	
Altitude above sea level	94 [m]
surface roughness	0,29

Utility prices	
Price of energy (to sell)	0,2493 [US$/kWh]
Price of energy (to buy)	0,0586 [US$/kWh]

Economical data	
Discount rate	10 [%]
Evaluation horizon	20 [years]
Inflation	3,1 [%]

Faults	
Frequency of faults	43 [1/year]
Average repair time	9 [hour]
Maximum repair time	3 days

Microgrid Design

Investment costs

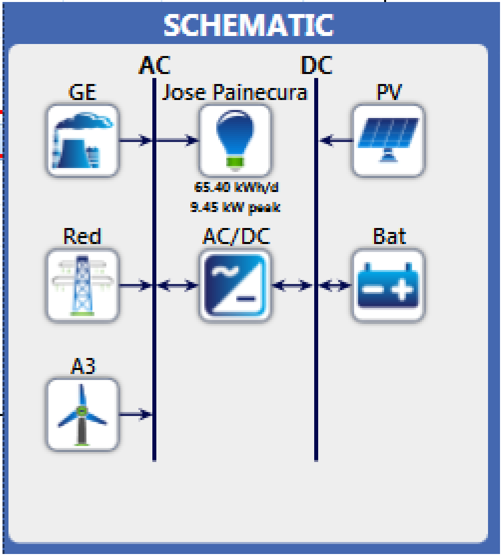
Capital expense [US$]	PV 0,25 KW	WT 10 kW	WT 3,5 kW	Battery Bank	Converter	Diesel Generator
Equipment	312,01	51.688,99	29.919,69	155,68	2.692,53	9.670,93
Installation	341,02	7.338,38	5.385,54	35,79	0,00	1.364,06
Project Management	18,72	2.446,13	1.795,18	0,00	0,00	580,26
Transport	491,52	30.092,93	5.517,04	777,40	1.003,10	436,81
Replacements	65,30	5.902,74	3.530,52	19,15	269,25	1.103,50
Contingency	174,49	13.734,96	6.392,62	145,33	554,34	1.807,81
Taxes	266,58	21.128,79	9.982,71	215,34	858,65	2.843,04
Total investment	**1.669,64**	**132.332,92**	**62.523,30**	**1.348,69**	**5.377,88**	**17.806,40**

Microgrid Design

Homer

Criterion: To increase the energy consumption without increasing the cost paid by the people of the community

Architecture						Cost				System	GE		
PV (kW)	A10	A3	GE (kW)	Bat	AC/DC (kW)	COE ($)	NPC ($)	Operating cost ($)	Initial capital ($)	Ren Frac (%)	Hours	Production	Fuel (L)
			10.0	10	3.00	-$0.0439	-$11,372	$3,662	-$51,114	0.0	271	1,271	436
3.00			10.0	10	3.00	-$0.0345	-$8,958	$2,038	-$31,079	15	225	1,016	352
5.00			10.0		3.00	$0.0193	$5,186	$3,354	-$31,209	23			
		1	10.0	10	3.00	$0.162	$43,648	$2,971	$11,409	21			
3.00		1	10.0	5	3.00	$0.172	$47,139	$2,068	$24,701	35			
5.00		1	10.0		3.00	$0.216	$61,763	$2,806	$31,315	41			
	1		10.0	10	3.00	$0.263	$92,799	$1,067	$81,218	60			
3.00	1		10.0	5	3.00	$0.269	$99,526	$462.11	$94,511	67			
3.00	1		10.0		3.00	$0.293	$108,415	$1,903	$87,767	66			
	1	1	10.0	10	3.00	$0.395	$156,355	$1,162	$143,742	67			
3.00	1	1	10.0	5	3.00	$0.399	$165,388	$769.82	$157,034	73			
3.00	1	1	10.0		3.00	$0.416	$172,645	$2,060	$150,291	73			

