Disruptive Innovation over the Wires: Business Models for Success

Thursday November 9 | Federation Hall | University of Waterloo

Welcome

Council for Clean & Reliable Energy — transforming the way we think about power | Enbridge | WISE Waterloo Institute for Sustainable Energy | Canadian Electricity Association / Association canadienne de l'électricité | Power Workers' Union | NSERC CRSNG | University of Waterloo

Welcoming Remarks

Glen Wright
Chairman
Council for Clean & Reliable Energy

Jatin Nathwani
Professor & Executive Director
Waterloo Institute for Sustainable Energy

Council for Clean & Reliable Energy — transforming the way we think about power
ENBRIDGE
WISE WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY
Canadian Electricity Association | Association canadienne de l'électricit
POWER WORKERS' UNION
NSERC CRSNG
UNIVERSITY OF WATERLOO

Keynote Speaker

Pamela Jones
Director
Transmission & Distribution Policy
Canadian Electricity Association

Panel 1

Is Technology Disruption Driven by Economics?

Moderator

Jatin Nathwani
Professor & Executive Director
Waterloo Institute for Sustainable Energy

Speakers

Paul Grod
President & CEO
Rodan Energy Solutions

Ingo Mauser
dr-Ing, Research Associate
Applied Informatics (AIFB)
Karlsruhe Institute of Technology

Malcolm McCulloch
Professor & Head
Energy & Power Group
Engineering Science
University of Oxford

Neetika Sathe
Director
Emerging Technologies
Alectra Energy Solutions Inc.

Panel 1

Is Technology Disruption Driven by Economics?

Jatin Nathwani
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UNIVERSITY OF WATERLOO

November 9, 2017
University of Waterloo
Federation Hall

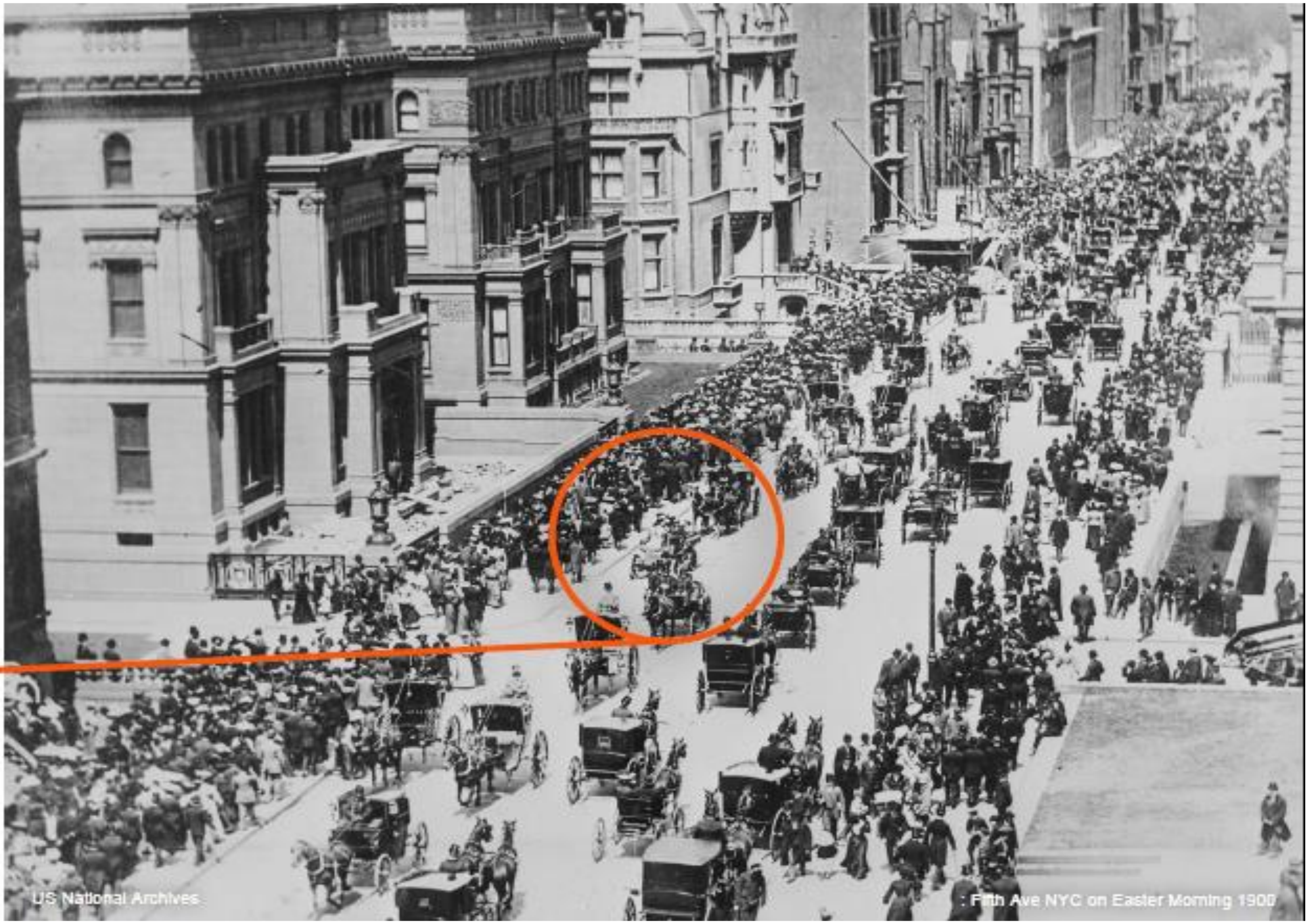
Panel 1:
Is technology Disruption Driven by Economics?

Moderator: Jatin Nathwani, Professor & Executive Director, Waterloo Institute for Sustainable Energy, University of Waterloo

- **Paul Grod**, President & CEO, Rodan Energy Solutions
- **Ingo Mauser**, Research Associate, Applied Informatics (AIFB), Karlsruhe Institute of Technology (KIT), Germany
- **Malcolm McCulloch**, Professor and Head, Energy and Power Group, Department of Engineering Science, University of Oxford, UK
- **Neetika Sathe**, Director, Emerging Technologies, Alectra Energy Solutions Inc.

5th AVE NYC
1900

Where is the car?



Copyright © 2016 Tony Seba

5th AVE NYC

1913

Where is **the horse?**

Copyright © 2016 Tony Seba

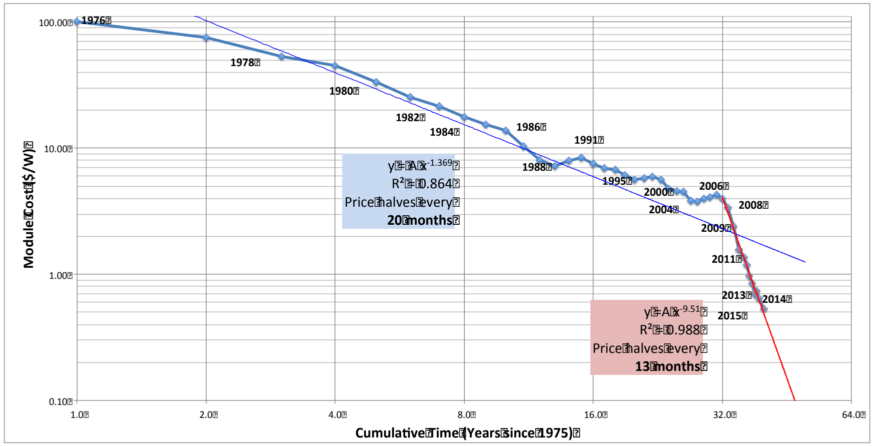
401 Toronto
2017

Where is **the EV?**

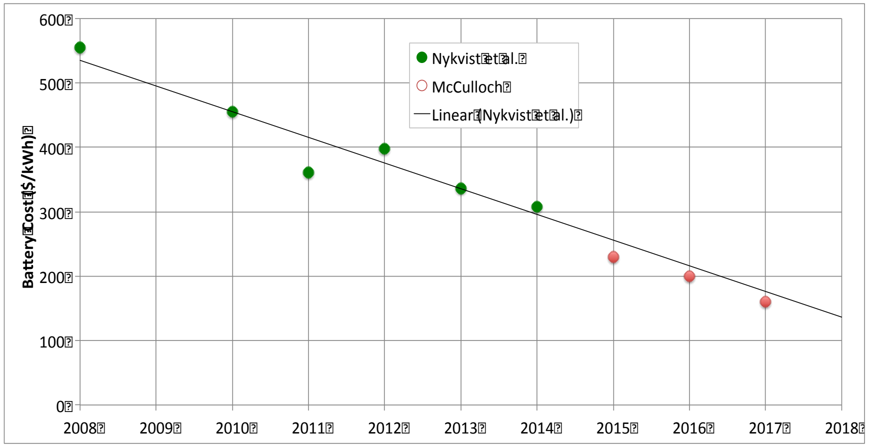
401 Toronto
2030

Where is
the
Gasoline Car?

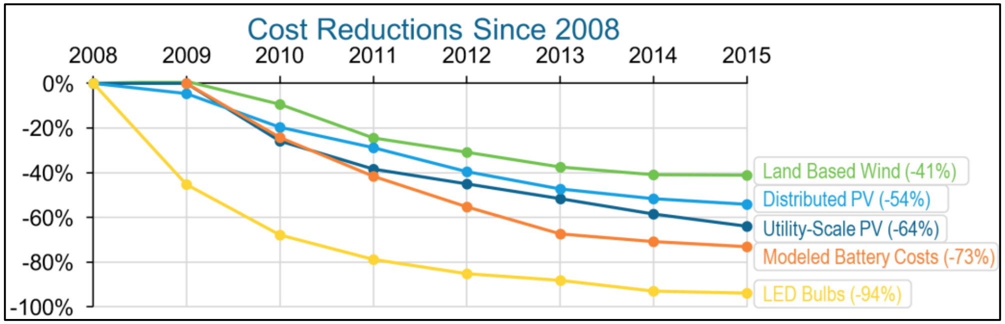
Solar costs are falling dramatically since 2008



Battery price are also falling



US DOE: Future Arrives for 5 Energy Technologies



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Cars controlling the Grid?

Electric Vehicles Sell Power Back to the Grid

Delaware Test Fleet Makes Money by Serving as an Electricity Reserve

Balance of Power

The numbers behind the University of Delaware program using cars as a money-making reserve for the electric grid

Cars used	23 (19 all-electric Mini E's, 3 modified Scion xB's, 1 experimental Honda Accord plug-in hybrid)
What they do	Store or discharge electricity according to grid needs
Special equipment needed	Control board, $200-$300 per car
Power of car batteries	12 kilowatts per vehicle*
Minimum capacity needed for a grid "bank"	100 kilowatts/9 cars
Time connected to grid	24/7 except when being driven
Average daily driving time	About an hour per car
Monthly revenue per car from grid operator	About $150
Monthly electricity cost/car	About $40
Monthly profit	About $110 per car/$2,500 total

*For Minis and Scions. Honda power not disclosed.
Source: University of Delaware

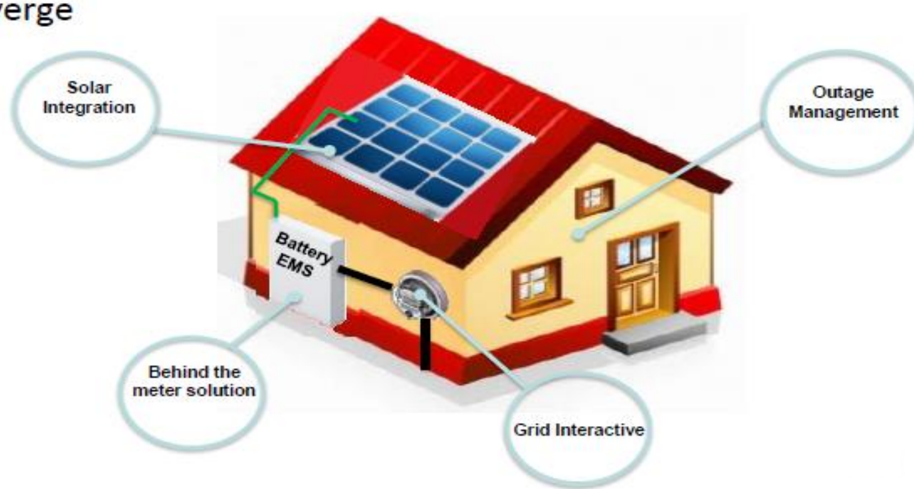
The Wall Street Journal

POWER.HOUSE VPP launched March 2016

PowerStream

IESO Conservation Fund for 20 homes:

- 20 targeted homes in PowerStream territory
- 5 KW solar array; Sunverge unit- 6.8 KW/11.4KWH battery and EMS
- Aggregation of distributed assets to create a Virtual Power Plant
- Technology partner: Sunverge
- Installation partner: RBI



POWER HOUSE

PowerStream SmartGrid Technologies

Panel 1

Is Technology Disruption Driven by Economics?

Paul Grod

President & CEO

Rodan Energy Solutions

RODAN
Energy Solutions

Is Technology Disruption Driven by Economics?

November 9, 2017

Council for Clean & Reliable Energy
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Is Technology Disruption Driven by Economics?

RODAN
Energy Solutions

Overview of Rodan

- Rodan is a North American smart grid integrator and a leading developer of demand side energy resources
  - Offices in Mississauga, Calgary and Kitchener/Waterloo
- Customers include power distribution companies, power producers and large energy users (key markets ON, AB, BC)
- Focus on power systems, demand response, utility services and energy management
- Leading Network Operations Centre ("NOC")
  - Monitors over $9 billion in power flows
  - Controls and operates 500 MW of demand response resources
  - Dispatches portfolio of several hundred thousand residential, commercial and industrial power users.
- Ontario Energy Association Company of the Year Award (2013 & 2016)
- Canada's Top 100 Small & Medium Employers 2015/16/17

RODAN Energy Solutions

Twelve potentially economically disruptive technologies

Mobile Internet	Increasingly inexpensive and capable mobile computing devices and Internet connectivity
Automation of knowledge work	Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments
The Internet of Things	Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization
Cloud technology	Use of computer hardware and software resources delivered over a network or the Internet, often as a service
Advanced robotics	Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans
Autonomous and near-autonomous vehicles	Vehicles that can navigate and operate with reduced or no human intervention
Next-generation genomics	Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology ("writing" DNA)

SOURCE: McKinsey Global Institute analysis

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Twelve potentially economically disruptive technologies

	**Energy storage**	Devices or systems that store energy for later use, including batteries
	**3D printing**	Additive manufacturing techniques to create objects by printing layers of material based on digital models
	**Advanced materials**	Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality
	**Advanced oil and gas exploration and recovery**	Exploration and recovery techniques that make extraction of unconventional oil and gas economical
	**Renewable energy**	Generation of electricity from renewable sources with reduced harmful climate impact

SOURCE: McKinsey Global Institute analysis

RODAN Energy Solutions

Disruptive Energy Technologies (DETs)

- Wind & solar generation
- Energy storage – battery, pump, thermal…
- Demand response
- Distributed generation
- New fuel sources – hydrogen, fission, etc.
- Others?

