SUMMARY OF MICROGRID ACTIVITIES IN THE USA

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CONTENTS

- Booming microgrid industry
- Government efforts
- Focus on resilience
- New initiatives

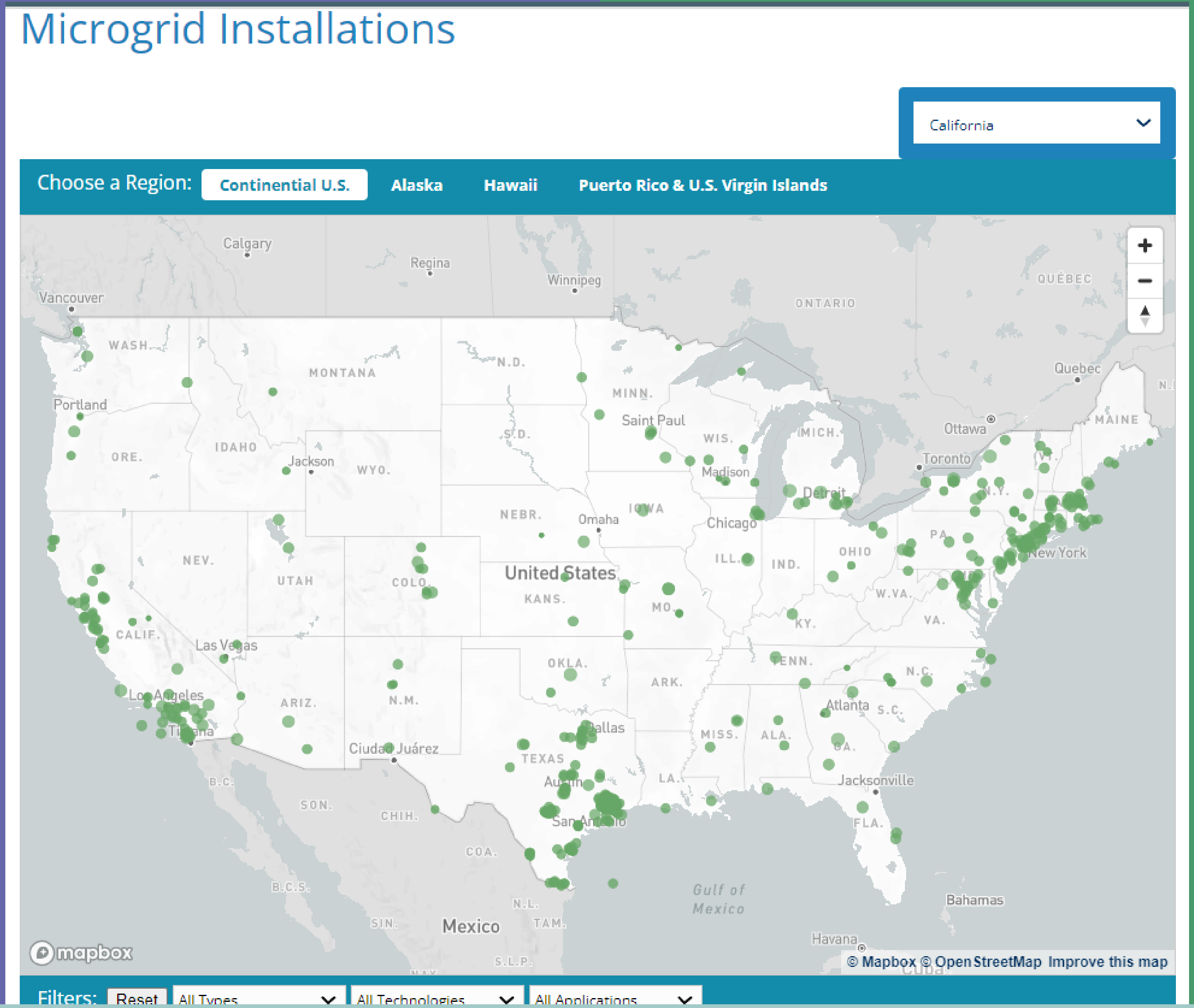
575+ MICROGRIDS IN UNITED STATES

Microgrids reached 7,000 MW

Operating in 2022 with 3,000 MW more in construction

Higher use of solar plus storage

https://www.woodmac.com/press-releases/us-microgrid-market-develops-at-rapid-pace--with-capacity-reaching-10-gw-in-2022/



NATIONAL FORECAST

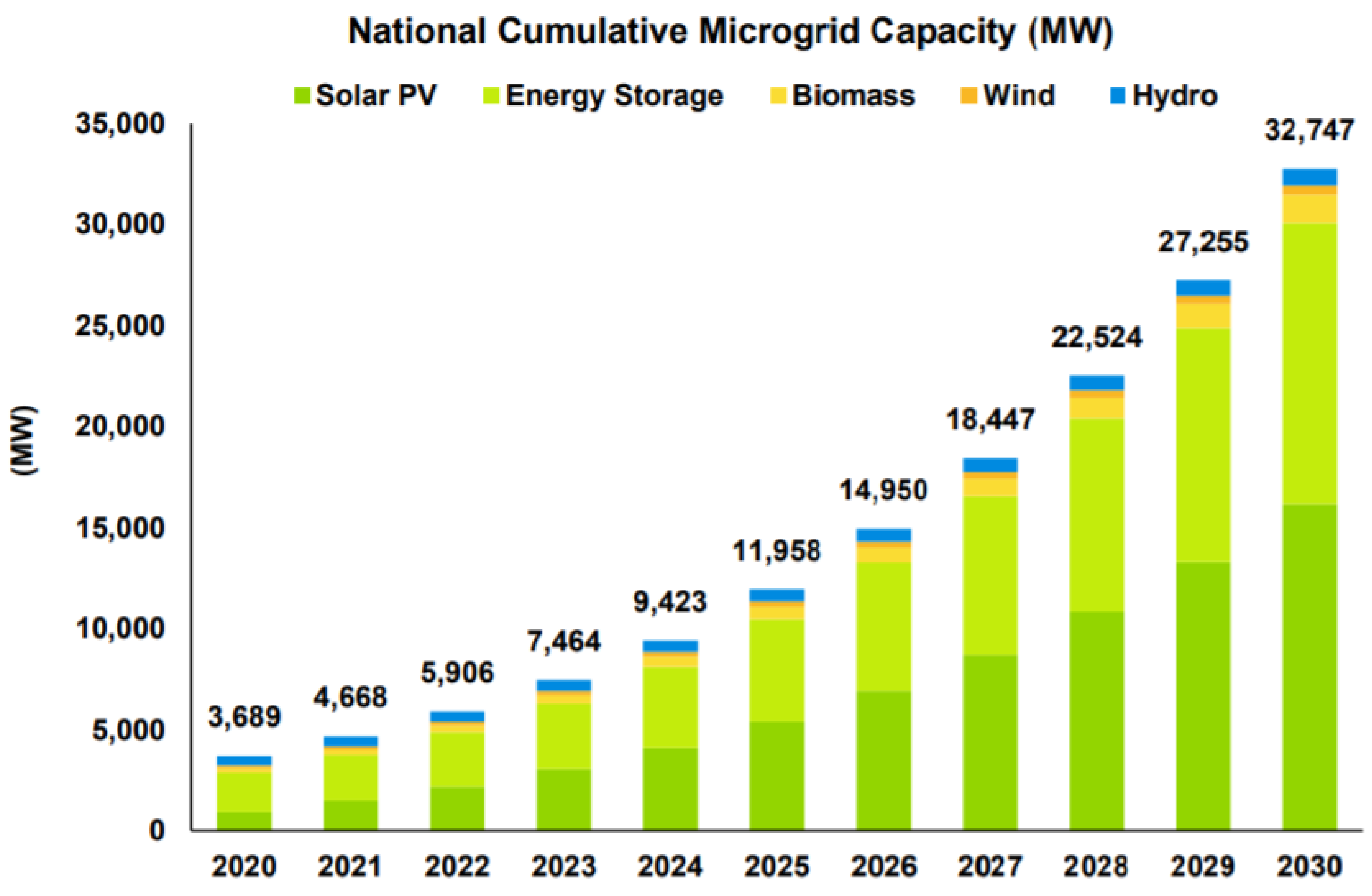
Guidehouse

The Renewable Energy Economic Benefits of Microgrids

National renewable asset microgrid capacity is expected to grow 3.5 times, bringing total to **32,470 MW by 2030**.

Microgrid assets are a powerful engine for change, not only for our environment and for resiliency, but also for our economy.