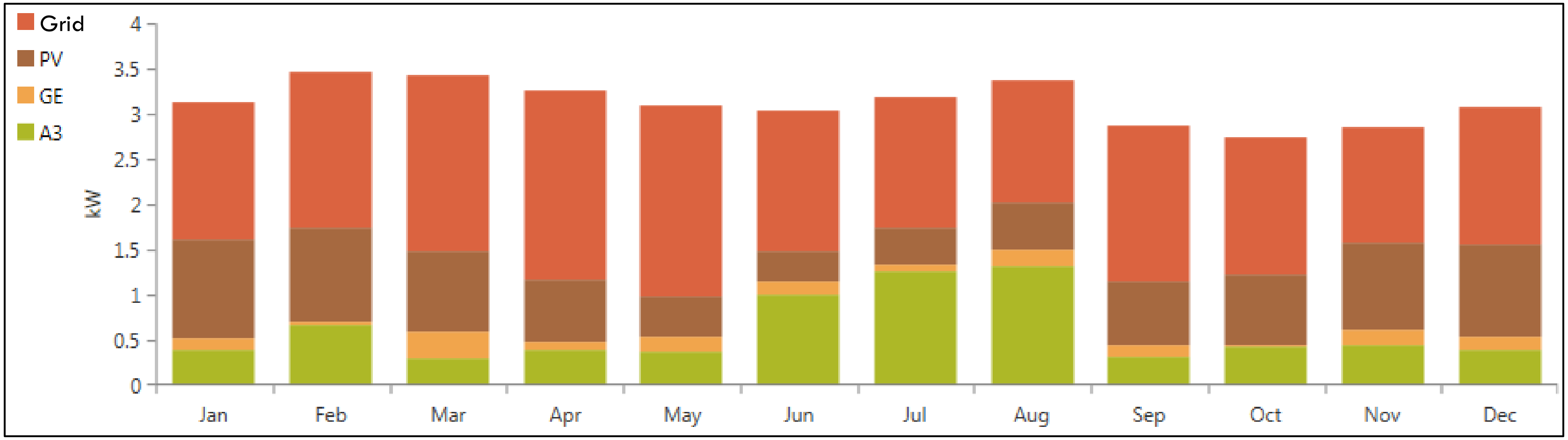


COE: Marginal cost of energy [US$/kWh]
NPC: Net present cost [US$]