Introduction of DETs

- Traditionally require
  - Subsidies – e.g. long term PPAs
  - Increased build-out of transmission & distribution assets
- Did not displace most fossil-fueled generation
- Dramatically increased system costs
- Depressed electricity market prices
  - Oversupply during low demand periods causing negative prices
- Costs recovered via capacity payments – Global Adjustment in Ontario

RODAN Energy Solutions

What is Global Adjustment?

- The Global Adjustment is an Ontario electricity market mechanism used to transfer certain types of costs among generators, agencies and consumers.
- Most of GA costs arise from long term contracts the IESO has with generators. A good portion of these contracts are at fixed prices, or they have revenue guarantees that behave like fixed-price arrangements. When spot prices are low, the generator does not earn enough revenue from power sales to meet its revenue guarantee or fixed price. The IESO pays the generator to make up the difference, and the IESO recovers that cost from consumers through the Global Adjustment. In a month when the market price of electricity is low, the cost of GA will be higher and when market prices are high, the GA will be lower.
- The remainder of the GA costs result from IESO-funded conservation, energy efficiency, demand management and other clean energy programs that are passed on to consumers. These costs are largely unaffected by electricity prices.

RODAN Energy Solutions

GA Cost Trends

		2017	2018	2019	2020	2021
contracted energy	TWh	145	146	147	140	138
weighted contract price	$/MWh	$ 81	$ 80	$ 83	$ 84	$ 87
HOEP	$/MWh	$ 19	$ 22	$ 25	$ 25	$ 27
GA total cost	$ million	$ 10,700	$ 10,900	$ 10,800	$ 10,900	$ 10,900
Class A value	$/MW/year	$ 474,000	$ 483,000	$ 480,000	$ 483,000	$ 482,000
GA total cost, sensitivity	$ million per $/MWh of HOEP	-$146	-$148	-$148	-$142	-$139

		2022	2023	2024	2025	2026
contracted energy	TWh	137	117	125	115	121
weighted contract price	$/MWh	$ 90	$ 92	$ 95	$ 96	$ 99
HOEP	$/MWh	$ 29	$ 37	$ 37	$ 37	$ 37
GA total cost	$ million	$ 10,800	$ 8,600	$ 9,200	$ 9,000	$ 9,700
Class A value	$/MW/year	$ 482,000	$ 384,000	$ 410,000	$ 398,000	$ 430,000
GA total cost, sensitivity	$ million per $/MWh of HOEP	-$138	-$118	-$127	-$116	-$122

Source: Global Adjustment Forecast by Bruce Sharp Energy, September 2016

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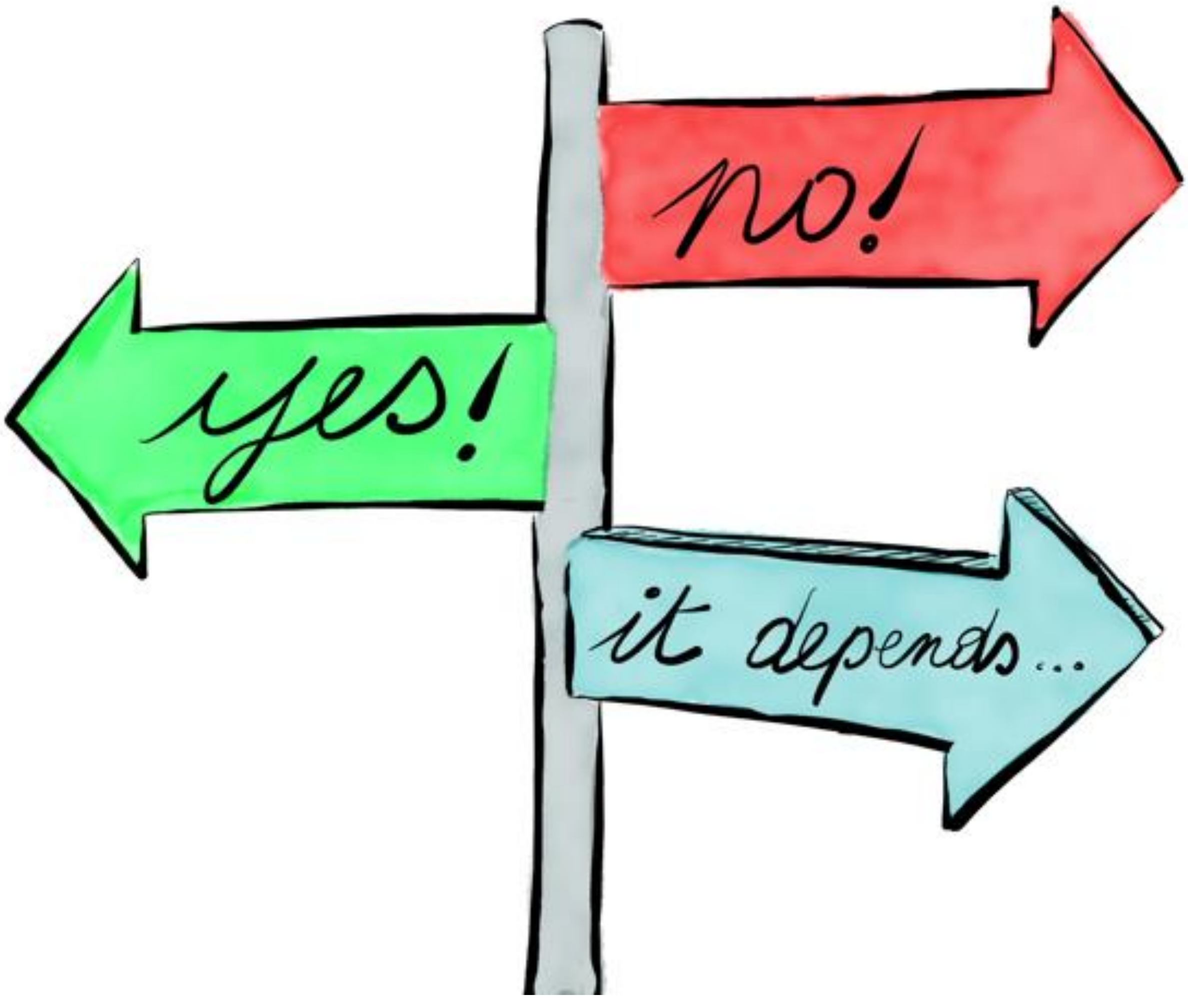
RODAN Energy Solutions

The Challenge

- Introducing DETs via subsidies has caused market/pricing imbalances and muted price signals
- Few opportunities for consumers (other than conservation) to reduce costs
- Economic impact
  - Manufacturing exists higher cost jurisdictions; or
  - Finds off-grid solutions
- Off grid or distributed energy resources are the next DETs
  - They will be driven by economics
  - System costs associated with Green Energy technologies with us for 20 years
  - Fewer consumers available to pay system costs
  - Utility infrastructure costs still remain

Is Technology Disruption Driven by Economics?



Thank You!

RODAN Energy Solutions

Delivering Innovative Energy Solutions

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Panel 1

Is Technology Disruption Driven by Economics?

Ingo Mauser, dr-Ing

Research Associate

Applied Informatics (AIFB)

Karlsruhe Institute of Technology (KIT), Germany

Panel 1: Is Technology Disruption Driven by Economics? – A German Perspective

Ingo Mauser
Karlsruhe Institute of Technology, Germany

Technology Innovation & Policy Forum 2017, 09 November 2017, Waterloo, ON, Canada

INSTITUTE OF APPLIED INFORMATICS AND FORMAL DESCRIPTION METHODS (AIFB)

KIT Energy Smart Home Lab

Source: Institute AIFB

Smart Meter Gateway

Source: devolo

Temporary ice rink at Karlsruhe Palace

Source: http://www.stadtwerke-eiszeit.de

“Kodak moment” for Utilities? (1/2)

- Is there a “Kodak moment” emerging for the utilities?
- Will energy distribution become redundant?
  - Most probably: Not. (Germany: high population density, comparably evenly spread)
- Will distributed energy generation and storage be cheaper than distribution?
  - 1st – “Kodak moment” for energy generation
  - 2nd – “Kodak moment” for ancillary services
  - 3rd – “Kodak moment” for distribution utilities (depending on population density)
- Battery storage systems
  - 2017: ~25% of the primary balancing power (frequency-responsive/spinning reserve)
  - Cannibalization of (demand side management) business models
  - N+1 redundancy → fallback on grid connection
  - System Average Interruption Duration Index: 12.7 min (Germany, electricity, 2016)

"Kodak moment" for Utilities? (2/2)

- Is there a "Kodak moment" emerging for the utilities? *(continued)*

- Distribution utilities
  - Network economics
  - Regulation
  - Roads, railway infrastructure, telecommunication, postal services
    → network effects, natural monopoly

- What are the costs and what are the benefits of privatization and regulation?
  - Why are state- and municipally-owned enterprises less efficient than private ones?
  - Many people don't worry about slightly higher costs
  - Public welfare, jobs
  - Germany: public swimming pools, ice rinks, sponsoring of cultural events, …

Source: http://www.stadtwerke-eiszeit.de, access: 07 November 2017

Regulated Entities or Innovation?

- Why did large-scale distributed generation by solar power not cause heavy problems in Germany?
  - Copper, a lot of copper → not really innovative
  - Regulation: fixed interest rates for investments
  - Long-term and lasting solutions (40+ years)
- Current regulation in Germany
  - Incentive regulation (cost, efficiency, revenue caps)
  - Decisions are based on the current situation (PV)
- What about electric mobility?
  - Electricity consumption is likely to rise
  - “There is no place like home for charging your electric” General Electric (1914)
  - **Innovation will be necessary to limit grid expansion**

Source: http://www.american-automobiles.com/Electric-Cars/Early-American-Electric-Automobiles.html , access: 21 September 2017

Benefits of ICT for the Customers?

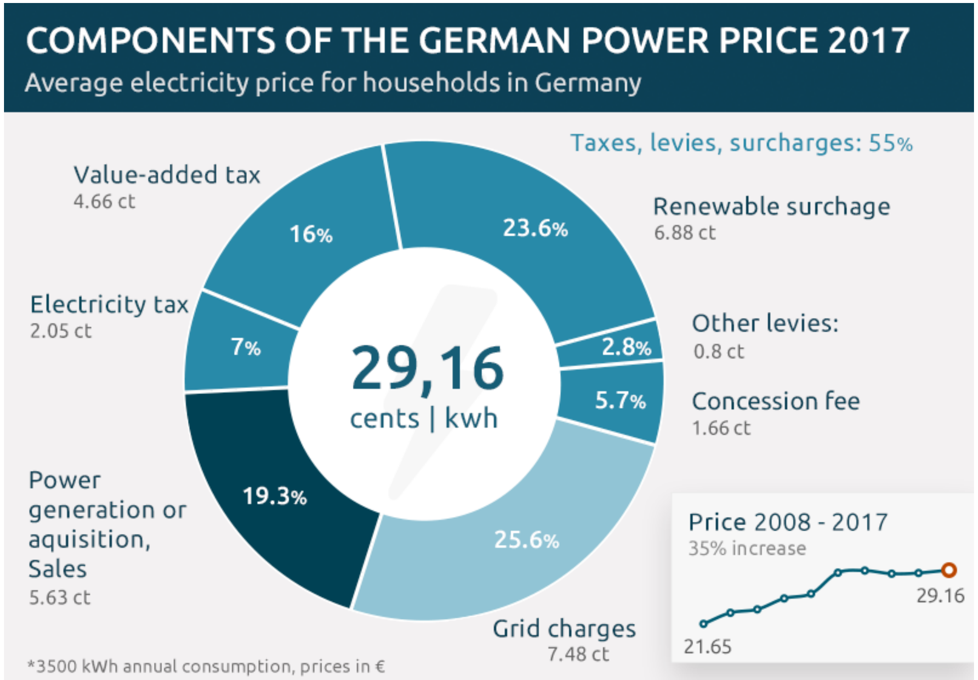
- What will be the unique benefits of ICT in grids for the customers?
- Is ICT for smart grids a sustainable solution?
  - Long-term and lasting solutions
  - Reliability, maintenance/support, liability, risks (e.g. cyberattacks, privacy)
- Do people really want more information about their electricity consumption?
- Electricity is a commodity
  - Refined sugar is refined sugar, table salt is table salt, and electricity is electricity
  - Commodity that is bought regularly and at a low price
  - Discount supermarket chains: ALDI, LIDL
    - Small quantities of quality products at a reasonable price (less focus on brands)
    - Organic products, mobile network operation, green electricity (hydropower from Austria)

Source: http://www.aldi-sued.de, access: 07 November 2017

Business Model in Network Economies?

- Is there a clash between distributed generation and existing network assets?
- Will the revenue model based on delivering kWh be replaced?

- Oversized water supply system
- Was electricity generation really as cheap as it seemed to be?
  - Nuclear power
  - Coal-fired power plants
  - Renewable energy surcharge
- Change of revenue model
  - Increase of basic charge is (politically) not acceptable
  - Social justice: students, retirees
  - Energy efficiency



Source: Wikipedia, Lindaholm, https://en.wikipedia.org/wiki/File:Electricity-price-germany-components.png, access: 07 November 2017

Disruption

Karlsruhe Institute of Technology

- Is technology disruption driven by economics?