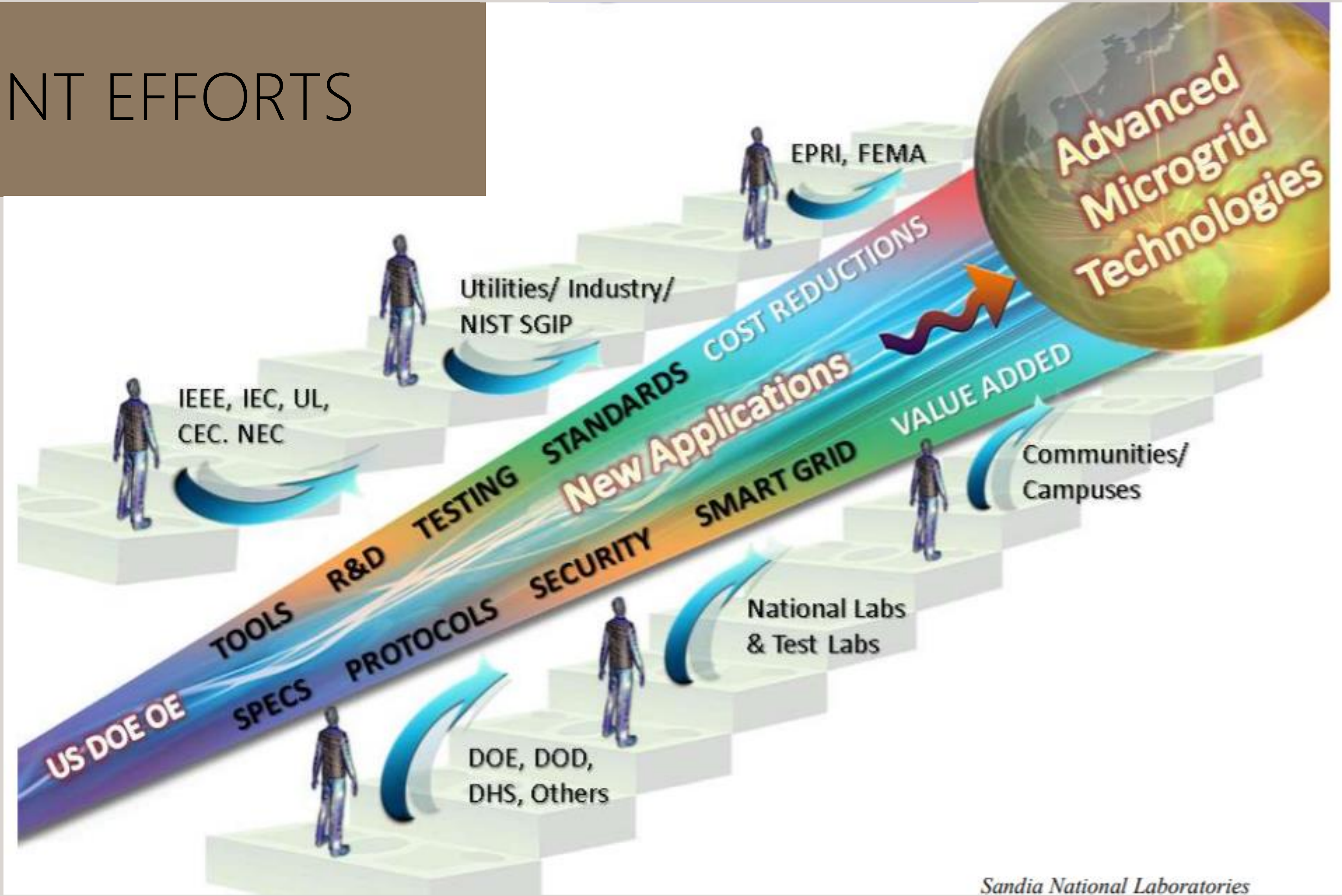
Guidehouse Insights, 2021



GOVERNMENT EFFORTS

Many years of efforts by multiple agencies have made a huge impact

Additional IEEE 2030 standards upcoming

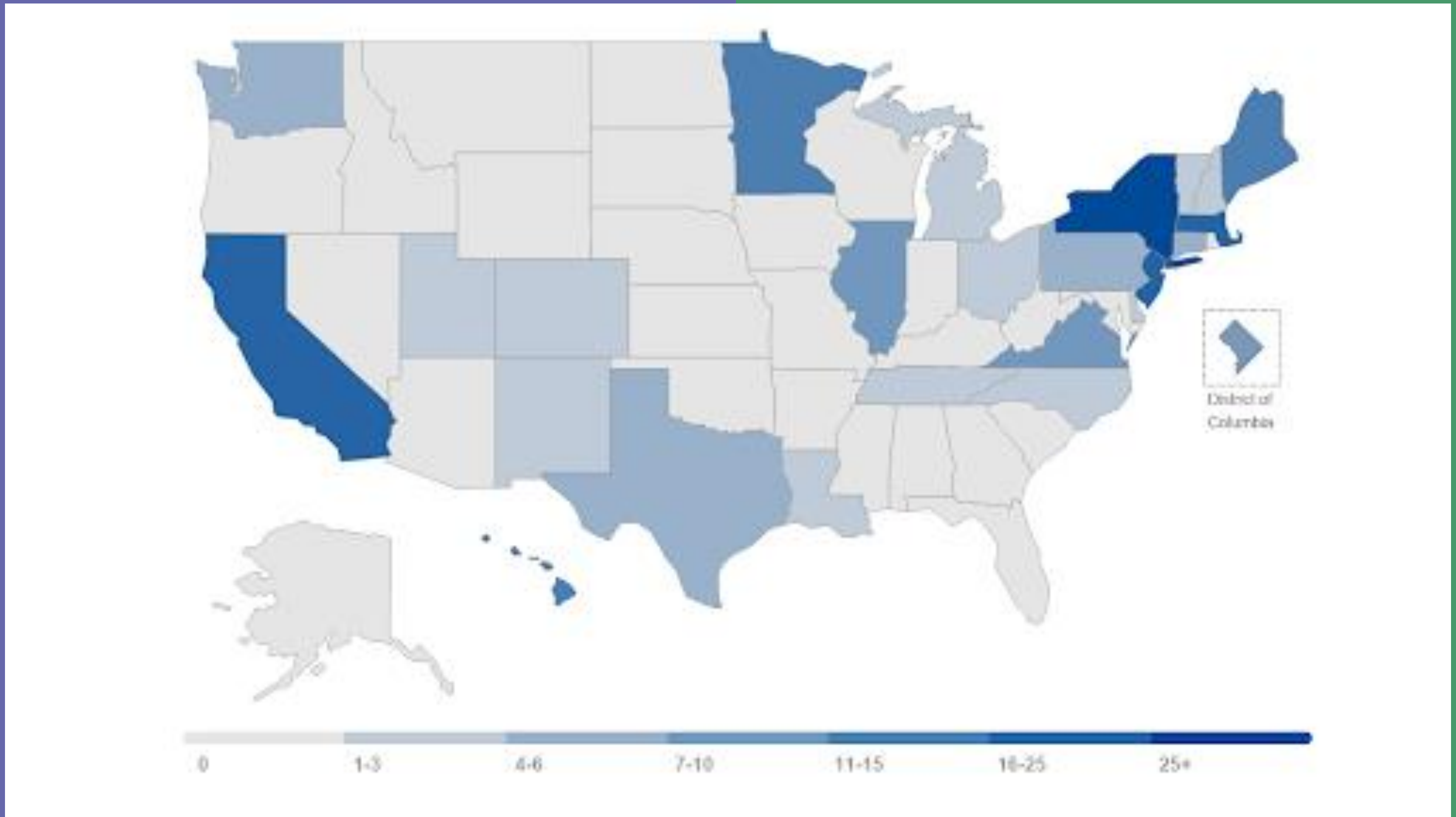


LEGISLATION

During the past six years, 21 states have proposed and enacted 53 microgrid-related bills largely for grid reliability and resilience.

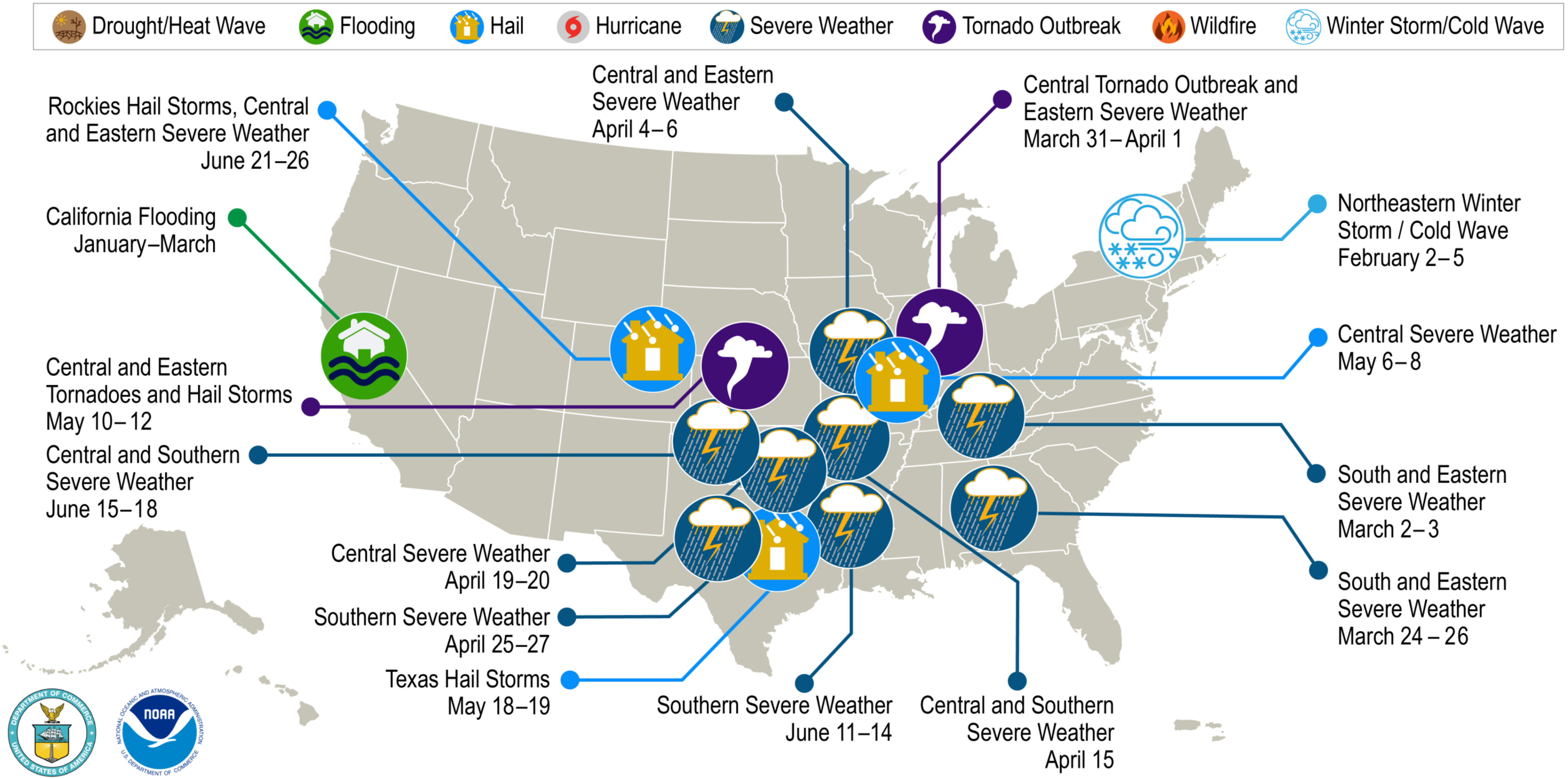
These often arise following an extreme weather event or prolonged outage.

Smart Electric Power Alliance (SEPA), 2021



"Resilience is the most commonly identified benefit of microgrids… most microgrids were initiated in the aftermath of a large-scale disaster or … interruption" (Analysis of the Microgrid Market, Thomas Hancock et al, 2021)

U.S. 2023 Billion-Dollar Weather and Climate Disasters



This map denotes the approximate location for each of the ***15 separate billion-dollar weather and climate disasters that impacted the United States through July 2023.***

https://www.ncdc.noaa.gov/billions/

VALUING RESILIENCE

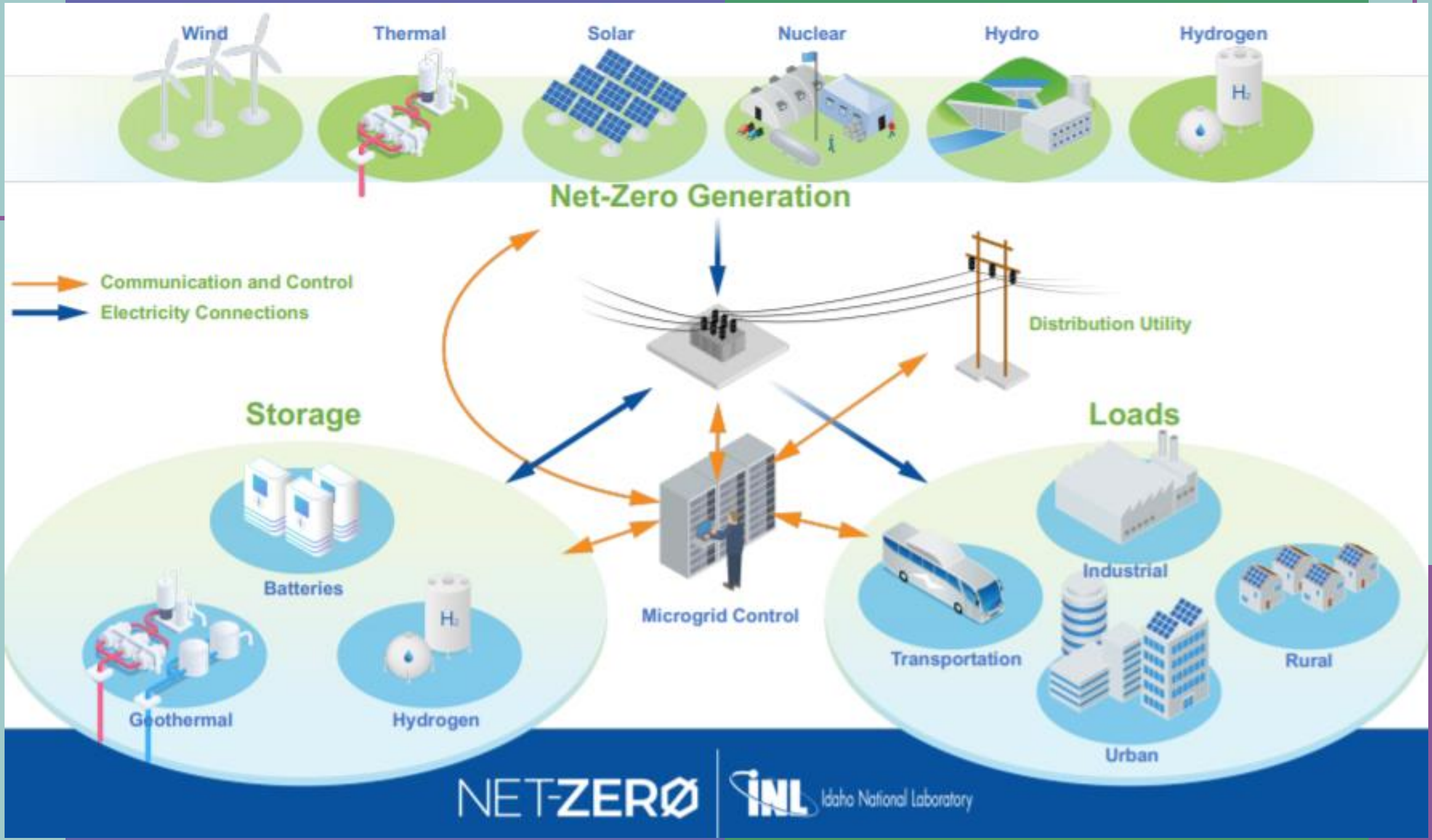
https://www.naruc.org/taskforce/topic-10-resilience/