Microgrid Design

Homer

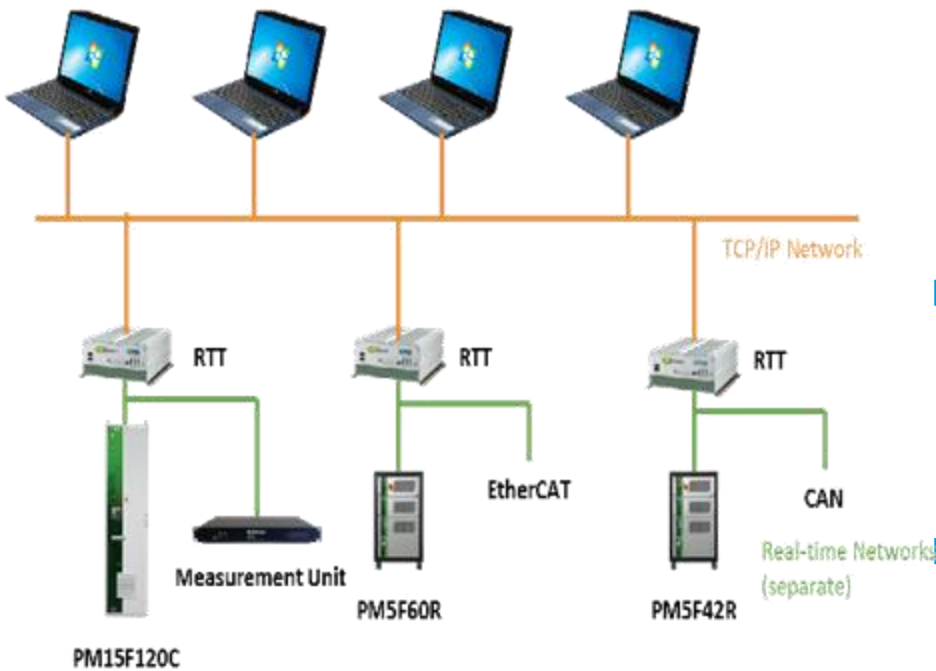
Monthly energy production



Energy	[kWh/year]	[%]
5 kW PV	6.486	23,70
3 kW WT	5.299	19,36
10 kW Diesel Gen.	1.159	4,24
Main grid	14.420	52,70
Total generation	**27.363**	**100,00**
Consumption	-23.869	90,47
Surplus sold to the utility	-2.513	9,53
Net energy	**-26.382**	**100,00**

Microgrid Design

Microgrid prototype



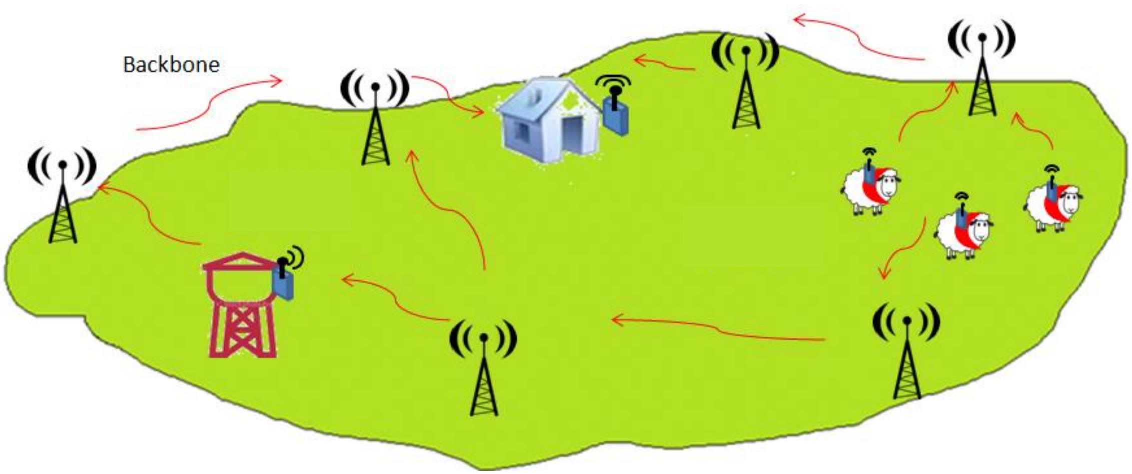
- Equipment:
  - Laboratory for microgrid control
  - Triphase emulator
- Study of the proposed microgrid topologies
- Performance evaluation considering technical and economical aspects
- Hardware in the loop (PV, WT)

Microgrid Design

- Triphase equipment:

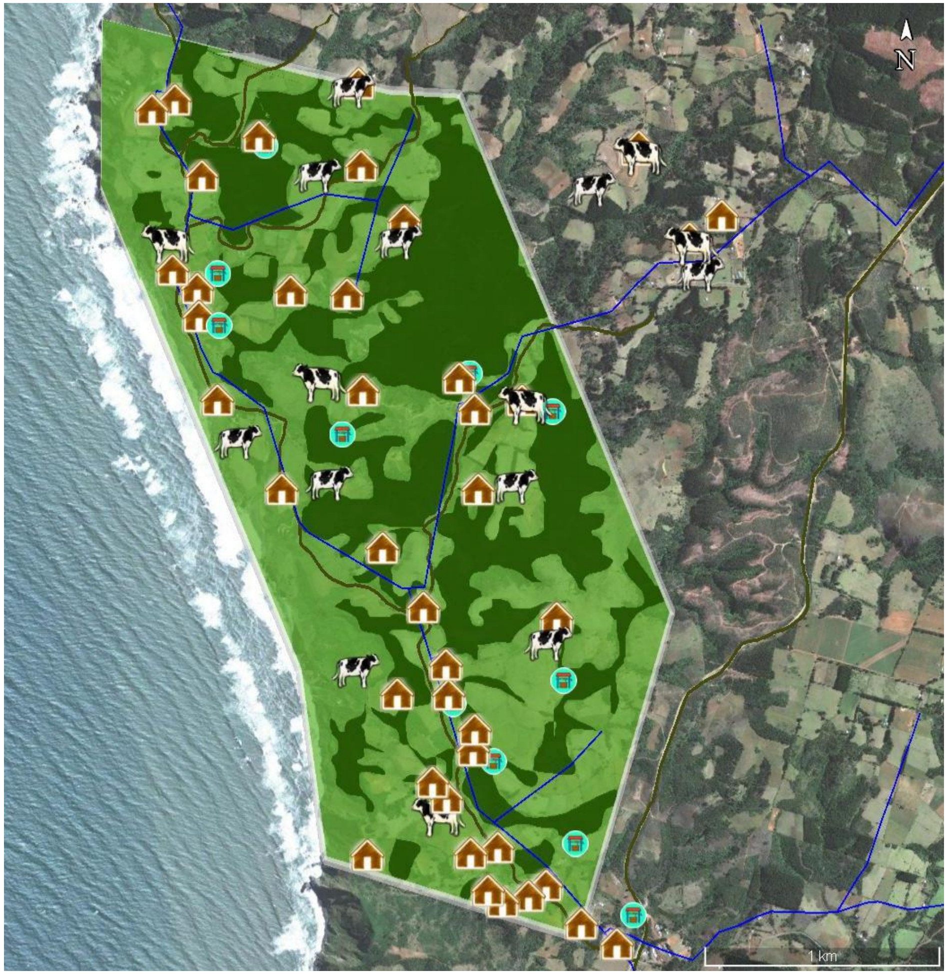
Smart Farm System

- Designed for small rural communities
- Wireless sensor network communication
- Components:
  - Wireless backbone
  - Real time livestock monitoring
  - Remote measurement of the water levels of wells