1. Superior products
   - Comfort, safety, product characteristics
   - lightbulb → CFL → LED   or   lightbulb → ~~CFL~~ → LED
   - horse → electricity → fuel → electricity?
2. Economics
3. Regulation and subsidies
   - Drivers and barriers for disruption and innovation
   - German Renewable Energy act *EEG 2000*: >50 Cent/kWh for PV feed-in

➢ Disruption: 1. energy generation 2. ancillary services 3. energy distribution

➢ Electricity grid: long-term and lasting solutions

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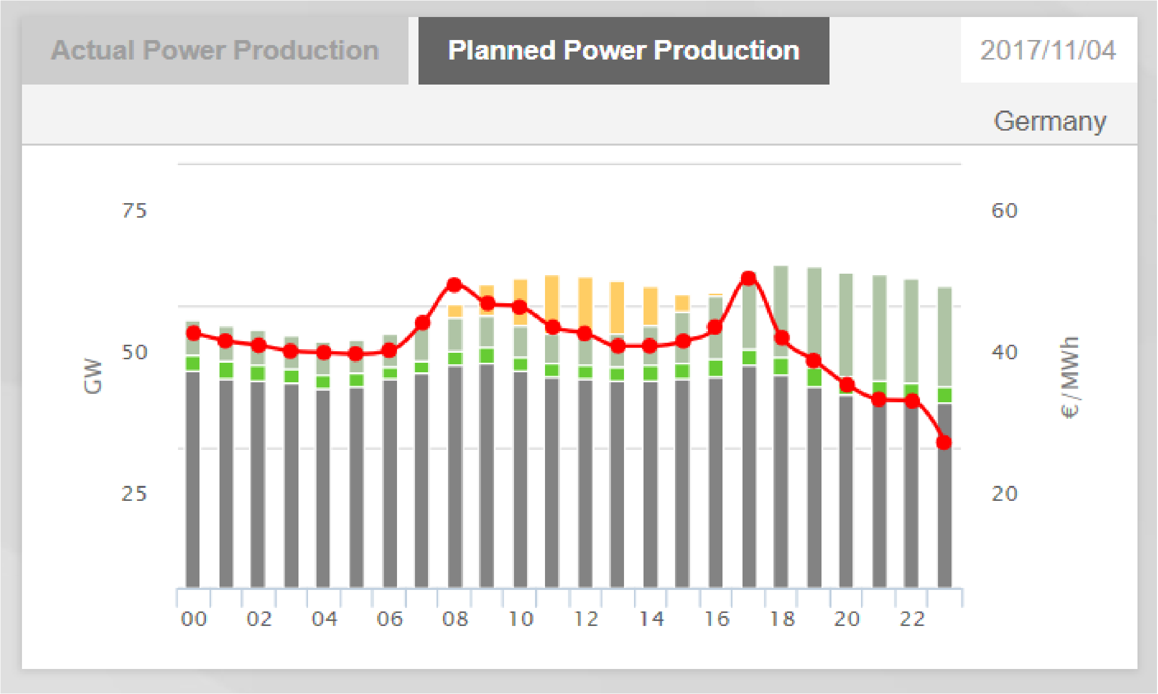
www.aifb.kit.edu
www.organicsmarthome.com
github.com/organicsmarthome

Duck Curve

- Duck curve is already reflected by the wholesale price of electricity in Germany



Source: EEX European Energy Exchange, 04 November 2017

Electric Mobility

Karlsruhe Institute of Technology

Charging of Batteries for Electric Vehicles

TWO-RATE TARIFF.

3d. per unit for all consumption registered between the hours of 4 p.m. and 8 p.m.

½d. per unit for all consumption registered at any other time.

A special two-rate meter will be fixed.

For Tradesmen who have Electric Vehicles, this Tariff enables them to re-charge during the night at the very low rate of ½d. per unit.

County Borough of Southport, Electricity Department: „Tariffs“ (*year unknown*, *~1910*)

Source: http://www.american-automobiles.com/Electric-Cars/Early-American-Electric-Automobiles.html , access: 21 September 2017

Panel 1

Is Technology Disruption Driven by Economics?

Malcolm McCulloch

Professor & Head

Energy & Power Group

Engineering Science

University of Oxford, United Kingdom

The Oxford Martin Programme on Integrating Renewable Energy

Change

Prof Malcolm McCulloch
November 2017

Who said this?

'The national grid will likely evolve into a battery charging service from about 2040'

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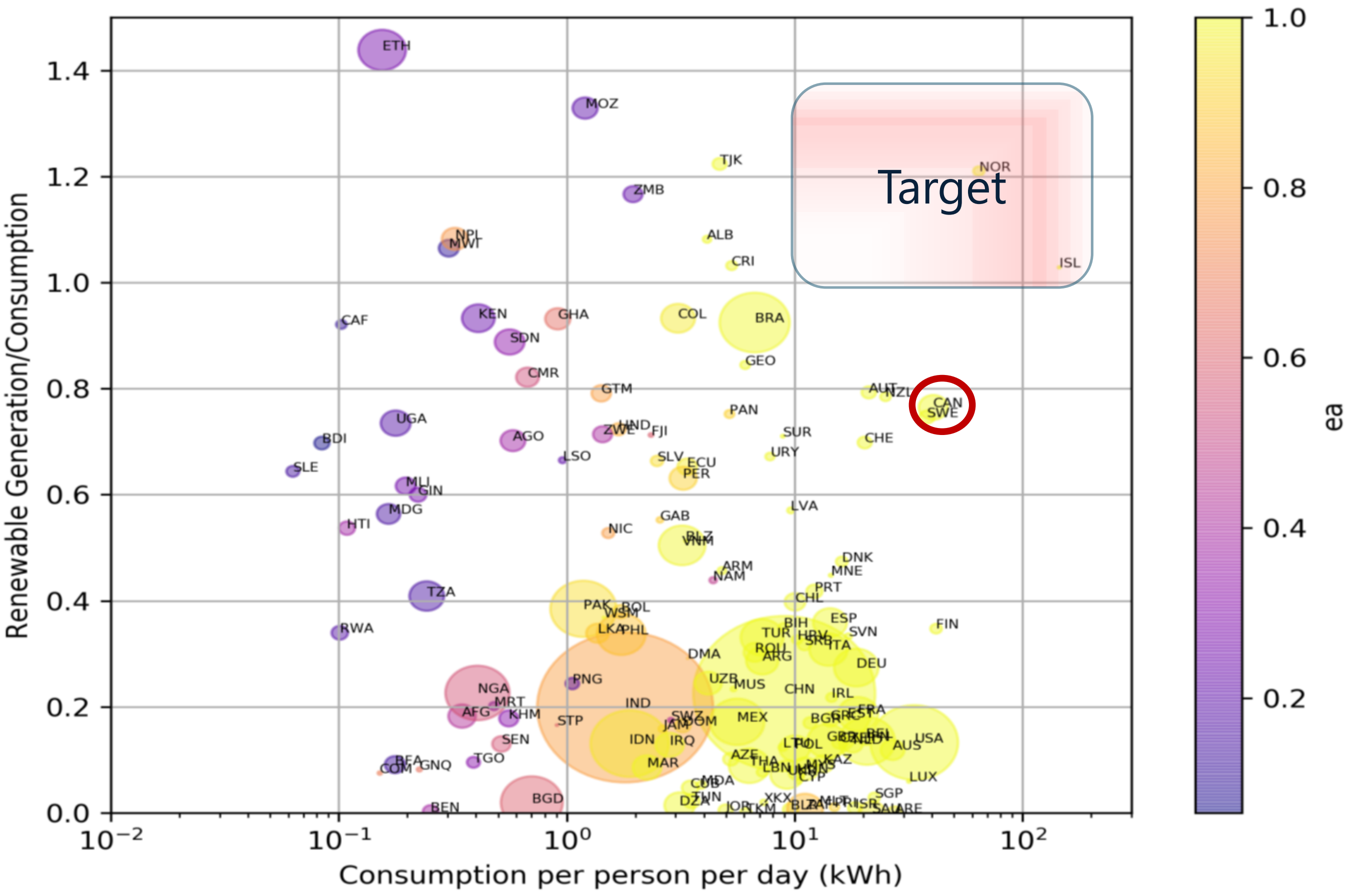
Energy access, Renewables generation



The big challenge for the existing system

Rise of the '*prosumer*'

'End user that provides energy services'

Solar Settlement at Schlierberg, 2001

1898

Cars: 0
Carriages: 2

0% Cars

IMAGE: MUSEUM OF THE CITY OF NEW YORK/BYRON COLLECTION/GETTY IMAGES

http://lynxthat.com/56f7cd9042513f13180b1955

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1899

Cars: 0
Carriages: 4

0% Cars

IMAGE: BUYENLARGE/GETTY IMAGES http://lynxthat.com/56f7cd9042513f13180b1955

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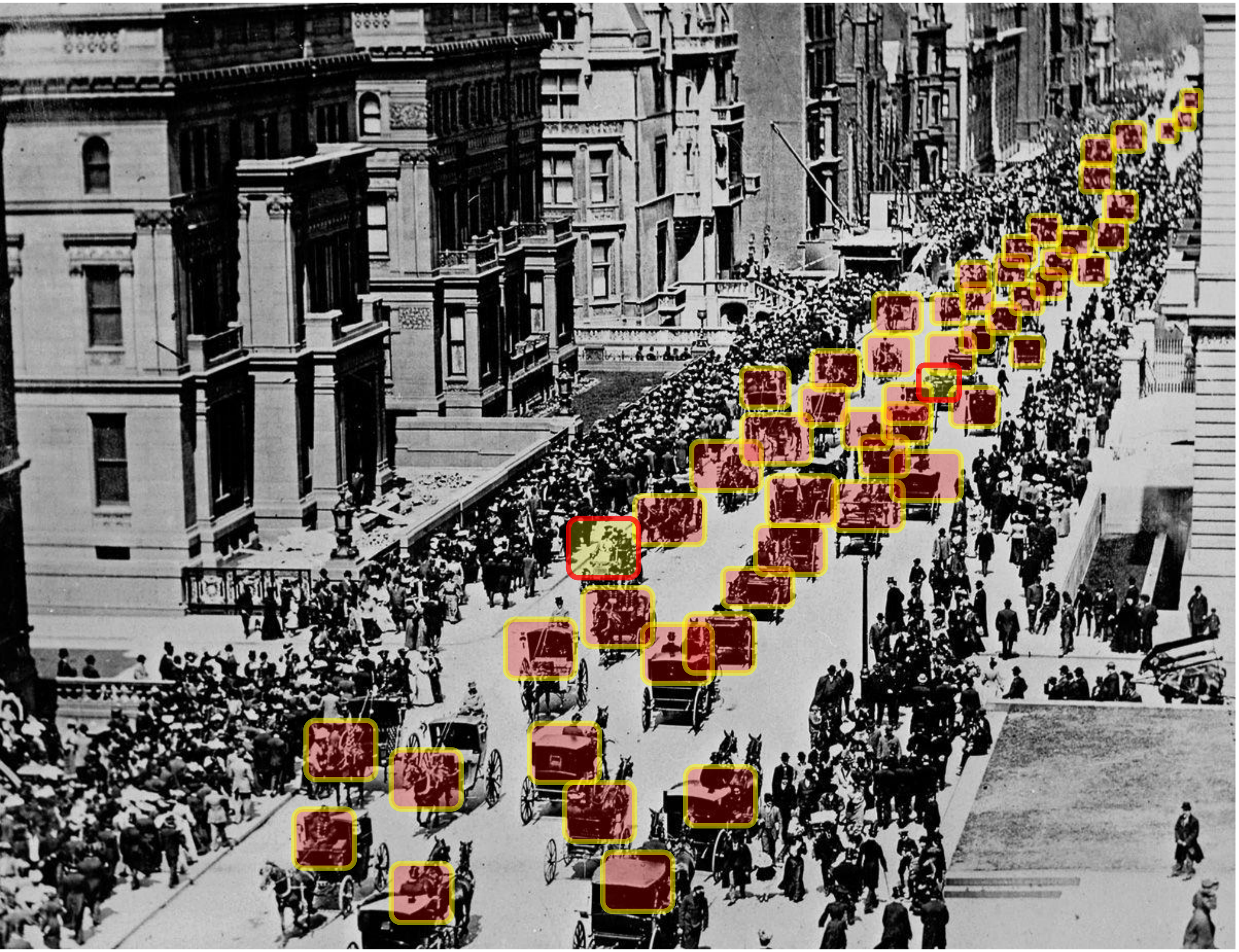

1900

Cars: 2
Carriages: 53

4% Cars

IMAGE: UNIVERSAL HISTORY ARCHIVE/UIG/GETTY IMAGES
https://commons.wikimedia.org/wiki/File:EasterParade1900.jpg

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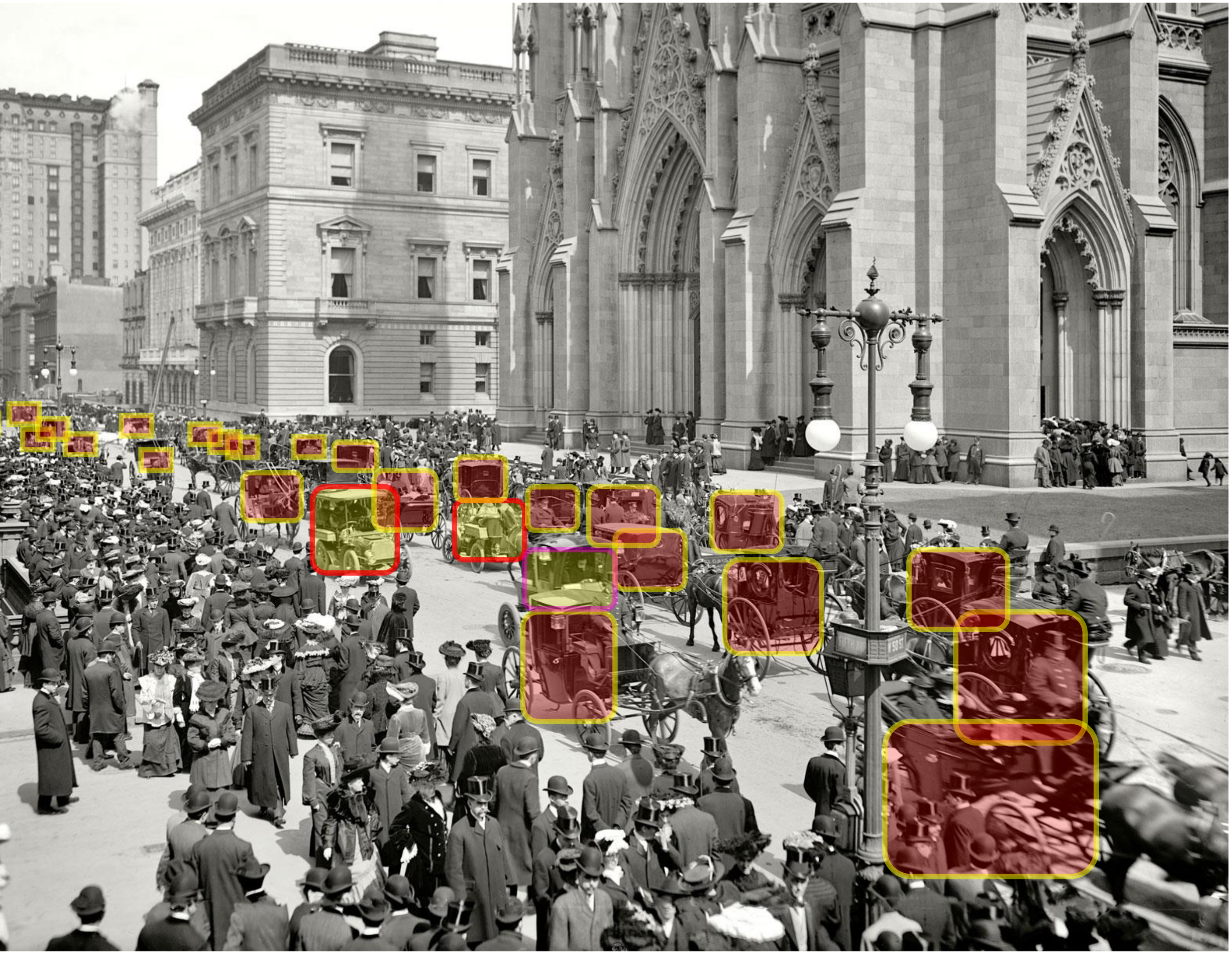