Method / Tool	Advantages / New Additions	Available
Interruption Cost Estimator 2.0 Tool	• Updated calculations of power interruption costs. • New willingness-to-pay surveys that will populate the tool with more recent data and more geographic specificity for power interruption cost estimates. • New data on customer responses to longer-duration power interruptions	2023
Customer Damage Function Calculator Tool	• Helps individual facilities (or groups of similar facilities) calculate power interruption costs, based on the specific losses that they project will occur. • Guided questions lead facilities through their own assessments.	2021
Social Burden Method	• Provides a metric for the social burden of power outages that emphasizes the needs of communities during power outages, rather than protecting critical infrastructure for its own sake. • Adopts a more neutral treatment of the ability to pay for resilience, rather than willingness to pay.	Pilot 2021-2022
FEMA Benefit-Cost Analysis Tool	• Provides quantitative values for lost emergency services, such as police, fire, and emergency medical response. • New pre-calculated values specifically for hospitals published in 2021. • The use of FEMA values aligns with the application requirements of FEMA grant programs.	2021
Power Outage Economics Tool (POET)	• Estimates the economic impacts of longer-duration power outages. • Accounts for how utility customers adapt their behavior during long-duration power interruptions. • Uses surveys of utility customers to collect data on how they would behave during a power outage.	Pilot 2021-2022

NET-ZERO MICROGRIDS

Program will develop technical tools, analysis, and studies to promote the eventual transition to net-zero microgrids

New generation technology based on hydrogen or microreactors needed to retire fossil-based generation



[Idaho National Laboratory](#)

microgridUp

Microgrid Planning Utilizing an Open Modeling Framework for Resilient Installations Leveraging Their Utility Privatization

NRECA

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Project Website
https://microgridup.org

2021	2022	2023
Develop Open Source Microgrid Planning Software	Comprehensive Microgrid Plans for 4 Military Installation	Final Goal: Accessible Microgrid Planning for all DoD

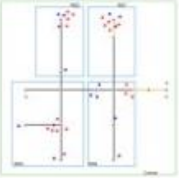
Components of Our Solution

Microgrids can offer a cost-effective option for multi-day installation resilience, but planning them is challenging.

Data Import	Leverage comprehensive data sets from utility privatization partners to locate microgrid opportunities across tens-of-thousands of grid components.
Network Segmentation	Segment the distribution network automatically, weighted by load criticality to find sets of maximum impact and mutually beneficial microgrid options.
Distribution Design	Add distribution upgrades to the system model to determine cost impacts and run automated interconnection to confirm nothing exceeds hosting capacity.
Generation Planning	Determine resilient and cost-optimal generation mixes of solar, wind, natural gas, energy storage and diesel for all candidate microgrids.
System Control	Execute detailed control simulations to determine load, generation, switching and protection changes needed to safely island/de-island and black start.

Bottom Line Output Example

- Tool identifies four load clusters suitable for microgrids (circuit diagram at right), compares to a central microgrid encompassing all load.
- Diverse mix of renewable and fossil generation identified as cost-optimal, providing resilience through critical period (24 hours of most difficult load behavior) but with average survival higher.
- Diverse set of net present values for the different microgrids identified–opportunity to stage deployment depending on funding available.
- Central microgrid has some cost savings and resilience benefits (c. 14 hours additional average survival) but requires bigger up-front investment.



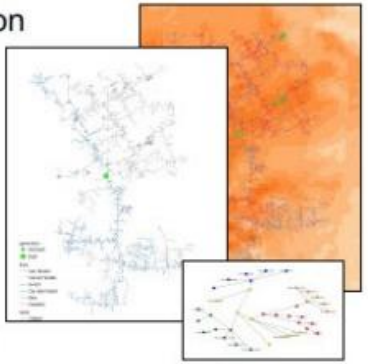
Microgrid Name	Min Load (kW)	Avg Day Load (kW)	Max Load (kW)	Diesel (kW)	Solar (kW)	Batt. Power (kW)	Batt. Capacity (kWh)	Total Gen on Grid (kW)	CO2 Reduced (%)	NPV ($)	CapEx ($)	CapEx w/ Incentives ($)	Outage Survived (Avg. h)
MG1	60	246	306	167	577	75	296	819	12%	46,159	496,464	347,076	116
MG2	211	498	713	329	1,146	156	531	1629	16%	346,155	2,349,583	1,442,504	48.4
MG3	316	684	909	451	1,598	250	635	2299	20%	426,626	3,303,194	2,020,414	58
MG4	28	216	384	137	570	111	286	816	10%	126,771	1,180,502	733,021	144
MG1+2+3+4	-	1,945	-	1,082	3,890	592	1,950	5,565	14%	916,585	7,336,733	4,543,017	48.4
central	676	1,945	2,262	1,032	3775	470	1490	5,357	15%	797,284	6,672,724	4,232,251	70

Data Import – The UP Advantage

- Utility Privatization (UP) partners maintain comprehensive data on distribution systems, which we leverage to quickly generate microgrid solutions.
- Meter data ingest through importers for SCADA and AMI.
- Circuit data ingest from Engineering Analysis tools (Windmil, CYMDIST, PSSE, etc.)
- GIS/oneline tools used for edits to imported data for new equipment and output visualization.

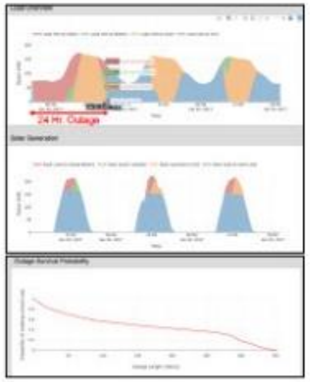
Network Segmentation

- Microgrid deployments benefit from economies of scale, but full-installation microgrids have high capital costs.
- We use critical facilities lists and the distribution model to automatically segment the network into sub-networks that can be supported by smaller microgrids.
- By applying a damage model based on past outages and forecasted threats, we identify deployment options that maximize support of critical loads.
- Network segmentation allows for incremental deployment while avoiding overlapping microgrids which are challenging to control.



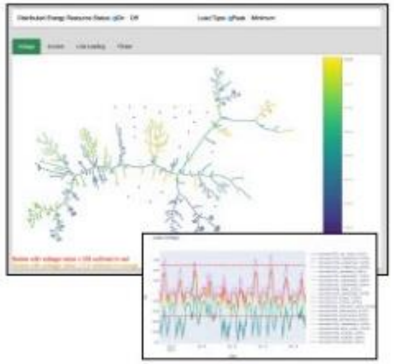
Generation Mix Planning

- Once the location of microgrids is decided, we generate a cost-optimal mix of generation to support the microgrid load.
- Climate data and fuel supply costs are used to specify the mix of solar, storage, and fossil generation needed.
- Generation mix is guaranteed to support the load through the critical outage limit (e.g. 14 days), and detailed survival probabilities are generated for all historical situations.



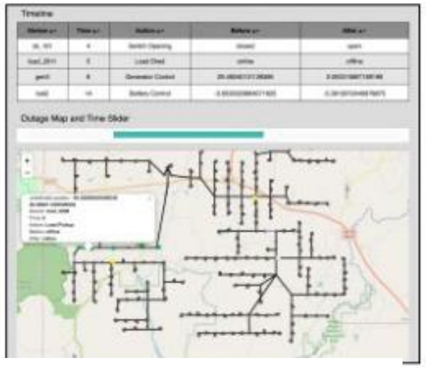
Distribution Design

- The distribution design module determines the set of sectionalizing, protection, and regulation changes that are necessary in the distribution system to host the microgrids.
- Changes are tested in an interconnection module to confirm that new distributed resources can be safely hosted.



Control

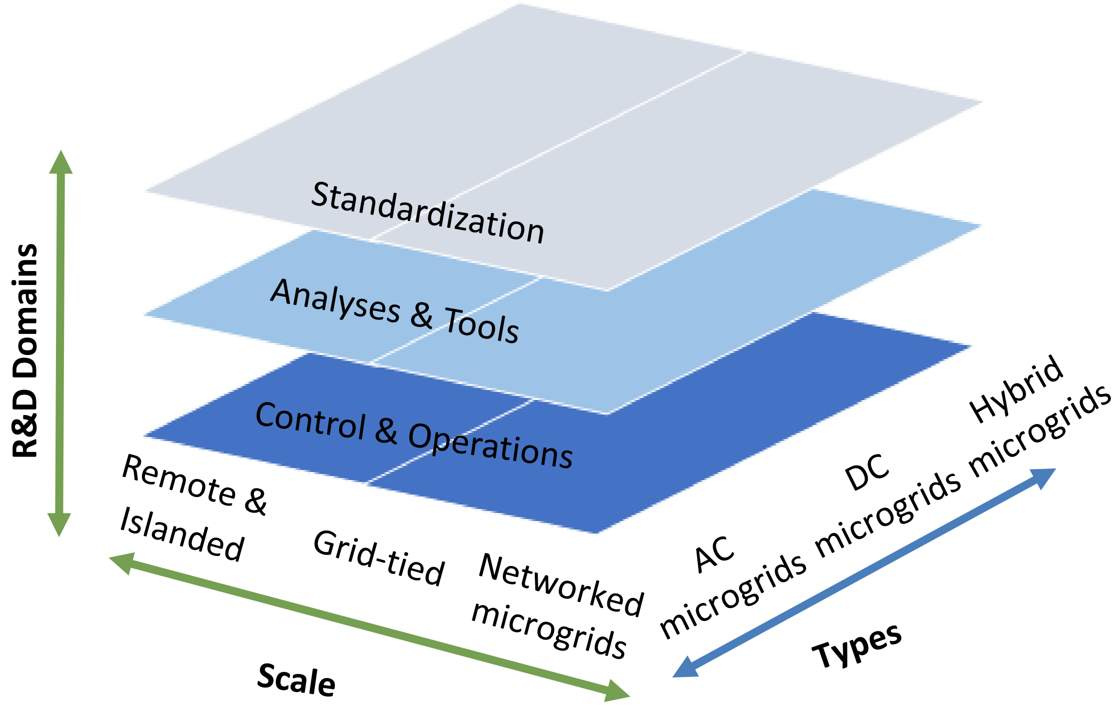
- We perform a control simulation to determine whether microgrid solutions can be effectively operated in concert.
- Simulation calculates generator, load, switching and protection changes that are necessary to safely island/de-island and black start.
- Final network with all upgrades is stored in OpenDSS format suitable for import into high-fidelity transient and HIL simulators such as TyphoonHIL.