Smart Farm System

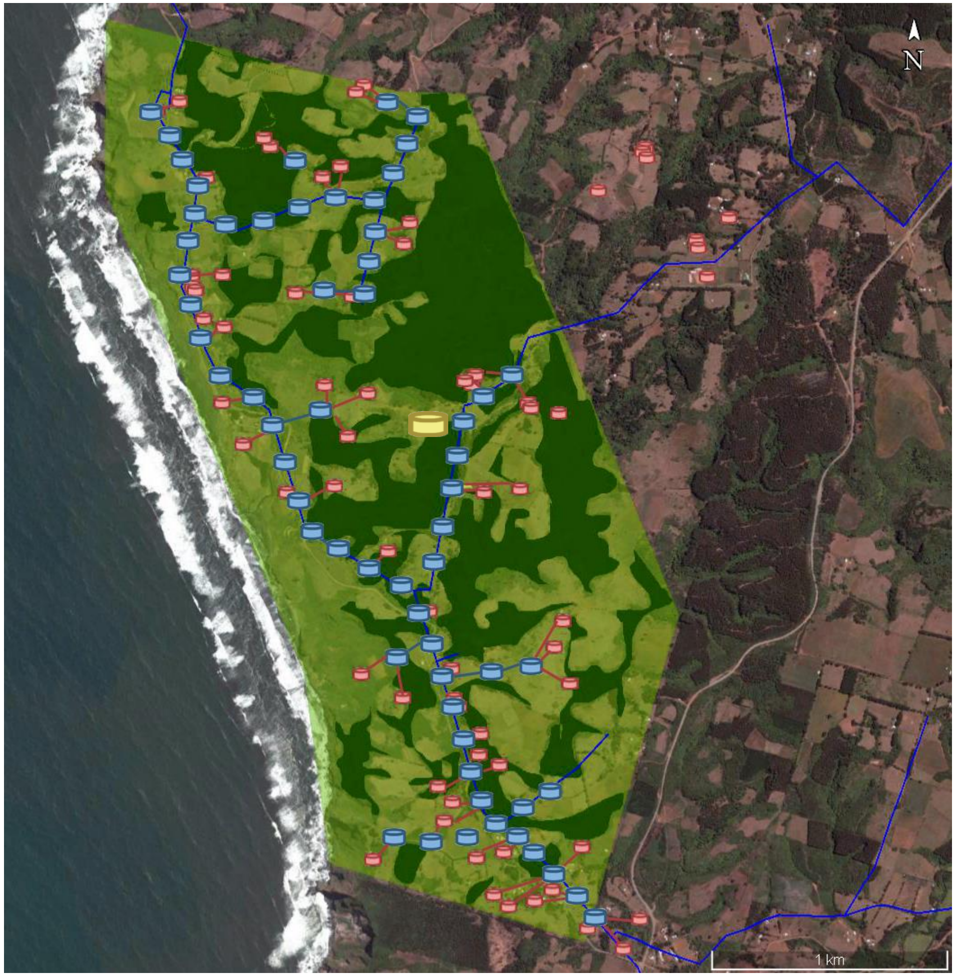
- José Painecura



509 [Ha]
44 homes
352 livestock (pigs, cows, sheep and horses)
36 water wells

Smart Farm System

- José Painecura



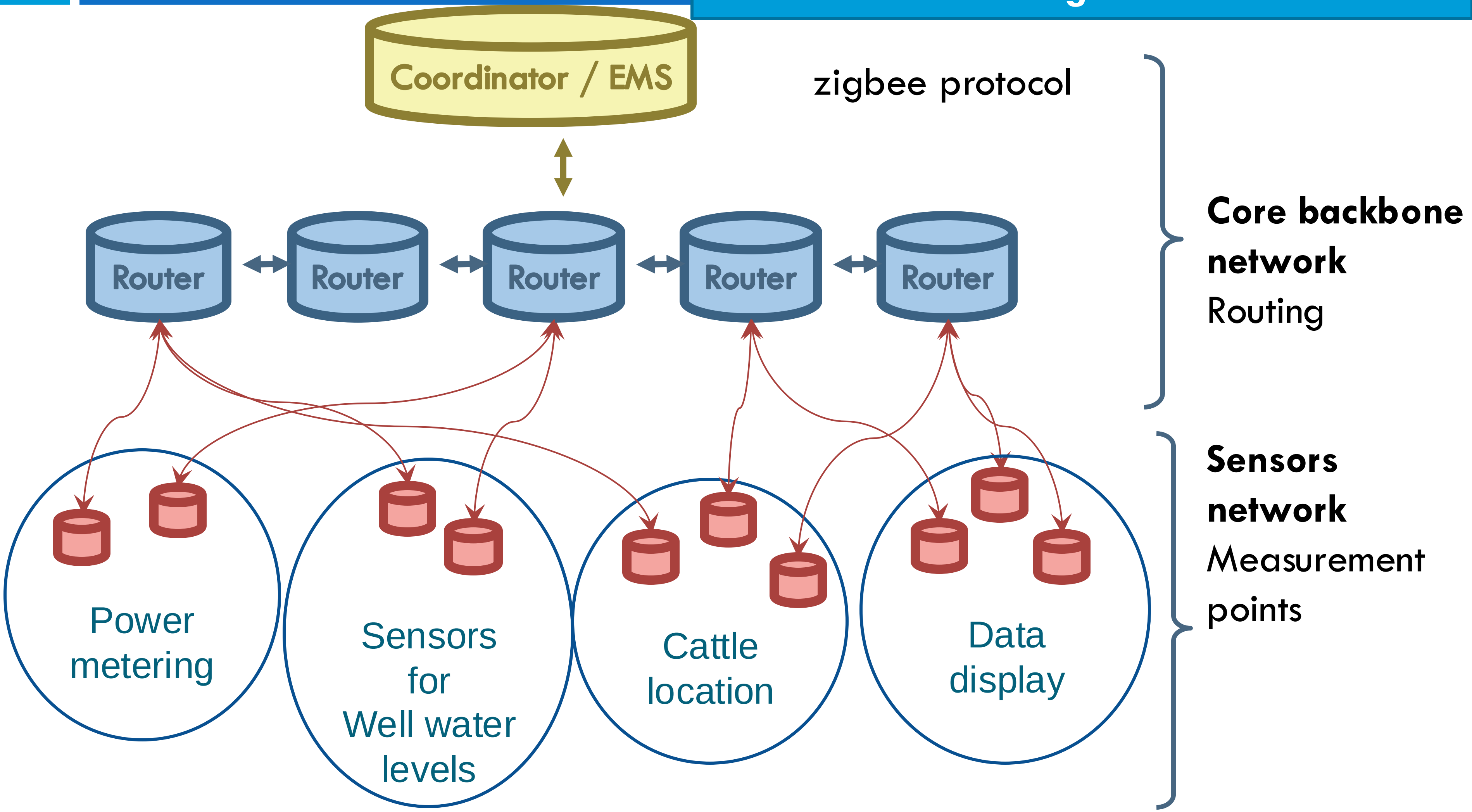
Communication network coordinator **EMS/Microgrid**