1904

Cars: 3 (1 EV)
Carriages: 28

10% Cars

IMAGE: HTTP://WWW.SHORPY.COM/NODE/10357

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1907 a

Cars: 3
Carriages: 8

27% Cars

IMAGE: HTTP://WWW.LOC.GOV/PICTURES/RESOURCE/STEREO.1S07704/ https://i.amz.mshcdn.com/uWGnobF_5WIDowIbnMcd8H6l8bY=/http%3A%2F%2Fa.amz.mshcdn.com%2Fwp-content%2Fuploads%2F2016%2F03%2Feasterparade-5.jpg

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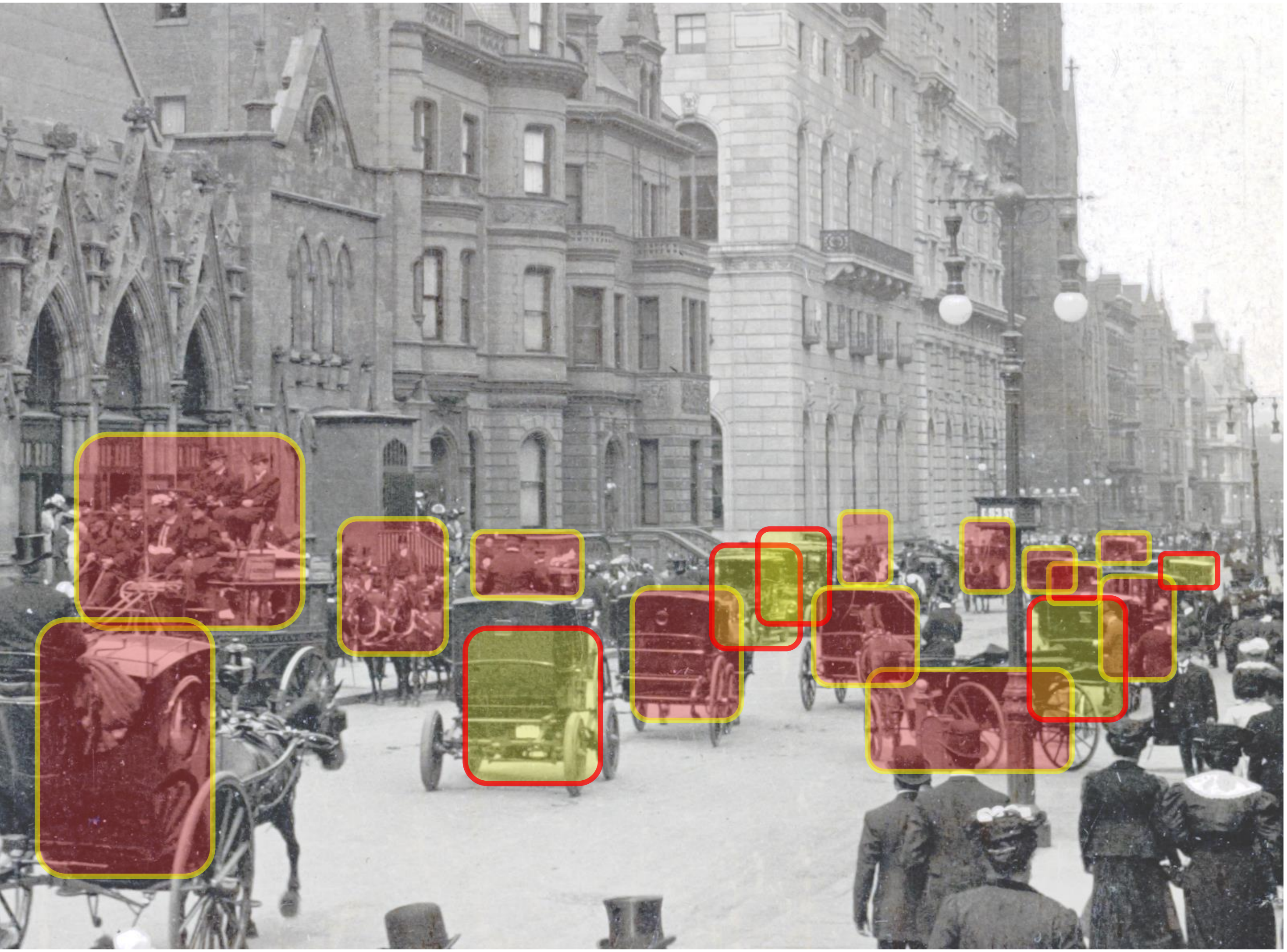

1907 b

Cars: 5
Carriages: 13

28% Cars

IMAGE:
HTTP://WWW.LOC.GOV/PICTURES/RESOURCE/STEREO.1S07704/

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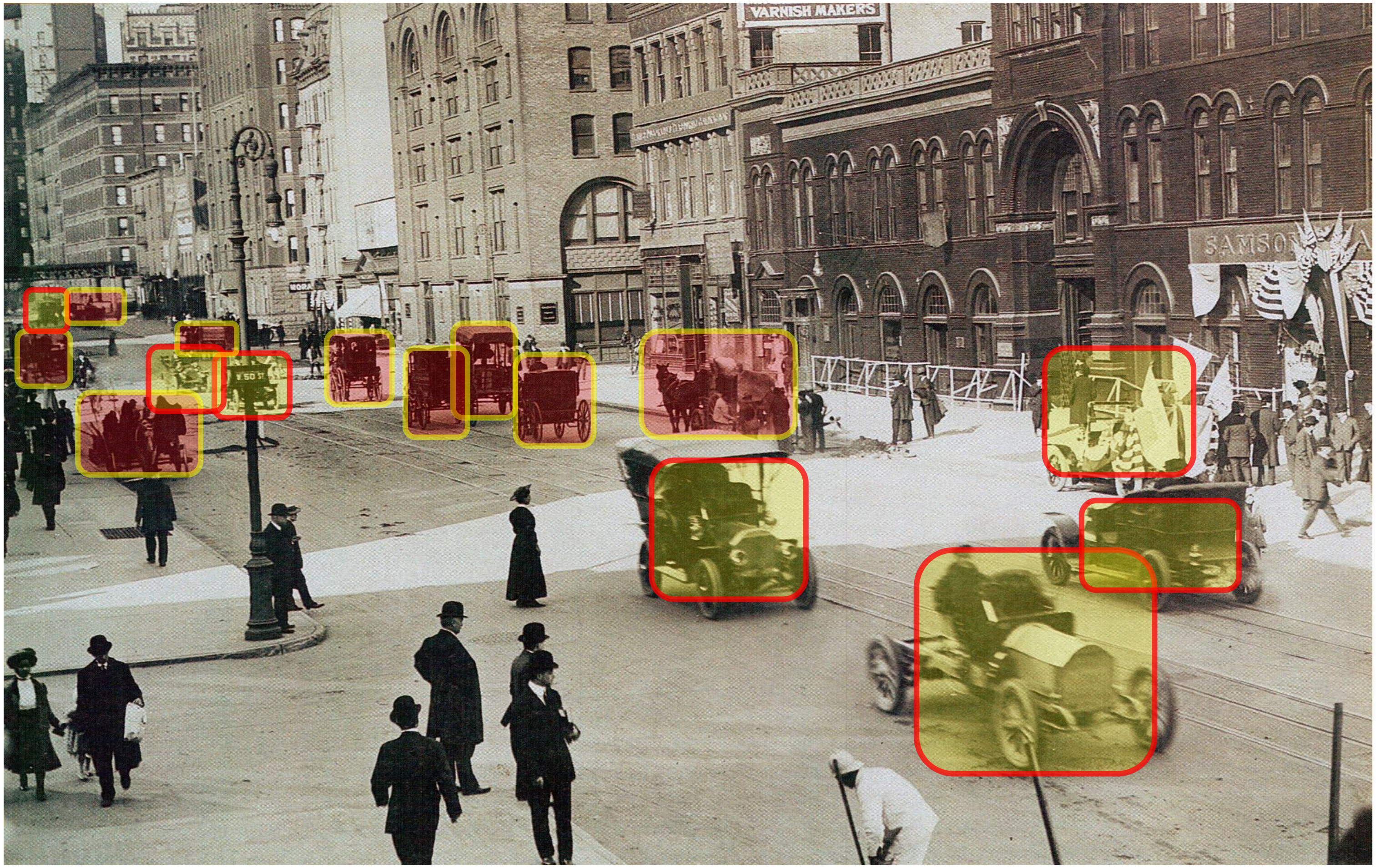

1909

Cars: 7
Carriages: 9

44% Cars

IMAGE:
HTTPS://WWW.FLICKR.COM/PHOTOS/46317563@N04/8582751607/IN/PHOTOSTREAM/

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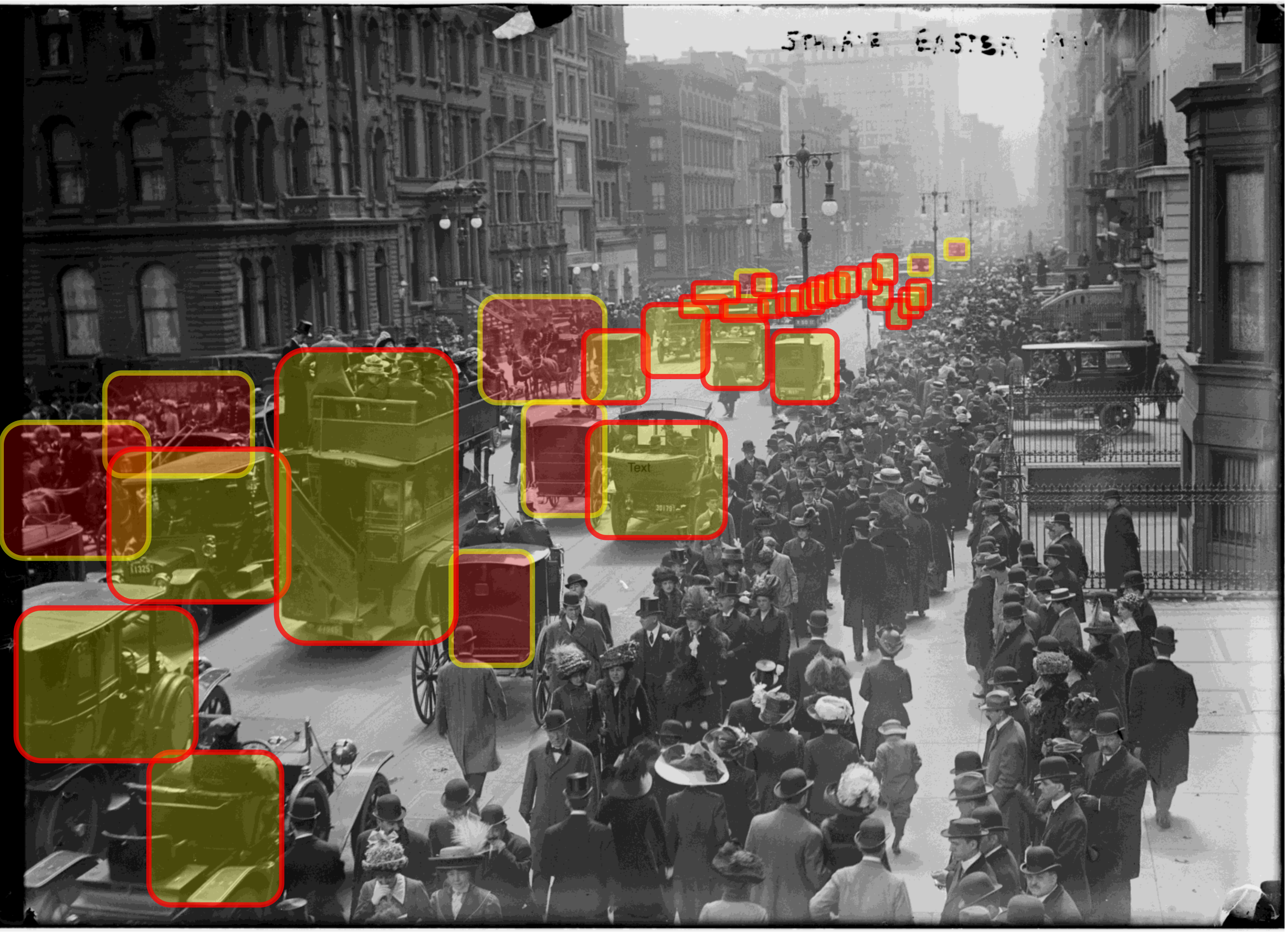