Demonstration Sites

https://microgridUP.org

DOE Microgrid Program and Its Strategy



- Topic 7: Enabling regulatory and business models for broad microgrid deployment
- Topic 2: T&D co-simulation of microgrid impacts and benefits
- Topic 6: Integrated models and tools for microgrid planning, designs, and operations
- Topic 5: Advanced microgrid control and protection

- Topic 4: Microgrids as a building block for the future grid
- Topic 3: Building blocks for microgrids

The *DOE Microgrid Program Strategy*, with its 7 white papers, is available for download from OE website.

THANK YOU

ADVANCED RESILIENT MICROGRID RESEARCH- STRATEGIC FOCUS AREAS

Microgrids and microgrid controls have already matured at basic level. Therefore, microgrid R&D should look ahead 3-5 years beyond the basic state-of-art and work on the next microgrid advancements, such as:

- **Enhancing resiliency**
- Seamless unplanned electrical transition
- Fast load shed relaying to rebalance with local generation
- Future load shape prediction methods
- High integration of thermal energy cogen/storage
- Redundant failover control architecture
- Design for hot-swap repair/maintenance
- Self-commissioning (plug-and-play) modules for remote mini-grids
- Promotion of microgrid education/visualization
- Transactive energy between microgrid components and integration with power markets
- Industry stakeholder working groups
- Implementation tool development
- Cost reduction pathways
- **Addressing cybersecurity challenges**

Status of Microgrids in Canada

Alexandre Prieur

2023 Symposium on Microgrids

Canada’s Net-Zero Objectives and Context

Canada’s electricity grid is over 83% emissions-free

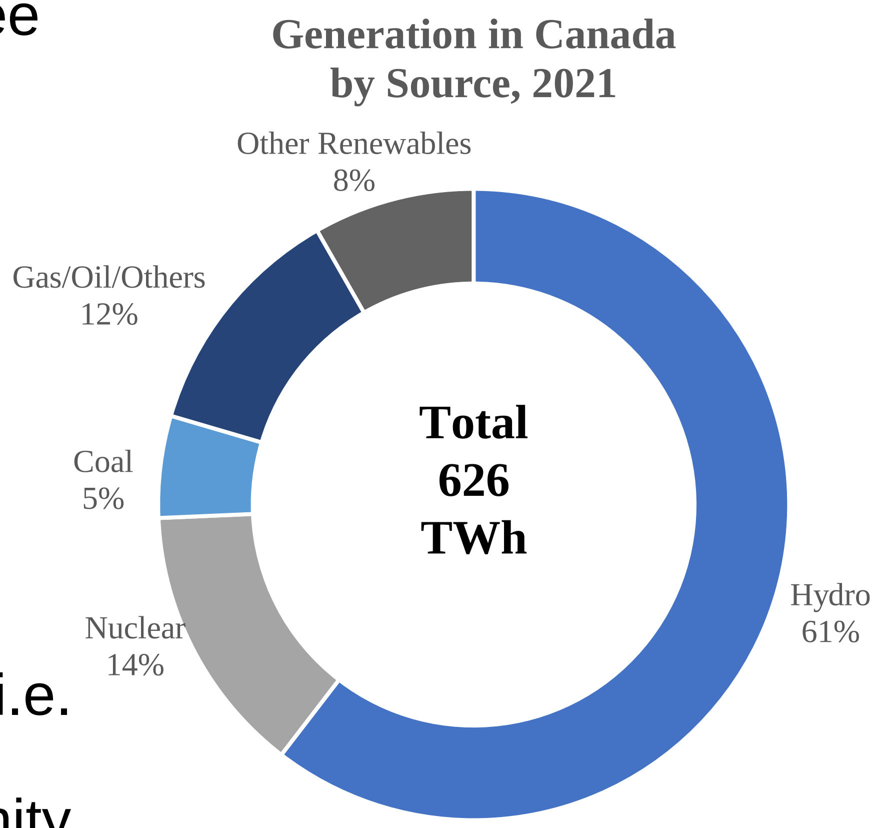
Around 300 Northern and remote (islanded) communities are not connected to the North American electricity grid.

Canada’s engagement

- By 2035, Net-zero electricity sector
- By 2050, Net-zero emissions

Microgrid main drivers

- Renewable generation integration to main grid (i.e. Net Zero community and DER integration)
- Reduce diesel dependence for isolated community



Federal Funding Programs - Microgrid

Program	Period	Funds
Energy Innovation Program	Ongoing	$52.9M / year
Program of Energy Research and Development	Ongoing	$35M / year
Green Infrastructure		
• Smart Grid	2018-2023	$100M (future funding announced in Budget 2023)
• Clean Energy for Rural and Remote Communities	2018-2027	$520M (includes an additional $300M in 2022)
Smart Renewables and Electrification Pathways Program	2021-2029	$1.56B (includes an additional $600M in 2023)

Aligning Federal Programming

NRCan – Clean Energy for Rural and Remote Communities Program (CERRC)
$220M over 8 years (2018-2026)

NRCan – Indigenous Off-Diesel Initiative (IODI)

CIRNAC – Responsible Energy Approach for Community Heat and Energy (Northern REACHE)

ISC – First Nation Infrastructure Fund (FNIF); Strategic Partnerships Initiative – Clean Energy

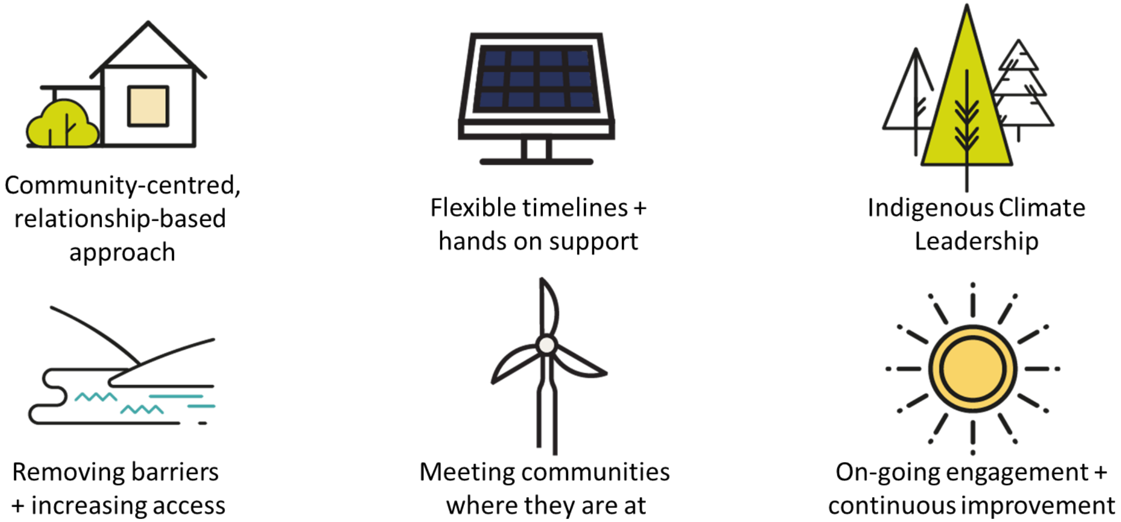
Clean Energy in Indigenous, Rural and Remote Communities Hub ('Wah-ila-toos')

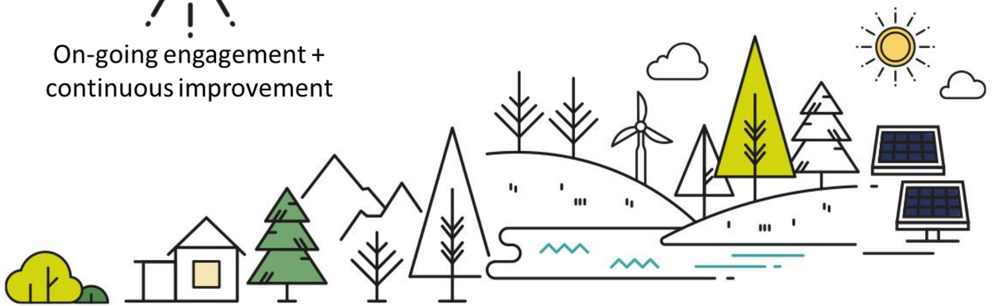
to support clean energy projects in rural, remote and Indigenous communities, including renewables and energy efficiency

+ $300M over six years (2021-2027)
identified in Canada's Strengthened Climate Plan

Wah-ila-toos : A **new approach** to supporting projects in Indigenous and remote communities

- **Clean Energy for Rural and Remote Communities Initiative** was gifted the name Wah-ila-toos
- Improve access to funding and provide support for clean energy initiatives in Indigenous, rural and remote communities across Canada.



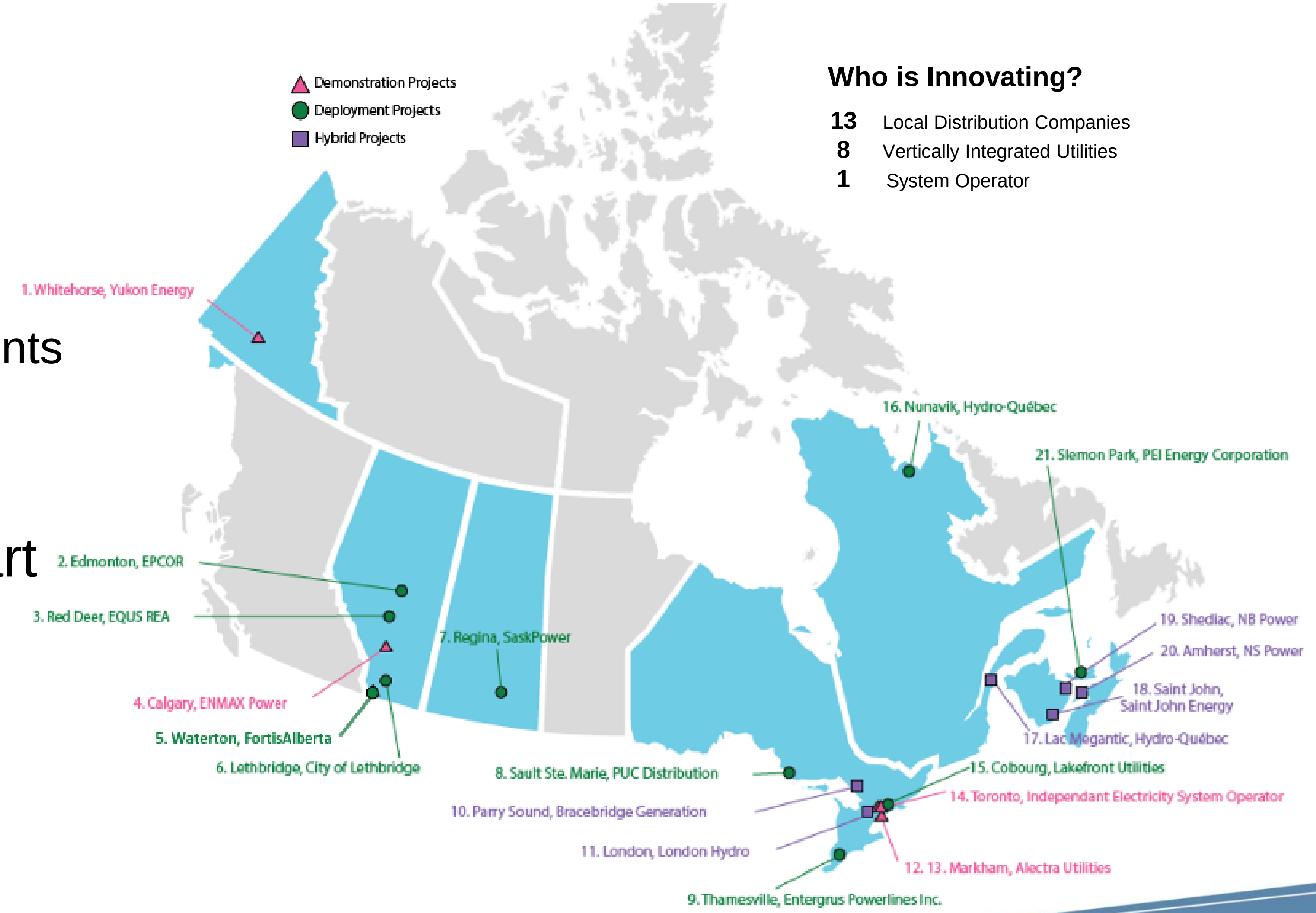


Smart Grid Program (2018-2023)