Router

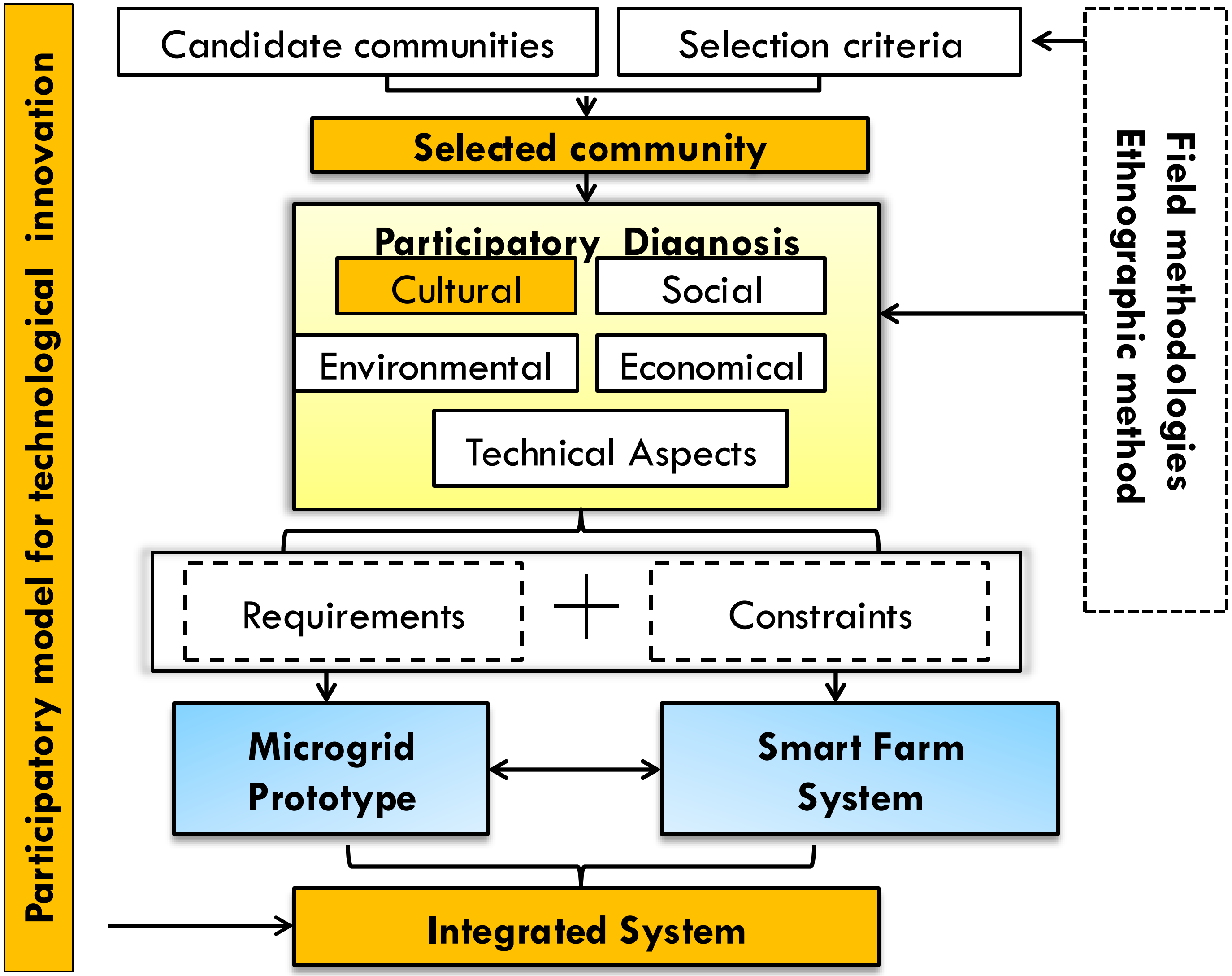
End device (sensors)