1911

Cars: 65
Carriages:7

90% Cars

IMAGE:
HTTP://WWW.LOC.GOV/PICTURES/RESOURCE/GGBAIN.50121/

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1913

Cars: 65
Carriages: 3

95% Cars

IMAGE: HTTP://WWW.LOC.GOV/PICTURES/RESOURCE/GGBAIN.11656/

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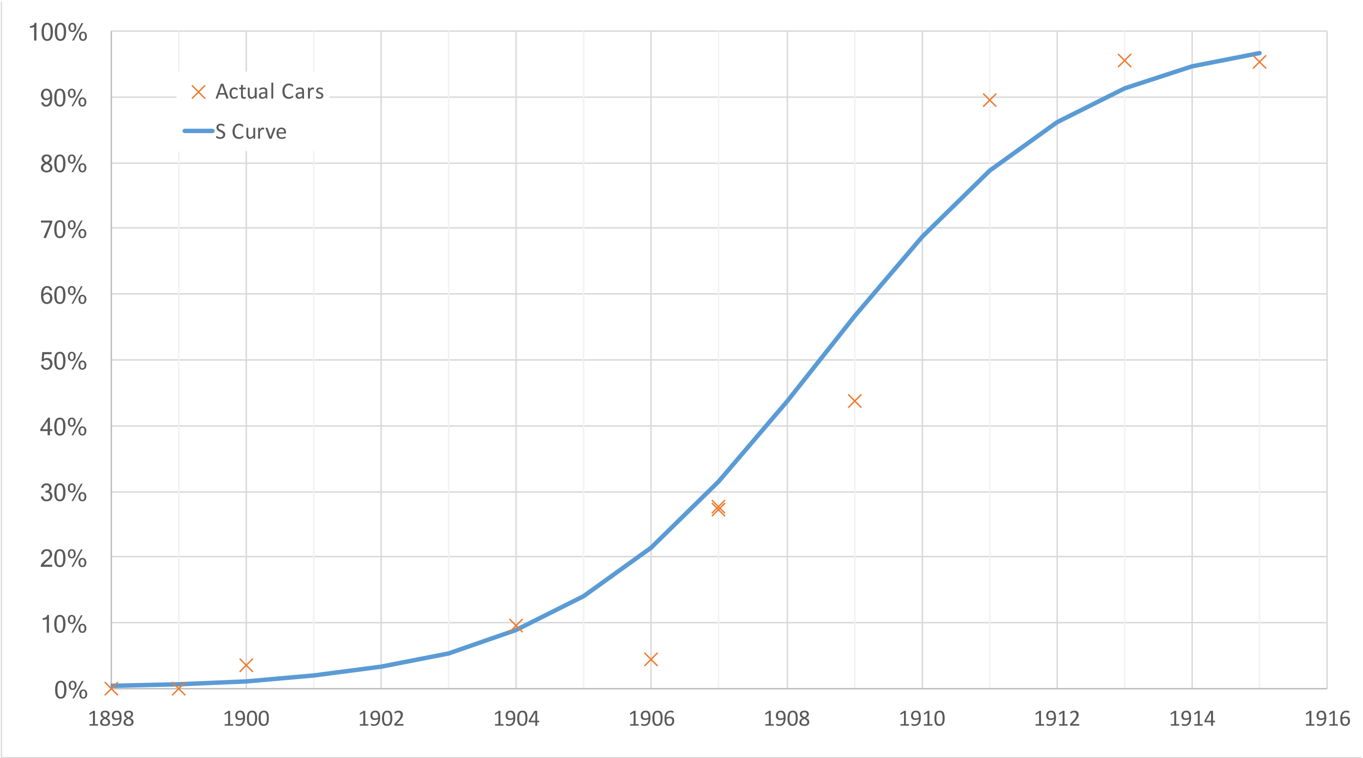
The rise of cars



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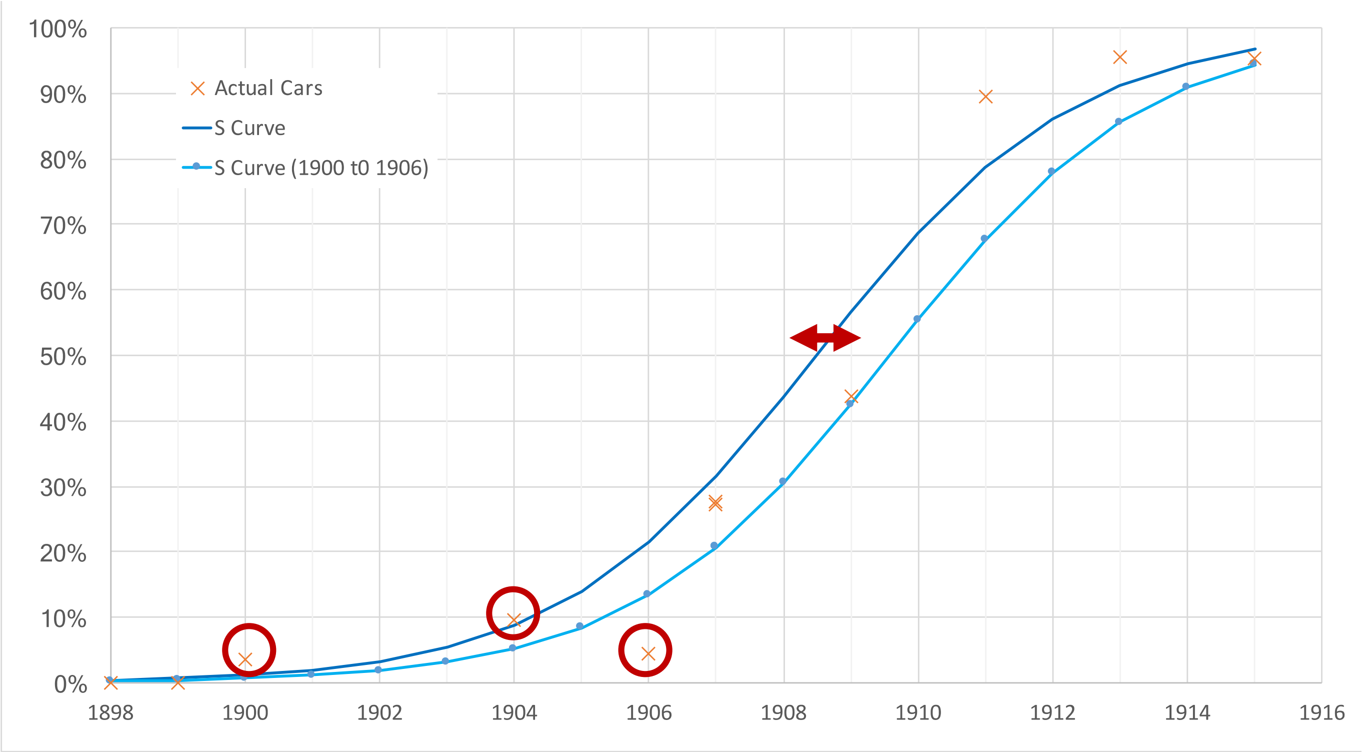
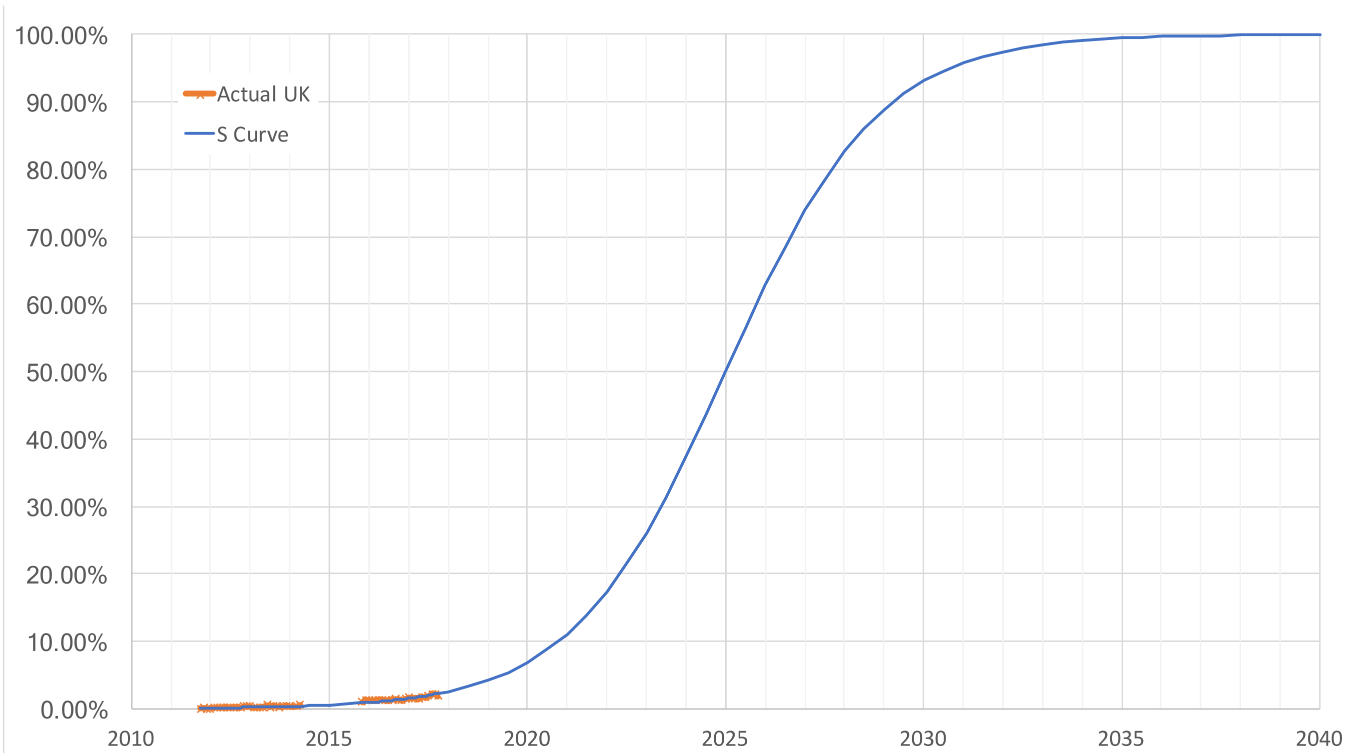
Early data good at predicting trends



Percentage of new sales of electric vehicles in the UK



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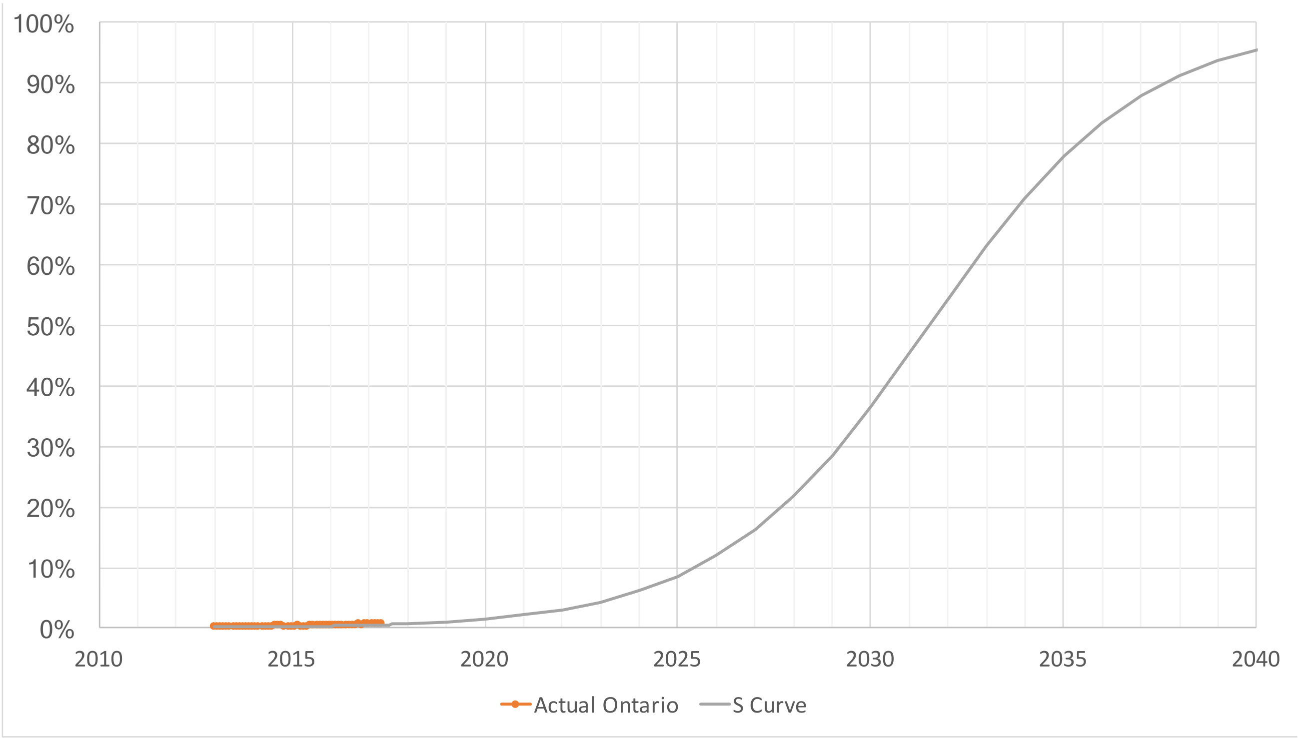
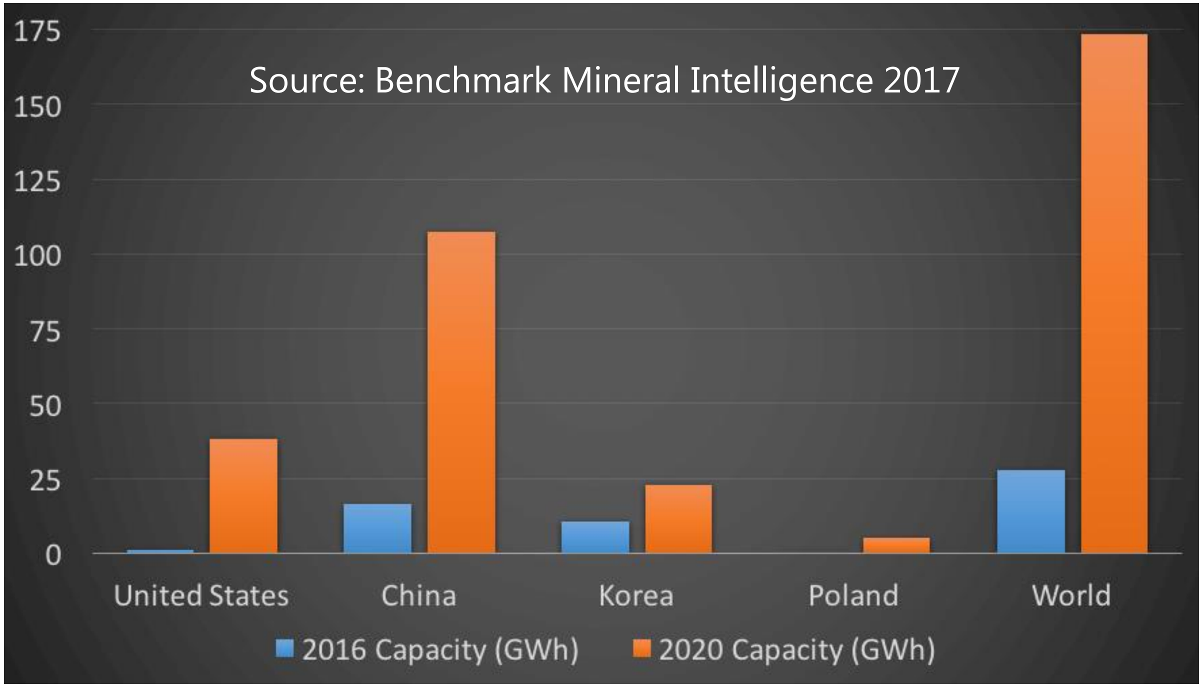
And in Ontario…