$100M in funding over 5 years

- Budget 2017, Green Infrastructure Program
- Demonstrations ($35M) & Deployments ($65M)

Case Studies funded under Smart Grid Program that have been completed include a Final Public Report



Who is Innovating?

13 Local Distribution Companies
8 Vertically Integrated Utilities
1 System Operator

Case Study: London Hydro

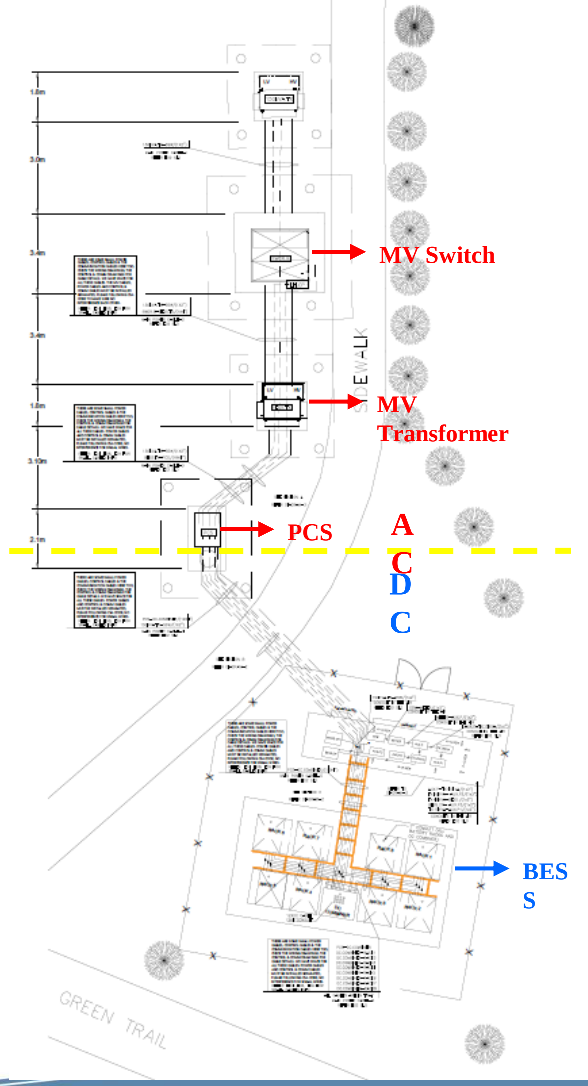
Recipient: London Hydro
Partners: s2e Technologies, Sifton Propertiers
Location: London, ON
Total Project Value: $12.6M
NRCan Funding: $5.3M
Project Duration: 6 years, 2018-2024

NRCan project website

Summary and benefits:

- The overarching objective is to successfully construct Canada's **first large-scale, fully integrated, net-zero energy community**
- This project will involve the following innovations:
  - Feeder-tied MV (27.6kV) Smart Hybrid Microgrid
  - Includes Six (6) buildings
  - Designed for Black start and Islanding capability
  - BESS with 0.99MW/2MWh Capacity and will be used as LDC feeder asset
  - 3.45MW of Solar Capacity from roofs, facades and carports of connected buildings
  - 10EV Charge ports installed and planned for Level 3 EV Charging facility
  - EVE Park eventually will have 104 – Level 2, EV Chargers
- Utilizes an innovative direct current topology alongside conventional alternating current to help catalyze widespread electric vehicle adoption, adaptation of codes and standards for Canadian microgrid grid and building codes, and ease permitting processes encouraging reproducible sustainable development.

Case Study: London Hydro



EVE Park, community building

Case Study: Ameresco

Recipient: Ameresco Canada Inc.
Location: London, ON
Total Project Value: $9.1M
NRCan Funding: $4.5M
Project Duration: 4 years, 2018-2022

[Ameresco project website]

[NRCan project website]

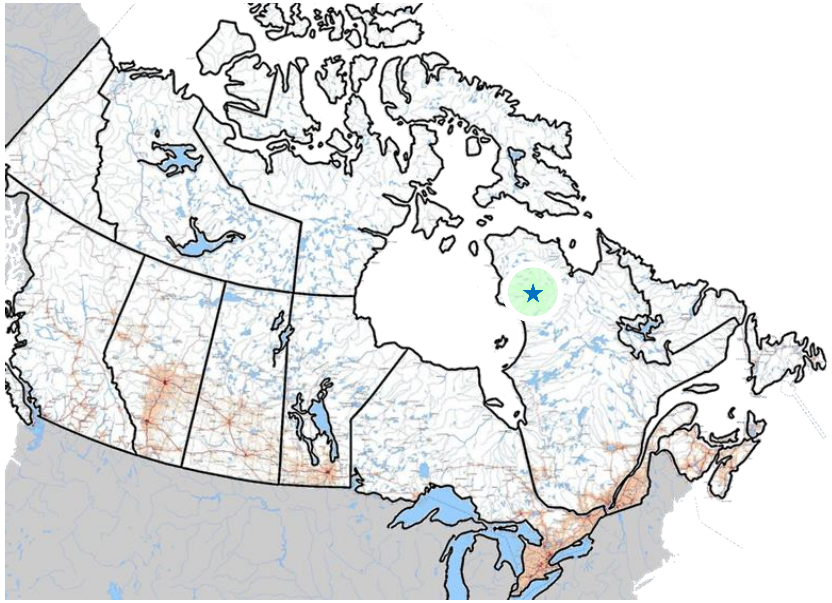
Summary and benefits:

- Transformed John Paul II Catholic Secondary School (JP II) into Canada's first school to be retrofitted carbon neutral
- Sought to reduce GHG emissions from 277 tonnes annually to near zero – demonstrating how public school systems could make significant contributions to Ontario's GHG reduction targets, while making schools a more comfortable place to learn and work
- Through an energy as a service model, Ameresco enabled JP II to generate its own energy entirely with on-site renewable sources.
- The project includes solar energy generation within a microgrid architecture controlled with assistance from energy storage. Load management of the school is fully integrated into the building control system and includes automated load shedding capability. The technology suite allows JP II to operate in island microgrid mode for electrical quality and resiliency purposes and to participate in the IESO Administered Markets.
- It also future proofs the school by enabling the local distribution company to use the microgrid system as an energy supply resource within a potential distribution system operator market architecture.

Case Study: Nunavik

Hydro Québec

Recipient: Hydro-Québec
Location: Nunavik and Haute-Mauricie, QC
Total Project Value: $29.9M
NRCan Funding: $7.3M
Project Duration: 5 years, 2018-2023



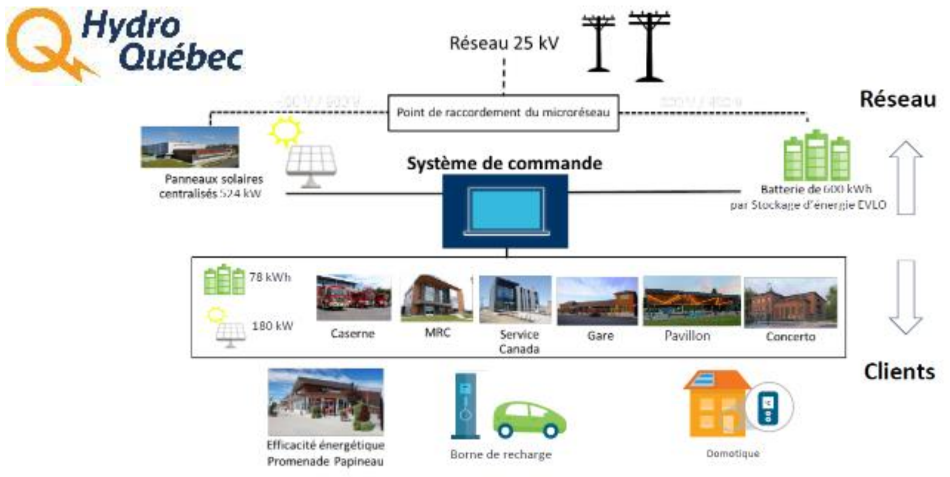
[NRCan project website]

Summary and benefits:

- Hydro-Québec will deploy a microgrid control system and battery energy storage system throughout 11 remote Indigenous communities.
- By using advanced automation technology, Hydro-Québec will improve the performance of its thermal generating assets and allow for the future integration of renewable energy.
- The project will be supported by research work that has been underway for more than 10 years at the Institut de recherché d'Hydro-Québec (IREQ)
- The lessons learned from this project will be used in other, similar projects aimed at reducing both diesel dependency and the carbon footprint of remote northern communities, while improving air quality and reducing health risks.
- These projects alone are expected to reduce total diesel consumption by approximately 500,000 litres per year and cut greenhouse gas emissions by 5,000 tonnes by 2030.