Smart Farm System

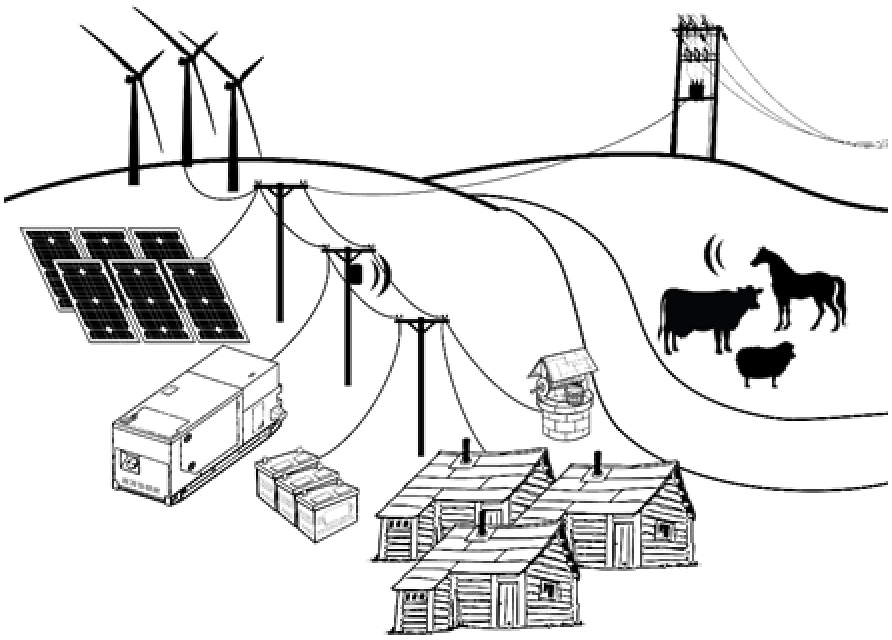
Communication Design



Integrated System



Integrated System



- The microgrid will cover the energy requirements of the selected Mapuche community and also will integrate a smart farm system considering the social, environmental, technical and cultural aspects.
- Final product: Microgrid/Smart Farm/Participatory model system to be implemented and replicated to other indigenous rural communities located in Chile as well as in other countries.

And in 5 years?   and in 50 years?

Mapudungun translation *"God has given to us this land where natural renewal energy exists.*
There are also several protective spirits, and their work is to give us strength and power.
Therefore, as Mapuche people, we are happy with the work of your team.
If the energy from the nature can be used we are going to be pleased"