Change in storage is happening fast and most work doesn't account for this



Annual Battery Production Capacity 2017 predictions

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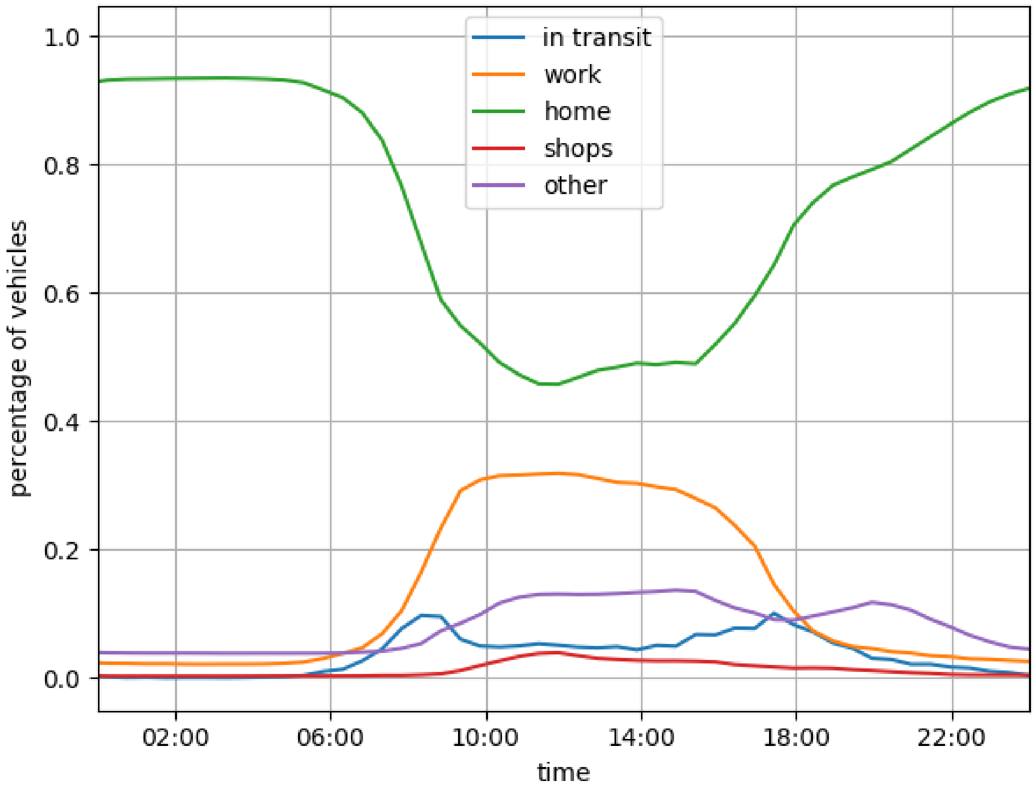
Who said this?

‘The national grid will likely evolve into a battery charging service from about 2040’

Alison Andrew

CEO Transpower, NZ

Travel habits



https://www.gov.uk/government/statistics/national-travel-survey-2014

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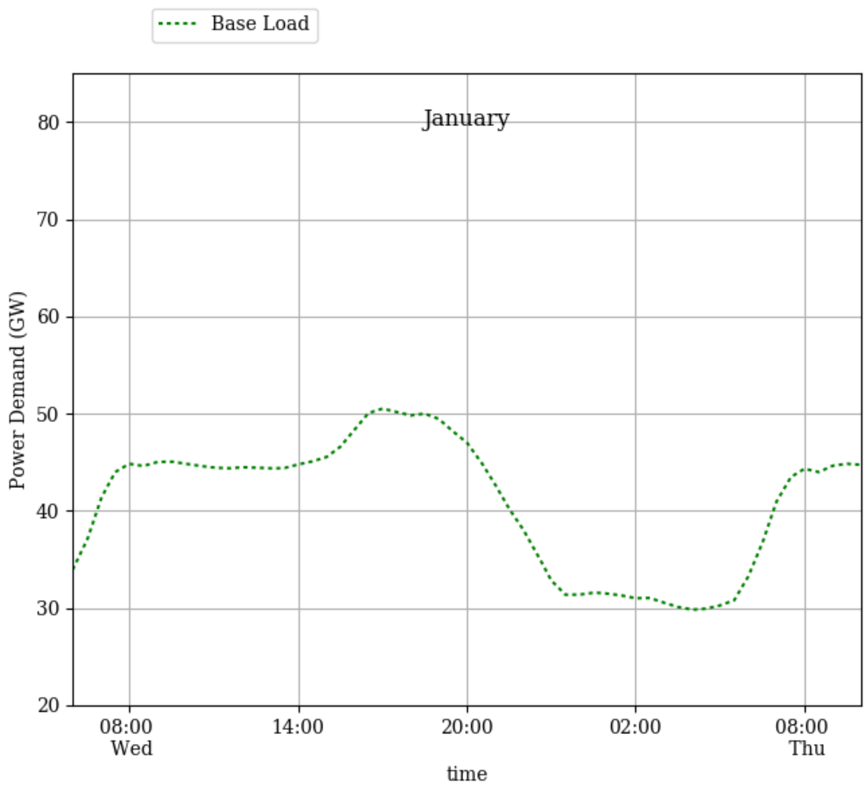
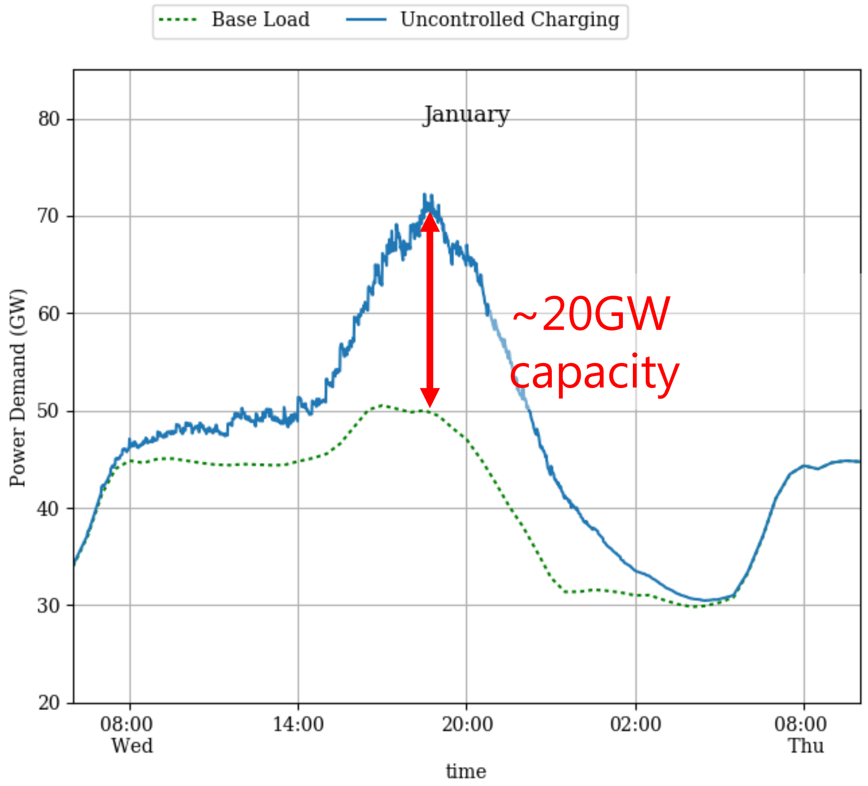
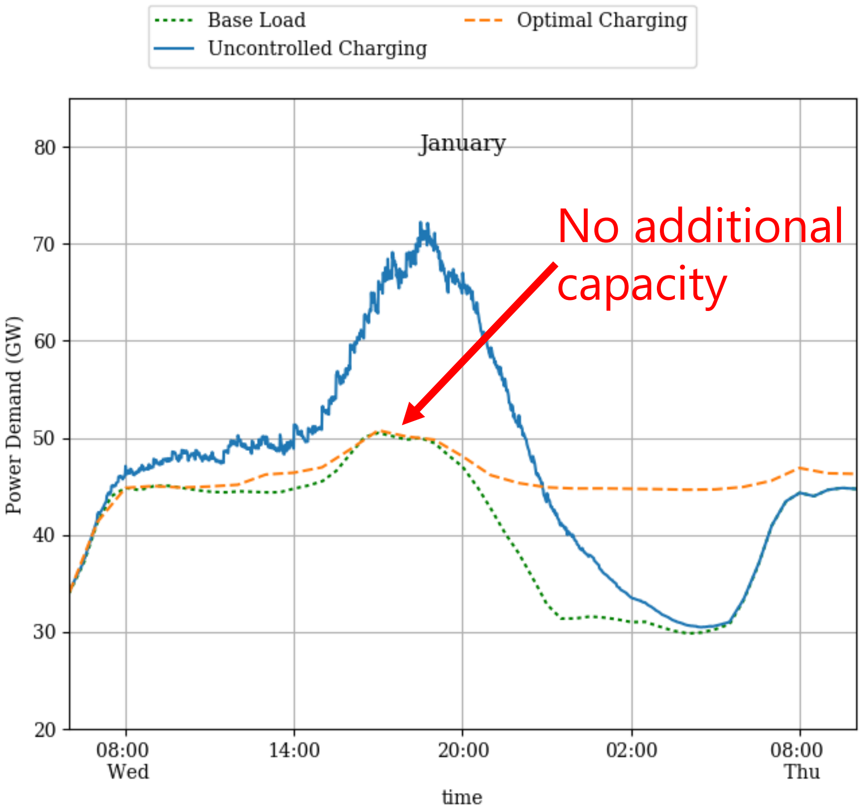
Impact on grid