Case Study: Lac-Mégantic Microgrid

Recipient: Hydro-Québec
Location: City of Lac-Mégantic, QC
Total Project Value: $12.8M
NRCan Funding: $5.2M
Project Duration: 4 years, 2018-2022



Summary and benefits:

- Partnership with the City of Lac-Mégantic to support the energy transition in Quebec, leveraging the reconstruction of the city following the train accident
- Test **control strategies** of an intelligent seamlessly islandable microgrid containing various DER technologies (batteries, solar PV, EV charging stations), home automation equipment, demand response, energy efficiency, and optimization software
- Demonstrate and deploy integrated solutions to scale **the adoption of decentralized renewable energy generation to remote communities across Quebec to reduce** diesel fuel consumption
- Improve reliability and resiliency of the grid
- Improve the **quality, affordability, and safety** of delivered power to customers

NRCan project website Final Public Report

Case Study: Project SPEEDIER

Recipient: Bracebridge Generation
Location: Parry Sound, ON
Total Project Value: $8.3M
NRCan Funding: $3.8M
Project Duration: 4 years, 2018-2022

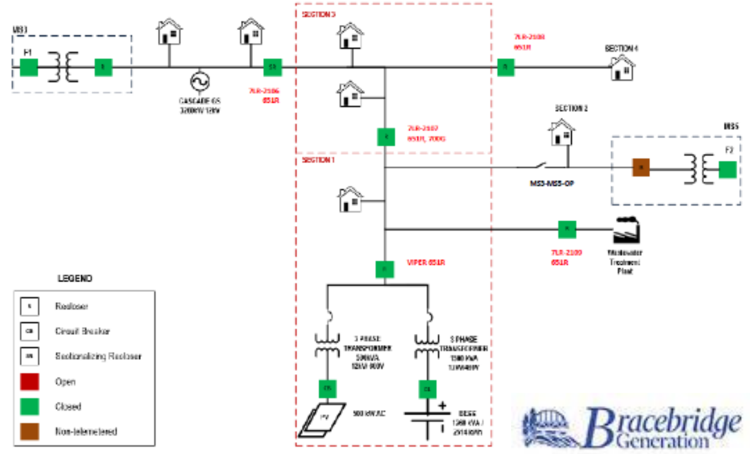
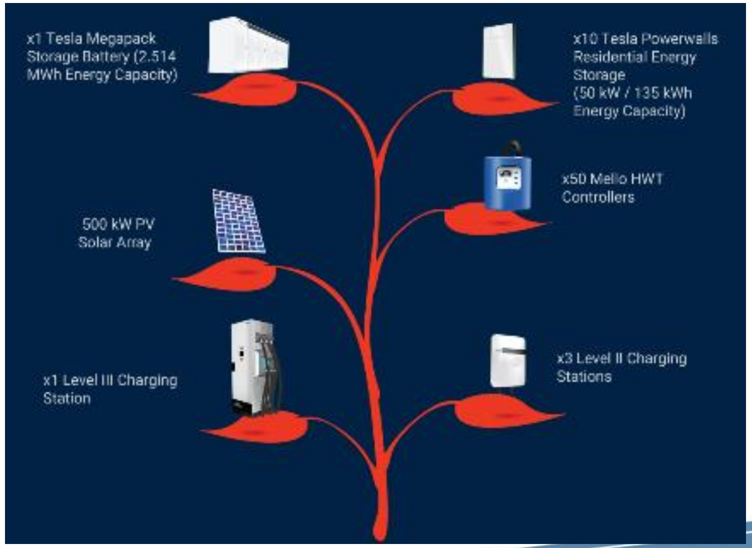


Figure 8: Project SPEEDIER Grid Connected Single Line Diagram

Summary and benefits:

- Create a Smart, Proactive, Enabled, Energy Distribution; Intelligent, Efficiently, Responsive (SPEEDIER) grid that builds towards a net zero smart community
- Addresses the issue of reducing load on a capacity-constrained transmission station identified in the long-term energy plan
- Increase solar PV, storage, EV penetration in the Town
- Develop greater automation and integration within the utility environment
- Explore new business models and market structures
- Build a seamlessly islanded microgrid that incorporates renewable energy and storage supporting the municipality's net-zero goals
- Serve as a model for expansion to other nearby communities

Final Public Report   NRCan project website



For more information…

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Announced CERRC Renewable & Bioheat Projects

Proponent	Community	Region	Project Title
Affinity North	Multi	Multi	N/A; a negotiations program that will seek to advance Indigenous leadership in the energy sector through workshops and dialogue with key First Nations leaders, lawyers, negotiators and others
Askii Environmental Inc.	Big Trout Lake First Nation; Pikangikum First Nation; North Caribou Lake First Nation	Ontario	Wood Chip Heating for Remote Ontario First Nation Communities
Bingwi Neyaashi Anishinaabek	Sand Point First Nation	Ontario	The BNA Diesel Displacement and Biomass Processing Project
Carcross / Tagish First Nation	Carcross	Yukon	Carcross Biomass District Heating System
Chu Cho Environmental Ltd (1)	Tsay Keh Dene Nation	British Columbia	Tsay Keh Dene nation Sustainable Biomass Energy Propect Preparedness Program - Feasibility Study
Chu Cho Environmental Ltd. (2)	Tsay Keh Dene Nation	British Columbia	Tsay Keh Dene nation Sustainable Biomass Energy Propect Preparedness Program - Feasibility Study
Copper Niisuu Limited Partnership	Beaver Creek	Yukon	Beaver Creek Solar Project
Eagle Hill Energy Limited Partnership	Whitehorse	Yukon	Haeckel Hill Wind Project
Esk'etemc First Nation	Alkali Lake	British Columbia	Esk'etemc Biomass District Heating System Expansion
Fort Severn First Nation	Fort Severn	Ontario	Fort Severn Solar Project
Gitxsan Energy Inc. (1)	Hazelton	British Columbia	Upper Skeena Recreation Centre (USRC) BioHeat Facility
Gitxsan Energy Inc. (2)	Hazelton	British Columbia	Conversion of Gitxsan Wet'suwet'en Education Society (GWES) College to Bioheat
Hamlet of Aklavik	Aklavik	Inuvialuit	Biomass heating for the Sittichinli Recreational Complex
Independent System Electricity Operator (IESO)	Multi	Ontario	Indigenous Energy Support Program
Indigenous Clean Energy	National	National	Three Island Energy Initiative
Kapawe'no First Nation	Narrows Point, North Shore of Flave Lake	Alberta	The Narrows Point Energy Project (NPEP)
Kluane First Nation (1)	Burwash Landing	Yukon	KFN Forest Resources Management Plan
Kluane First Nation (2)	Destruction Bay (Kluane First Nation Traditional Territory)	Yukon	Kluane First Nation Wind-Diesel Project
Kwadacha First Nation	Kwadacha First Nation	British Columbia	Briquette Manufacturing for Community Bioheat
Kwikwasut'inuxw Haxwa'mis First Nation	Gliford Island	British Columbia	Hybrid, smart-grid solar PV and battery demonstration project
Lake Babine Nation	Lake Babine (Wit'at FN)	British Columbia	Wit'at Biomass District Heating System
Lhoosk'uz Dene Nation	Kluskus Village, Quesnel Area, Cariboo	British Columbia	Kluskus Biomass Combined Heat and Power

Announced CERRC Renewable & Bioheat Projects (cont'd)

Proponent	Community	Region	Project Title
Mee Toos Forest Production	Multi	Saskatchewan	School Biomass Heating Systems
Nihtat Corporation (1)	Inuvik	Inuvialuit	Biomass in the Beaufort Delta
Nihtat Corporation (2)	Inuvik; Iqaluit	Inuvialuit	NWT and NU Thermal Community Solar PV Deployment Project
Nishnawbe Aski Nation	Nishnawbe Aski Nation	Ontario	Growing Bioheat in Nishnawbe Aski Nation
NRStor Inc.	Arviat	Nunavut	Arviat Clean Energy Microgrid
Ontario Power Generation	Gull Bay	Ontario	Gull Bay First Nation Diesel Offset Micro Grid Project
Oujé-Bougoumou Cree First Nation	Ouje-Bougoumou	Quebec	Ouje-Bougoumou District Heating System Renovation
Qikiqtaaluk Business Development Corporation (1)	Iqaluit	Nunavut	Iqaluit Inuit Owned Land Smart Micro Grid
Qikiqtaaluk Business Development Corporation (2)	Sanikiluaq	Nunavut	Sanikiluaq High Displacement Renewable Energy
Rat River Development Corporation	Gwich'in (Fort McPherson)	Northwest Territories	Remote Bioeconomy: Willow to Energy
Sagatay Cogeneration Limited Partnership	White Sand First Nation	Ontario	Whitesand First Nation: Community Sustainability Initiative AKA the Bio-Economy Centre
Skidegate Band Council	Moresby Lake (Skidegate), Old Massett	British Columbia	Haida Gwaii Clean Energy Project
St. Mary's River Energy	Mary's Harbour	Newfoundland and Labrador	Mary's Harbour Renewables
Tarquti Energy Inc.	Multi	Nunavik	Renewable Energy Capacity Building in Nunavik
Teslin Tlingit Council	Teslin	Yukon	Teslin Biomass Phase 2 Build out Planning
Three Nations Energy	Fort Chipewyan	Alberta	Fort Chipewyan Renewable Hybrid-Diesel Project, Phase II
Town of Inuvik	Inuvik	Inuvialuit	Inuvik Reservoir - Biomass Energy System Project
Tulita Land Corporation	Tulita	Northwest Territories	Tulita Bioenergy Project
Twin Sisters Native Plant Nursery	Moberly Lake	British Columbia	Twin Sisters Plants Nursery Biomass Conversion Project
Vuntun Gwitchin First Nation	Vuntun Gwitchin First Nation	Yukon	Old Crow Solar Project
Wahgoshig First Nation	Wahgoshig First Nation	Ontario	Wahgoshig First Nation Bioheat Demonstration Project
Wikwemikong Development Commission	Wikwemikong	Ontario	Wikwemikong Wood Pellet Heating and Infrastructure Project
Yukon Conservation Society	Whitehorse	Yukon	Yukon Electric Thermal Storage Demonstration Project



Status of Microgrids in Latin America
2023 Symposium on Microgrids

Guillermo Jiménez Estévez

September 2023

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  - SPP

A Review of Microgrids in Latin America

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A Review of Microgrids in Latin America: Laboratories and Test Systems

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A Review of Microgrids in Latin America

After performing a literature revision (Journal Papers) two main types of microgrids were identified: Laboratories and Test Systems.

Laboratories	Test Systems
Microgrids with the capability of simulate different operation scenarios with focus on research, experiments and scientific interest. Three main research topics identified: • Control and operation, hierarchical structures • Demand response • Energy production	Pilot projects dedicated to energy supply (Validation), most of them located in remote areas or interconnected zones with a poor quality of service.