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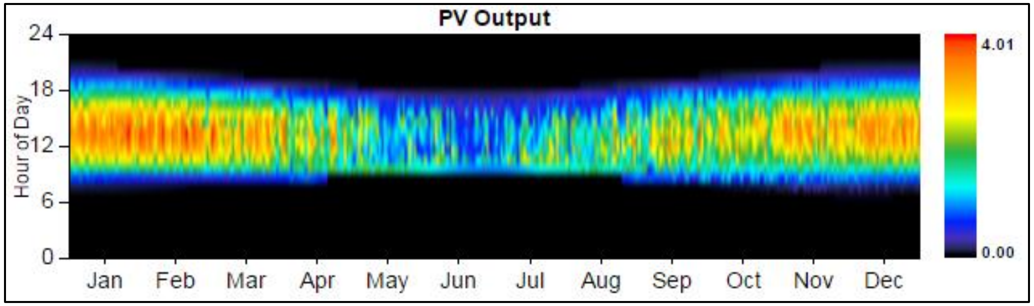
Microgrid Design

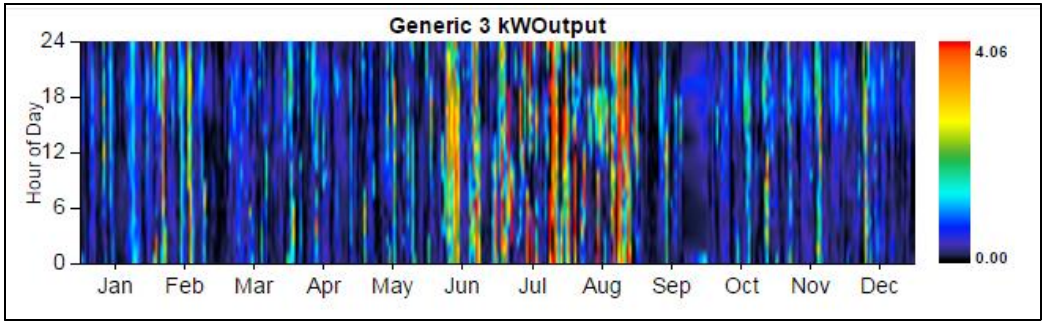
Homer

- PV generation



	Value	Unit
Energy average	17,77	[kWh/day]
Total energy	6.485,50	[kWh/year]
Maximum power	4,01	[kW]
Plant factor	14,81	[%]

- WT generation



	Value	Unit
Energy average	20,16	[kWh/day]
Total energy	5.298,80	[kWh/year]
Maximum power	4,06	[kW]
Plant factor	20,16	[%]

Microgrid Design

Technical and economical data

Photovoltaic panel	
Model	Amerisolar AS-6P30
Nominal Power	250 [W]
Nominal temperature	45 [°C]
Efficiency for standard conditions	15,4 [%]
Temperature effect over the power	-0,44 [%/C]
Useful life	20 [years]
Reduction factor of power	80 [%]

WT 1	
Model	Osiris 10
Nominal power	10 [kW]
Shaft height	15 [m]
Starting speed	2,5 [m/s]
Nominal speed	9,5 [m/s]

WT 2	
Model	Enair 3.5
Nominal power	3,5 [kW]
Shaft height	9 [m]
Starting speed	2,5 [m/s]
Nominal speed	15 [m/s]
Model	20 [years]

Microgrid Design

Technical and economical data

Converters	
Model	Victron Multiplus
Nominal power	5 [kW]
Inverter efficiency	94 [%]
Rectifier efficiency	85 [%]
Useful life	20 [years]

Generator	
Model	Kipor KDE60SS3
Fuel	Diesel
Fuel cost	0,64 [US$/litre]
Useful life	15.000 [hours]

Batteries	
Model	Luxcel 12 V 100 AH
Nominal capacity	100 [Ah]
Useful life	5 [years]

Microgrid Design

Net Present Costs

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
PV 0,25 KW	33.393	0	677	0	-1.828	32.242
WT 3,5 kW	62.523	0	10.178	0	0	72.701
Diesel Generator	273.343	0	15.718	3.053	-37.610	254.504
Grid	0	0	40.086	0	0	40.086
Converter	3.227	0	175	0	0	3.402
Other	-341.171	0	0	0	0	-341.171
System	31.315	0	66.834	3.053	-39.439	61.743

Fieldwork

Fieldwork