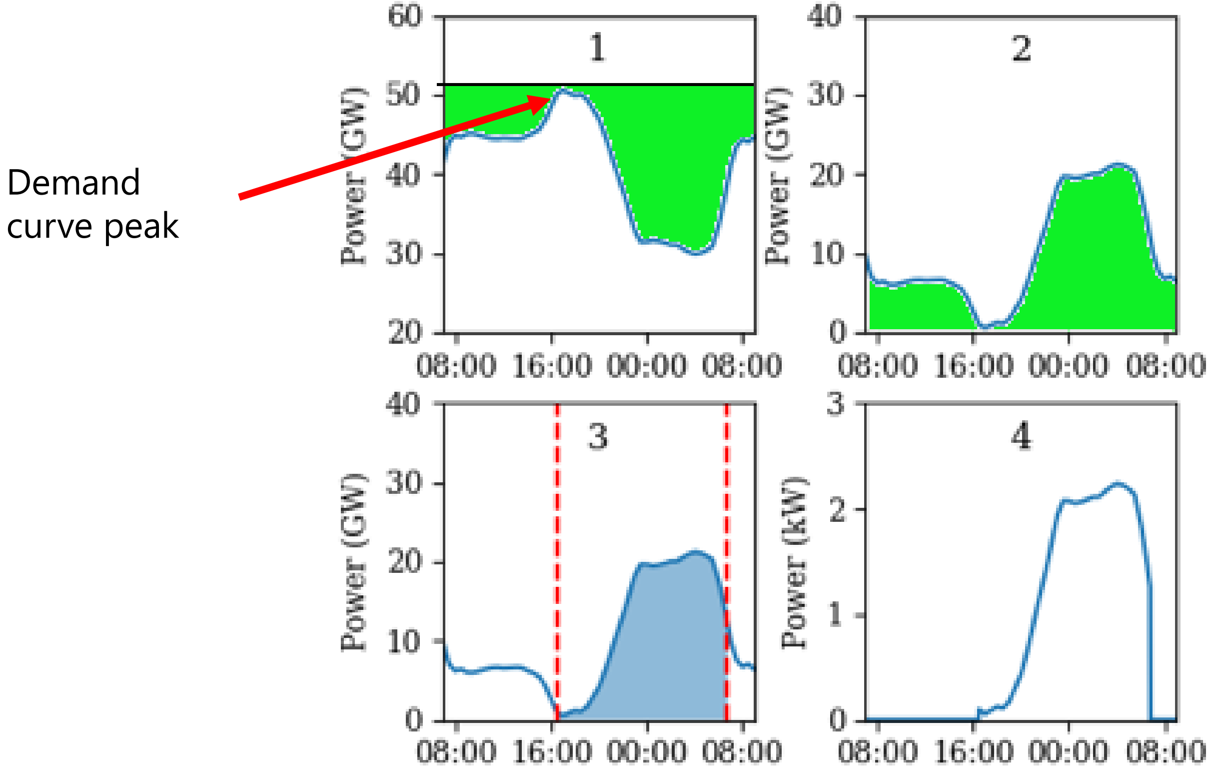
Impact on grid



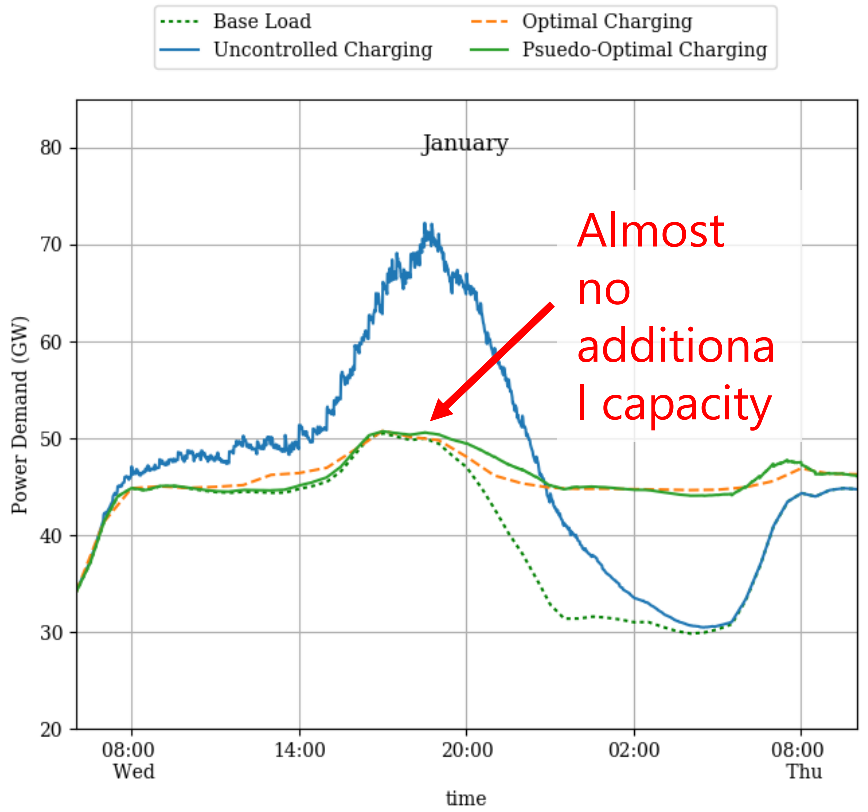
Impact on grid



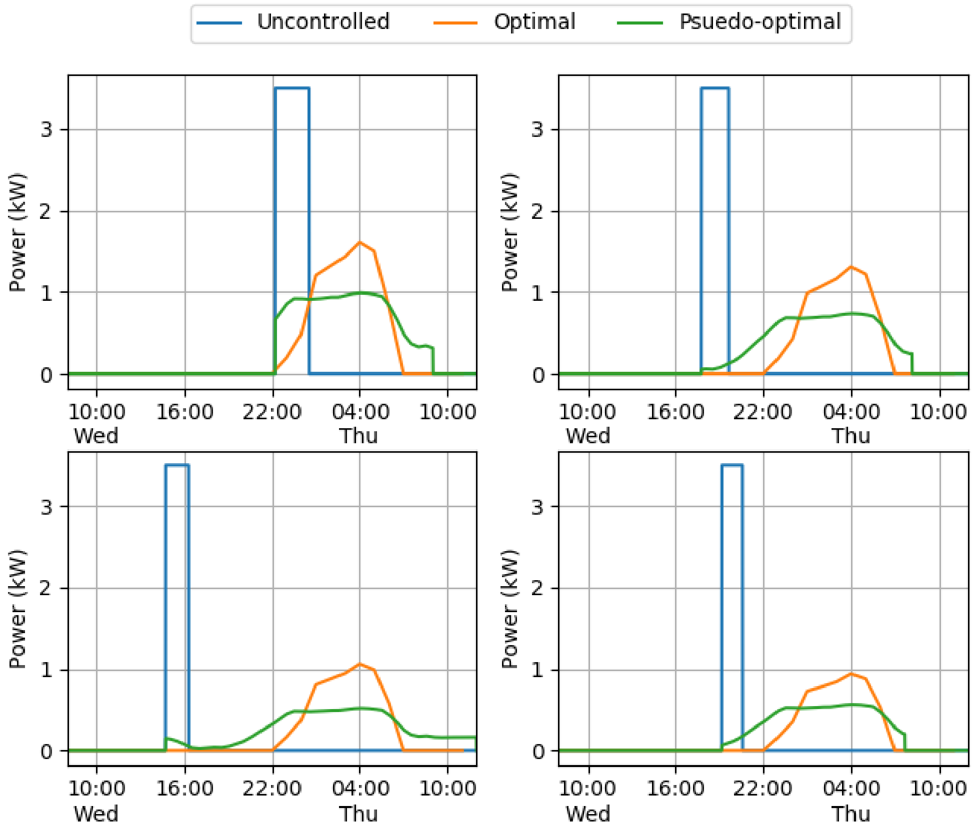
Practical implementation: pseudo-optimal



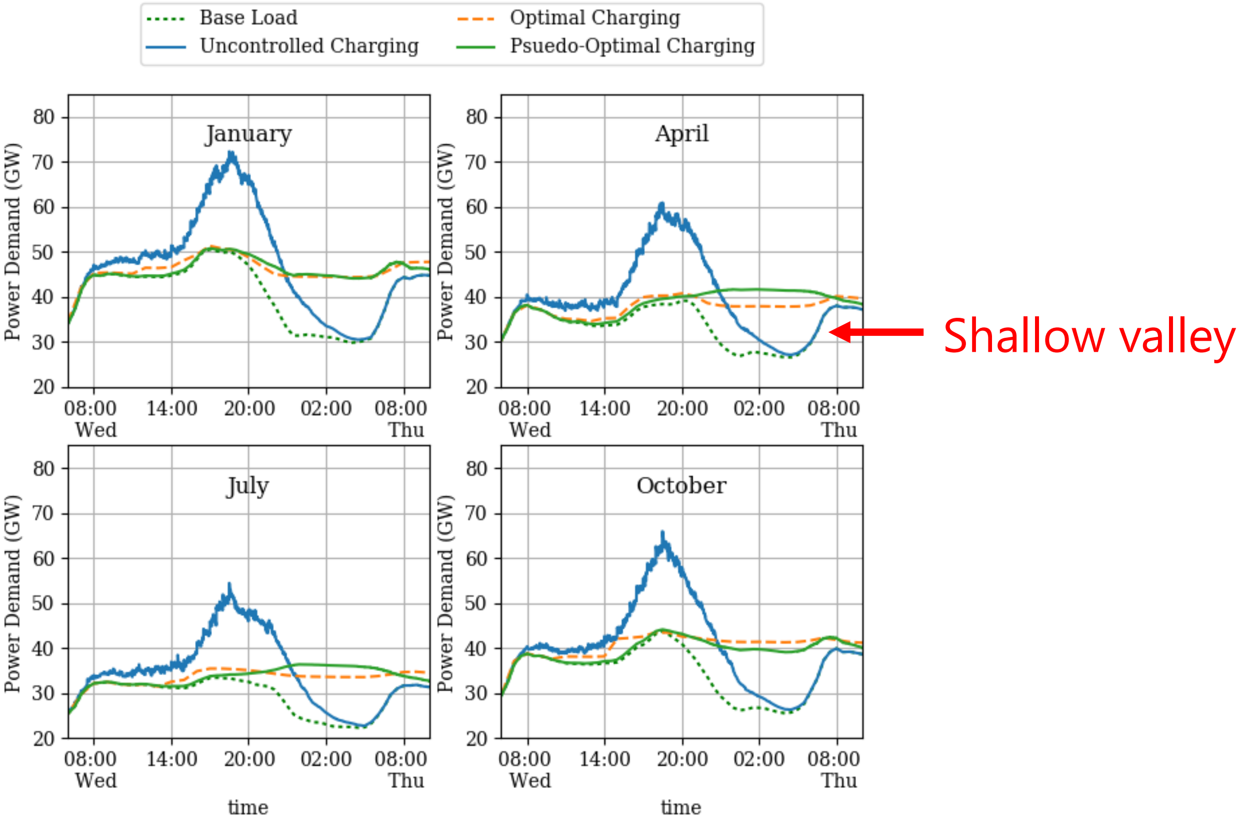
Impact on grid



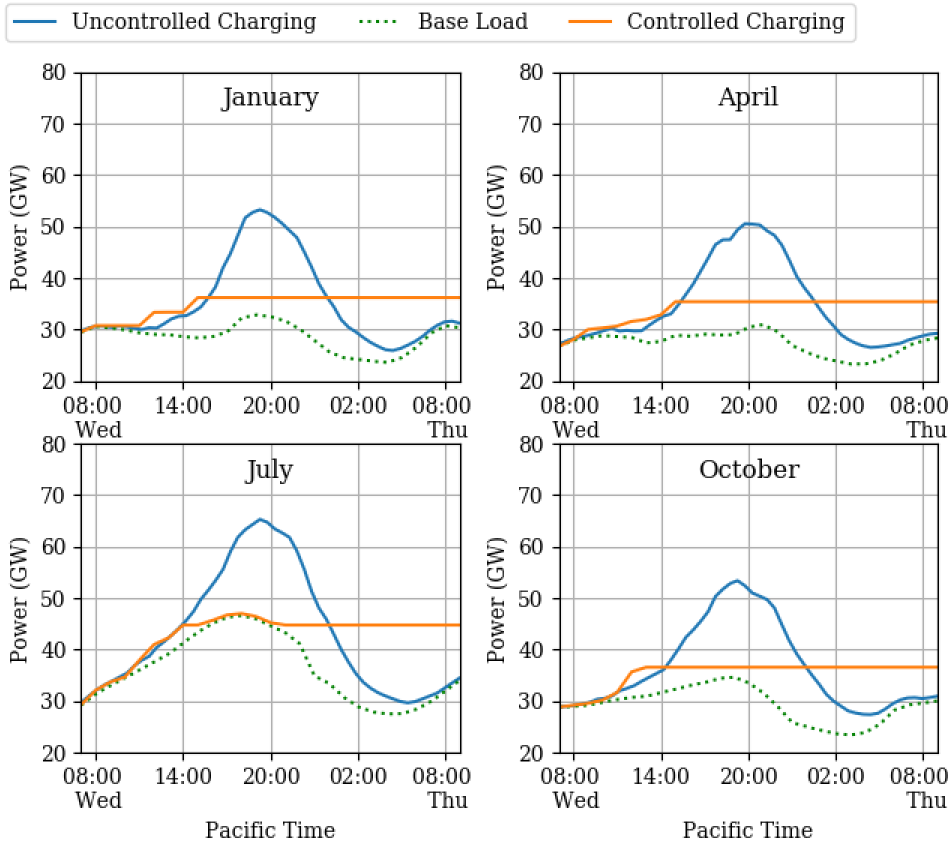
Individual charging profiles



Rest of the year…



California



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Challenge or opportunity?

The '*prosumer*' is coming...

Need to think through:
1) What will be the impact?
2) What value is created?
3) Who captures the value?

What about autonomous?

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Weekly Newsletter: http://www.renewableenergy.ox.ac.uk

Welcome to the weekly roundup from the Oxford Martin Programme on Integrating Renewable Energy.
View this email in your browser

Clean energy around the globe

In the UK, £18bn Hinkley Point C has been given the go ahead by the government, subject to safeguards to prevent Chinese involvement threatening national security. For more information, Carbon Brief have compiled the media reaction across the UK.

Scotland launched the world's first large scale tidal farm this week, with the first of four 1.5MW turbines, beginning its journey to the waters off the north coast of Scotland between Caithness and Orkney. Ultimately, Atlantis Resources hopes that the project will have 269 turbines and generate enough electricity to power 175,000 homes.

In Sweden, Vattenfall have won a tender to build two offshore wind farms for $67.33/kWh, 20% lower than the previous record. Low costs are supported by the location (close proximity to the shore in the Danish North Sea) and reduced costs of foundations and transportation, and the project is anticipated to have a

Academics (Oxford and other)

Consultancy and Research (e.g. Energy Systems Catapult Aurora)

Industry (e.g. Ofgem, EDF Energy, National Grid, E.On)

Commercial (e.g. BP, Siemens)

Global >20 countries

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Panel 1

Is Technology Disruption Driven by Economics?

Neetika Sathe

Director

Emerging Technologies

Alectra Energy Solutions Inc.

Panel 1

Is Technology Disruption Driven by Economics?

Audience Question & Answer Session

Please use the microphones provided, thank you!

Disruptive Innovation over the Wires: Business Models for Success

Thursday November 9 | Federation Hall | University of Waterloo

Break

Council for Clean & Reliable Energy — transforming the way we think about power | ENBRIDGE | WISE Waterloo Institute for Sustainable Energy | Canadian Electricity Association | Association canadienne de l'électricit | Power Workers' Union | NSERC CRSNG | University of Waterloo

Presentations by Technology Developers

Speakers

David Teichroeb
Business Development
Emerging Technologies
Enbridge Inc.

Paul Pauze
Vice President
Business Development & Sales
Innovus Power

Julie Morin
Internet of things
Global Black Belt Team
Microsoft Canada

Alif Gilani
Head
Engineering
Energy Management Division
Siemens Canada

Presentations by Technology Developers

David Teichroeb

Business Development
Emerging Technologies
Enbridge Inc.

Technology Innovation & Policy Forum

Technology Priorities For Our Low-Carbon Energy Future

David Teichroeb
Business Development, Low-Carbon Energy Solutions and Strategy

ENBRIDGE®

Council for Clean & Reliable Energy – Waterloo University, Nov 9, 2017

Achieving The Trifecta of Building Energy Performance

ENBRIDGE
Life Takes Energy

Hybrid
Heatin
g

Smart
Thermal
Networks

Solar PV,
Energy
Storage &
CHP

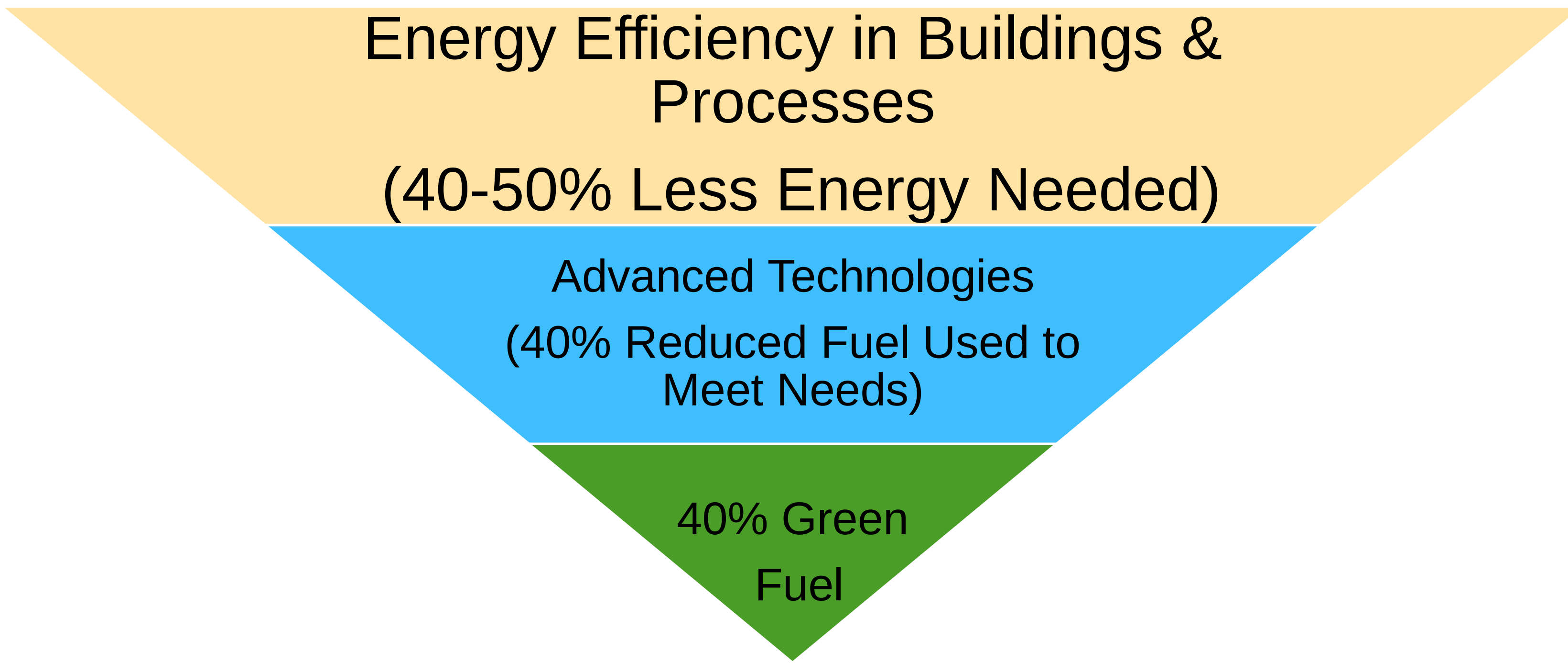
Low-Carbon Footprint for Sustainability

Household Energy Affordability

Increased Energy Resiliency

Alternative Pathways to Deep Decarbonization

a) Reduce The Energy Needs, b) Reduce Fuel Used and c) Green the Fuel



80% Reduction in GHG Emissions by 2050

Net Zero Energy Emissions

Start With Emphasis on Deep Energy Efficiency Improvements While Maintaining Consumer Choice For Energy Supply