A Review of Microgrids in Latin America - Laboratories

Country	Laboratory	Generation and storage technologies							Operation mode	Since	Research lines
		PV	W	BESS	DG	H	FC	PPS			
Brasil	Juiz de Fora	X	X				X	X	Hybrid	2012	O&C, DR, E
Argentina	REILAC	X	X	X					Hybrid	2012	O&C
Chile	Uchile Lab	X	X	X				X	Hybrid	2015	O&C, DR, E
Perú	UTEC	X	X			X		X	Hybrid	2015	O&C,E
Ecuador	CCTI-B	X	X	X	X	X	X	X	Hybrid	2017	O&C, DR, E
Colombia	Nanogrid	X							HYbrid	2017	O&C
Brasil	UFRN	X	X	X		X			HYbrid	2017	O&C
Puerto Rico	UPRM							X	Hybrid	2018	O&C, DR
México	FIE-UMSNH	X	X					X	Hybrid	2019	O&C,mE
Brasil	UFPR	X		X	X				HYbrid	2019	O&C
Colombia	LIE-UIS	X	X	X	X		X	X	Hybrid	2021	O&C, E

Note: Photovoltaics (PV), Wind Generator (W), Battery Energy Storage System (BESS), Diesel Generator (DG), Hydro Power (H), Fuel Cell (FC), Programable Power Source (PPS), Microgrids Operation and Control (O&C), Demand Response (DR), Energy Production (E)

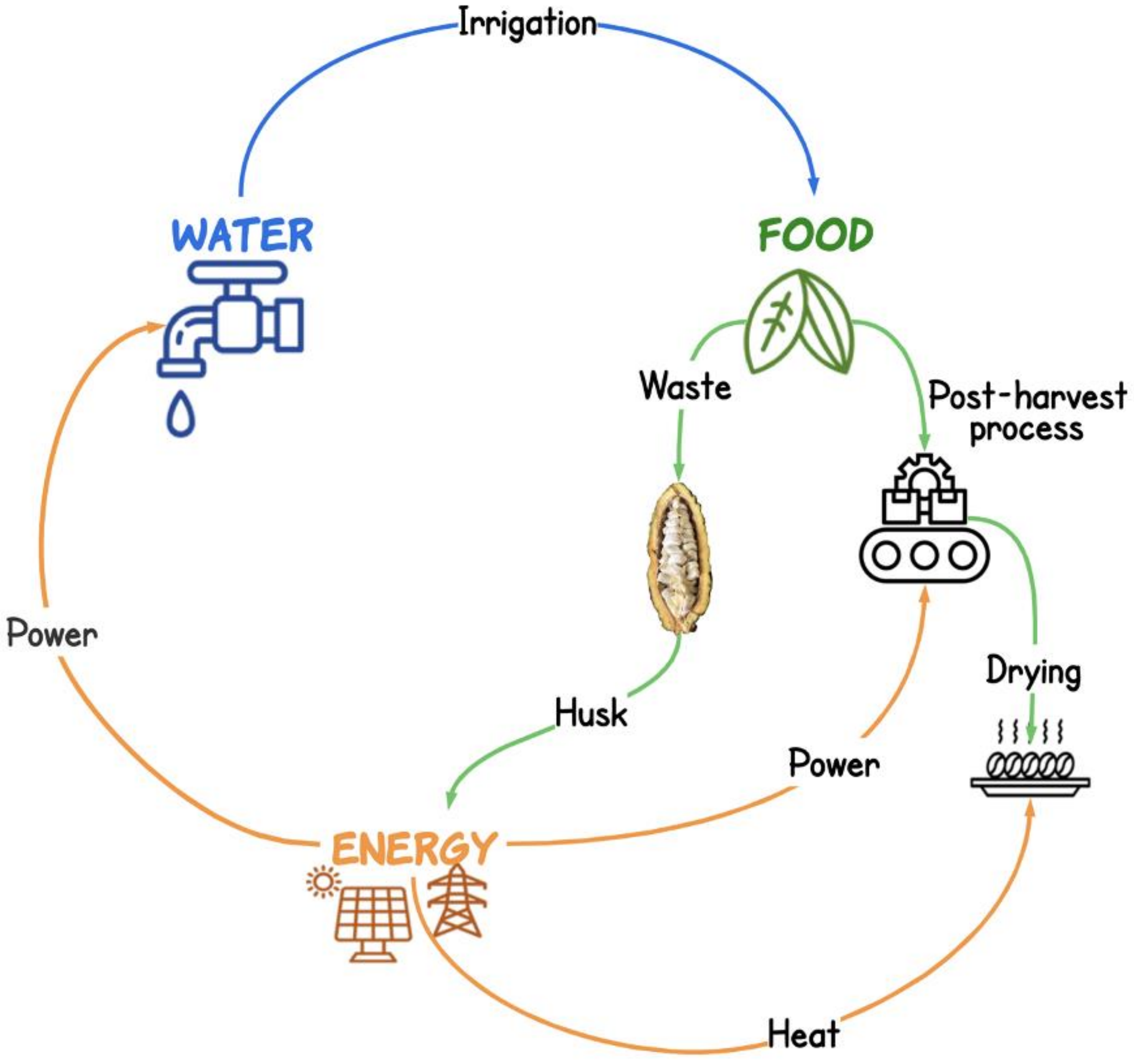
A Review of Microgrids in Latin America - Test Systems

Country	Proyecto	Generation and storage technologies					Operation mode	Since	Users
		PV	W	BESS	DG	H			
Bolivia	Saqa'saqa	X		X			Isolated	2008	25 people
Venezuela	Jacuque	X	X	X	X		Isolated	2009	10 families
Perú	El Regalado			X		X	Isolated	2009	175 people
Perú	Alto Perú	X		X		X	Isolated	2009	65 users
Ecuador	San José del Coca	X	X	X		X	Isolated	2010	54 families
Chile	Esuscon	X	X	X	X		Isolated	2010	Community
Brasil	Lencois	X	X	X	X		HYbrid	2011	90 houesholds
Brasil	CERTI	X	X	X	X	X	Hybrid	2014	Community
Bolivia	El Espino	X	X	X	X		Isolated	2015	124 families
Brasil	Ihla Grande	X		X	X		Isolated	2015	200 inhabitants
Perú	Tambopata	X		X	X		Isolated	2016	2 shelters
México	Puertecitos	X	X	X	X		Isolated	2016	20 families
Argentina	Armstrong	X				X	Grid Connected	2018	12000 inhabitants
Colombia	Guajira	X	X	X			Isolated	2019	Indigenous community

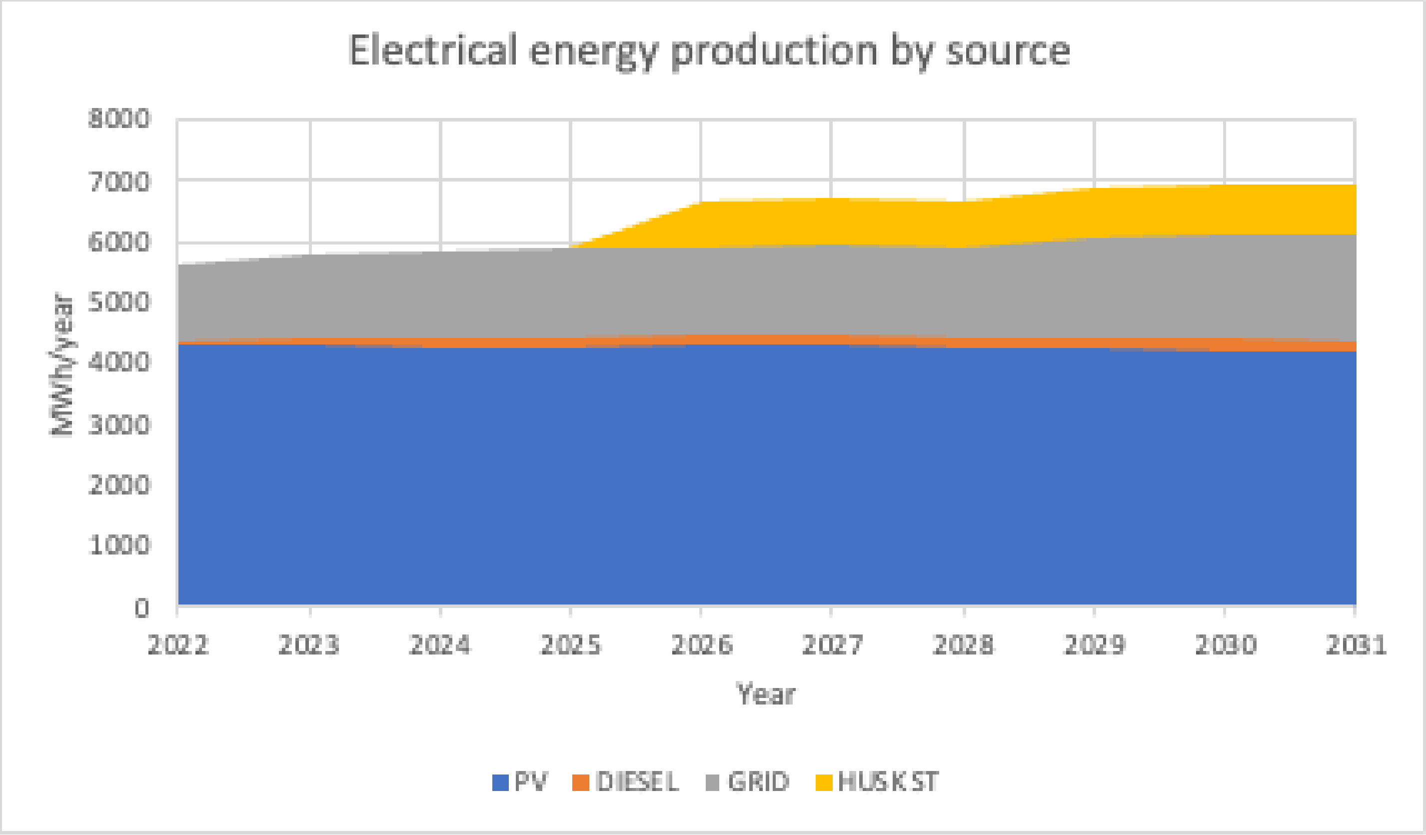
Note: Photovoltaics (PV), Wind Generator (W), Battery Energy Storage System (BESS), Diesel Generator (DG), Hydro Power (H)

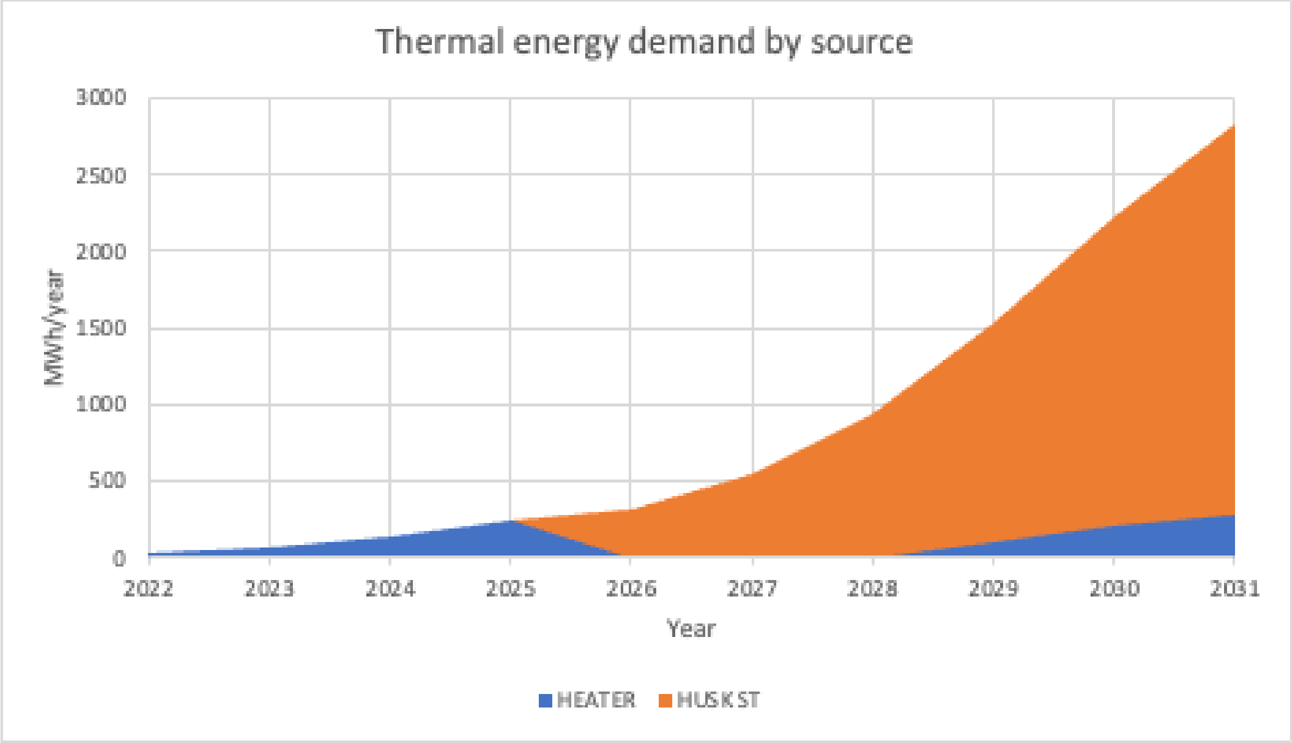
Universidad de los Andes
Colombia

Ongoing research – Nexus WEF

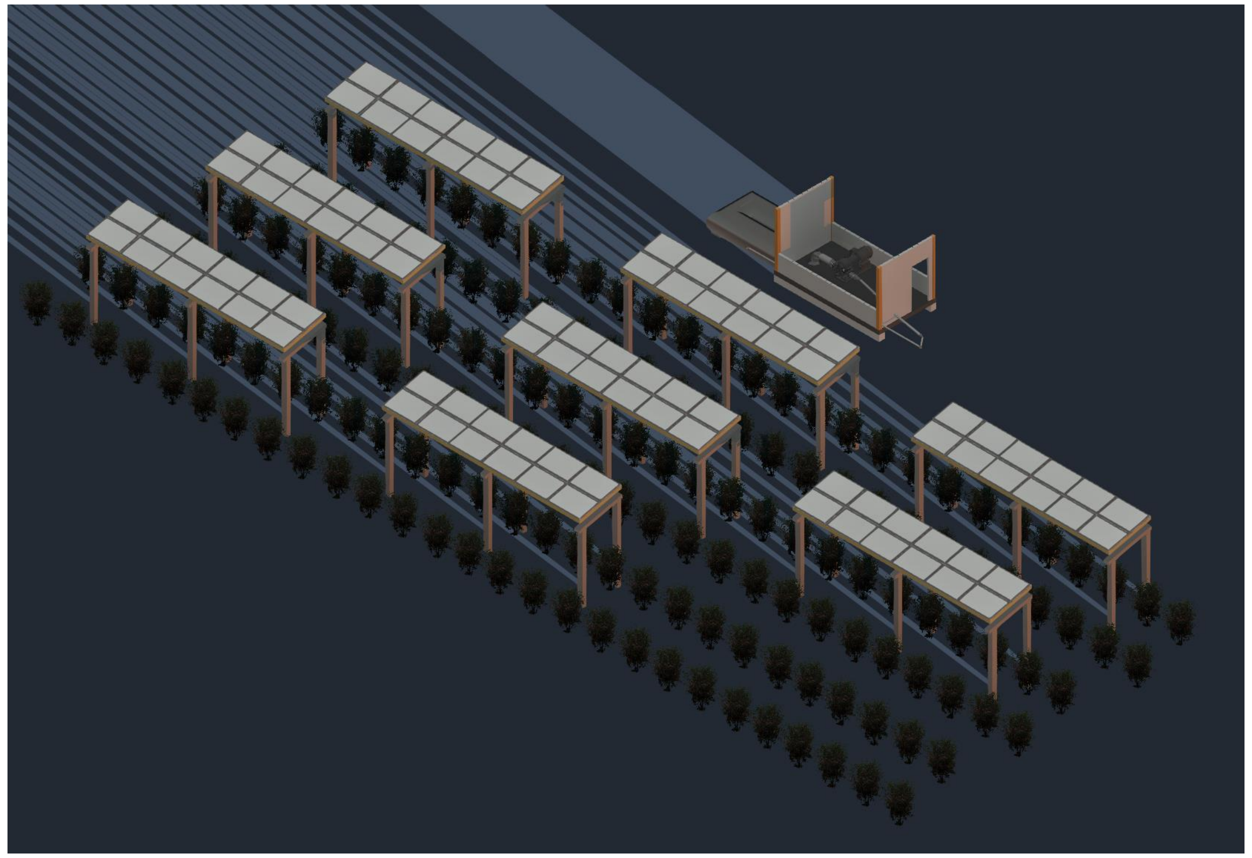


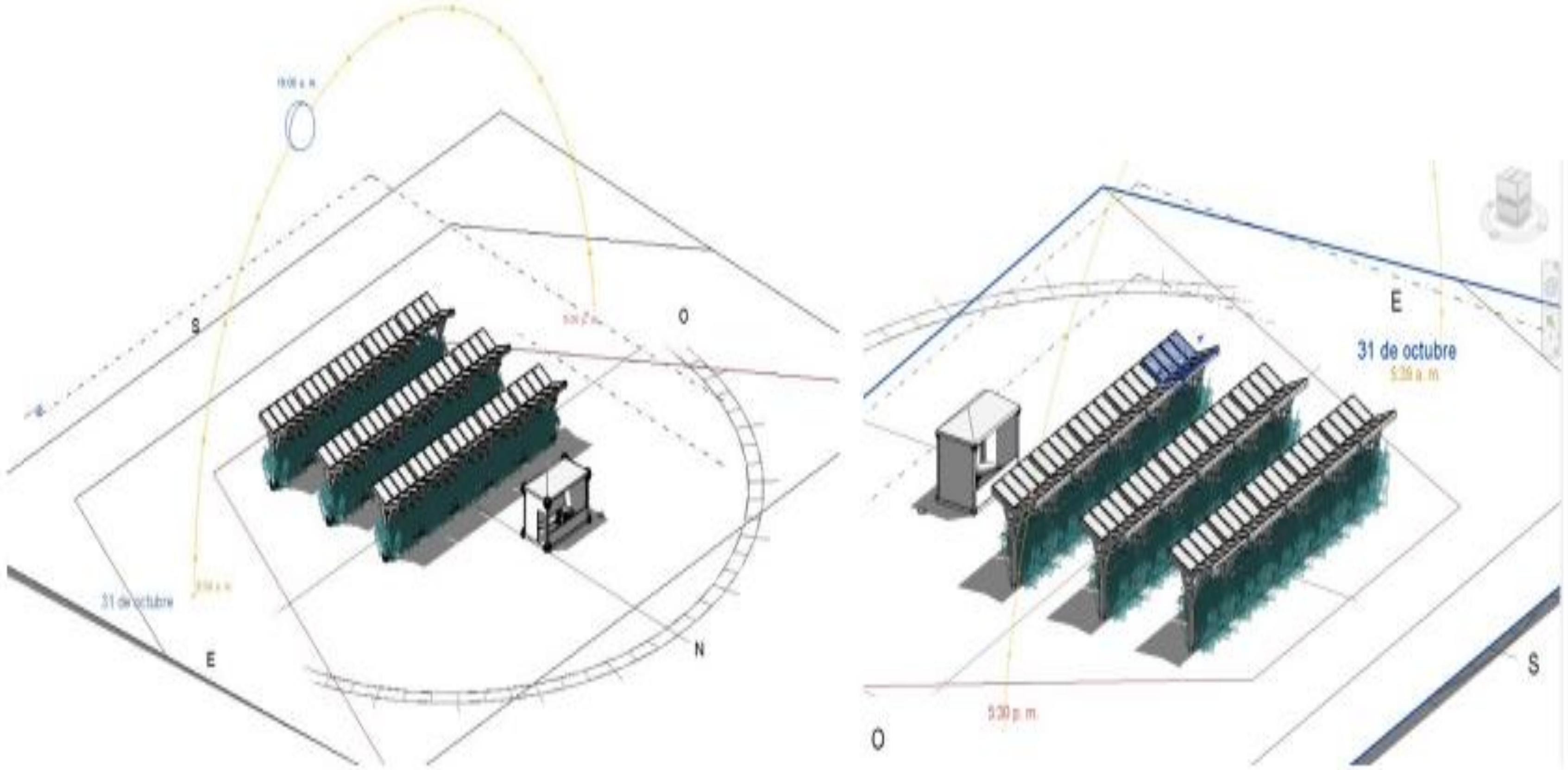
Cocoa Plantation, Energy and Water use





Ongoing research – Agrivoltaics





Coffee, cocoa, lettuce

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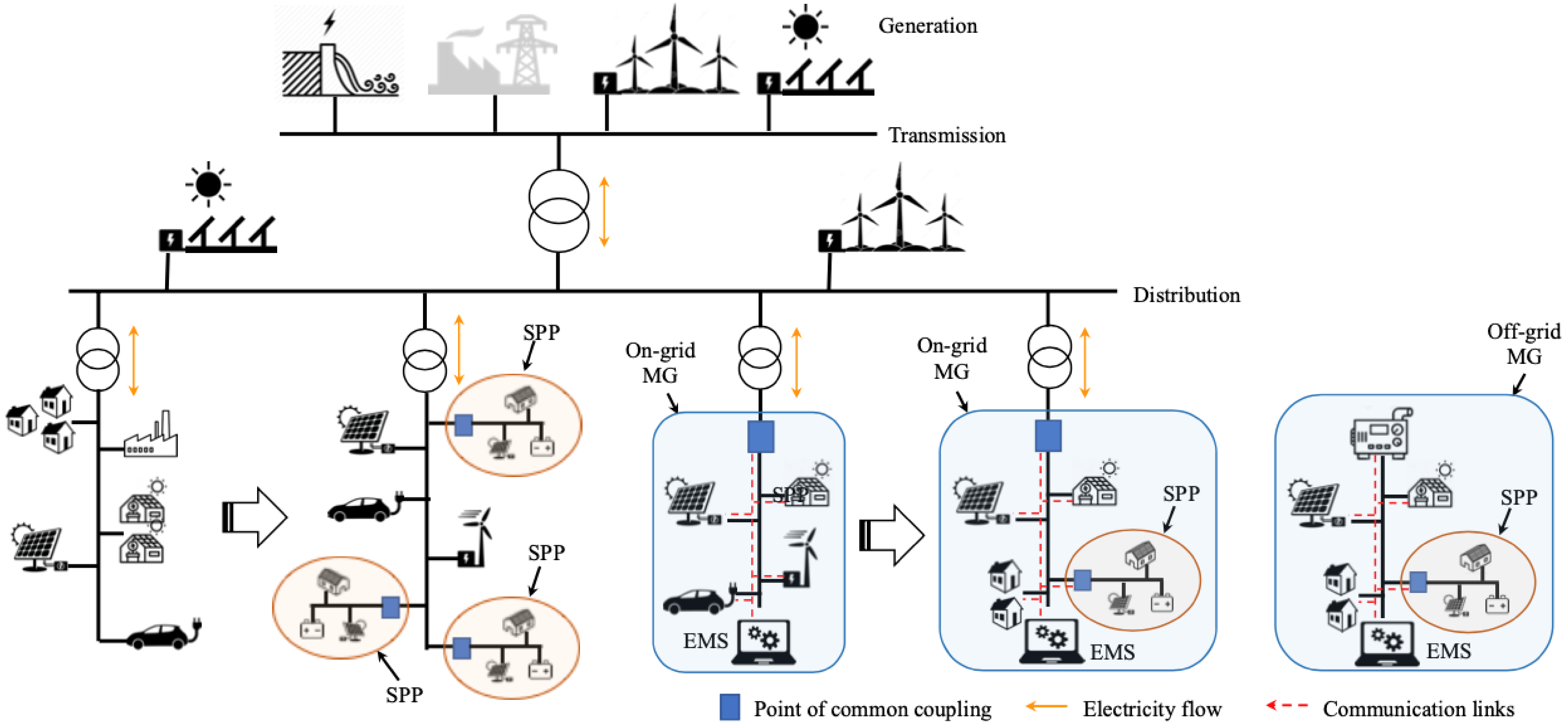
Ongoing research – SPP



Source: Danny Espín, tesis doctorado, U. de Chile

Gracias