Today's Energy Conservation Results

Average Residential Customer Usage Reduced Natural Gas use by 21%

$ Residential Customers save $2.67 for each dollar spent on natural gas conservation
(Environmental Commissioner of Ontario, 2016)

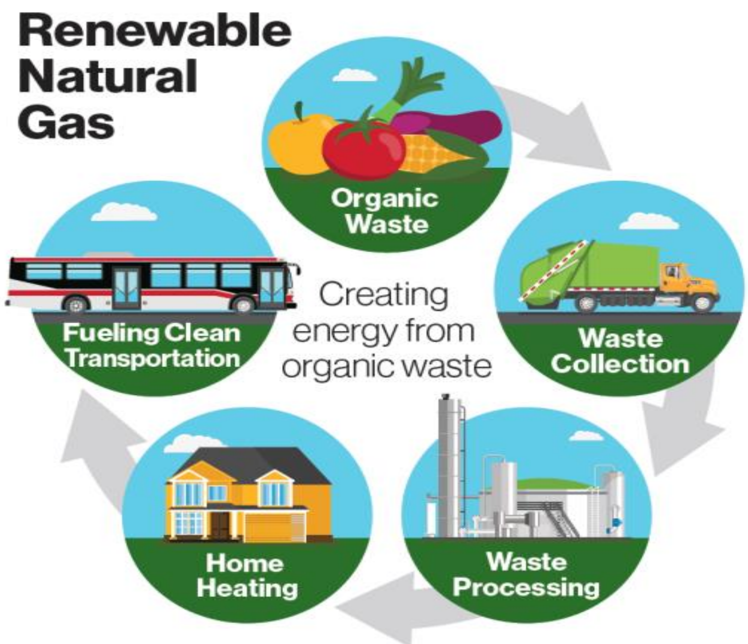
Ontario
HOME ENERGY CONSERVATION INCENTIVE PROGRAM
With funding from Ontario's Green Investment Fund

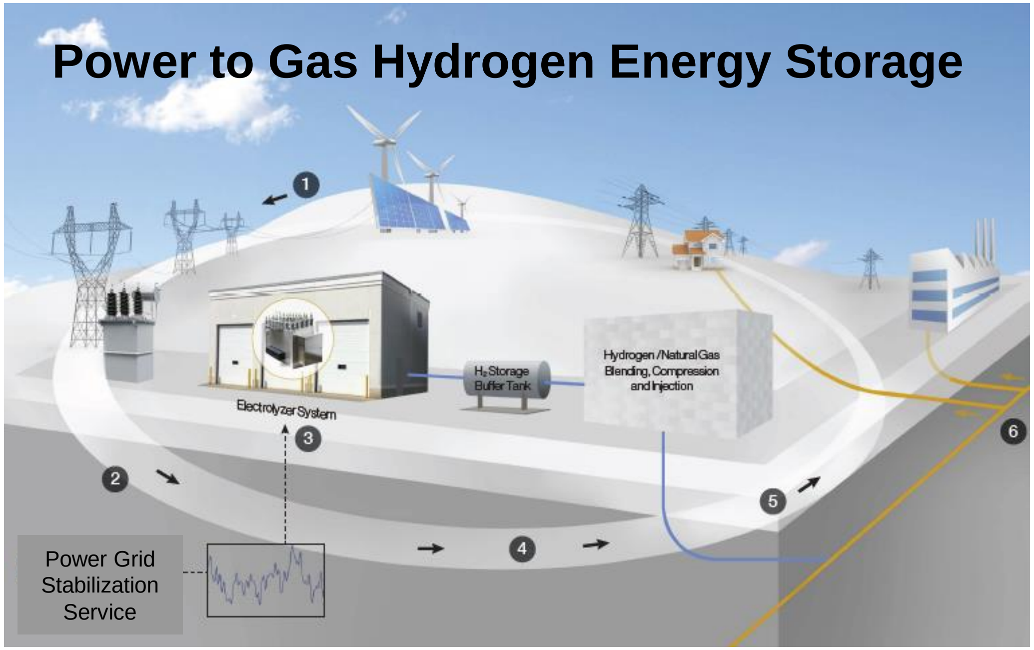
Deep Energy Efficiency Measures Targeting

- Improved Thermal Envelope
- Advanced Window Performance Standards
- Improved Insulation Standards and Advanced Building Skins

Renewable Natural Gas & Power to Gas (Hydrogen)

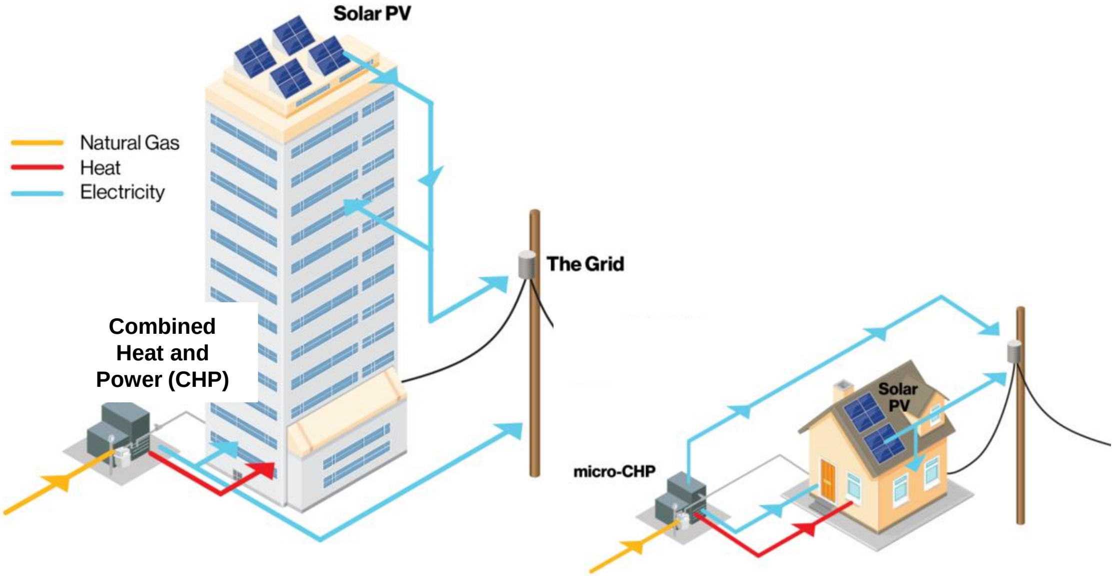
A Renewable Energy Option With Cost-Effective Storage to Complement Household Renewable Energy Generation





Integrated Energy Systems

Combining Solar PV With Combined Heat & Power & micro-CHP)

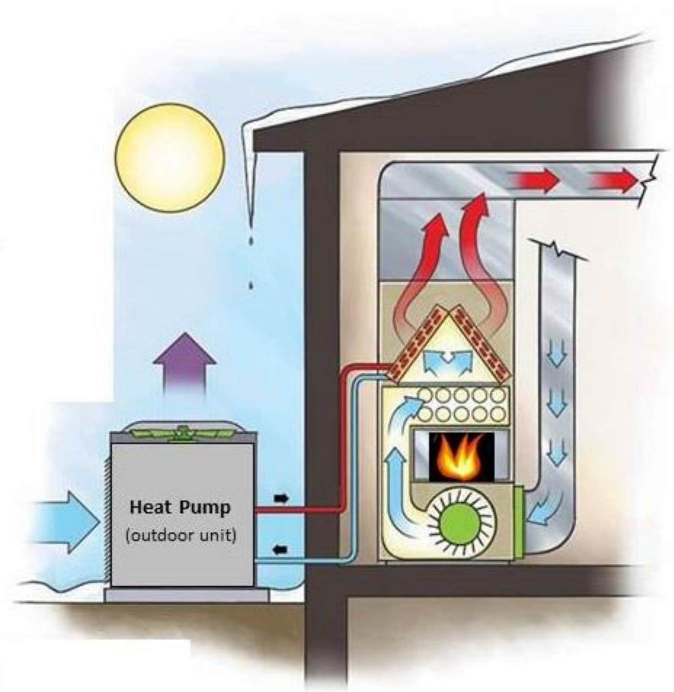


Right-Size All On-Site Generation & Energy Storage

- Delivers improved GHG reductions (seasonal balancing)
  - Strong solar harvesting in spring & summer
  - mCHP more efficient use of natural gas (winter power demand
- Improved energy resiliency
- Improves net-zero affordability by right-sizing solar & battery storage

Hybrid Heating Systems

Natural Resources Canada Has Identified This As Dual-Fuel Thermal Energy Supply Using Air Source Heat Pump (ASHP) and Natural Gas



Source: www.familyhandyman.com

- ASHP When Bulk Power Grid Has Adequate Renewables
- Direct , High-Efficiency Natural Gas When Power Grid Has Peak Needs
- More Affordable GHG Reductions
- Energy Resiliency Greatly Improved

Renewable Natural Gas for Large Plug Loads

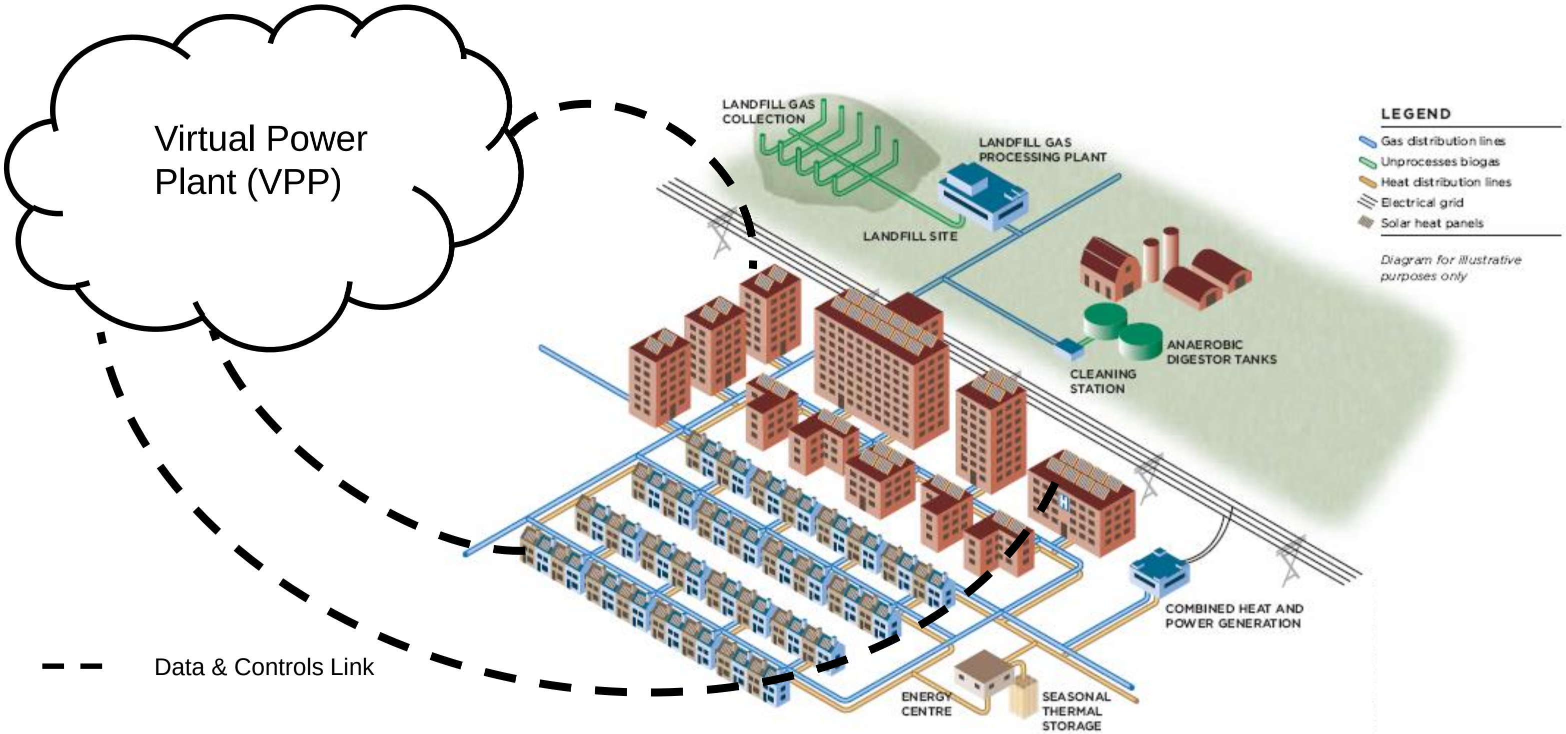
EV Charging Largest Plug Load In Future; Fuel Switch Other Appliance Loads to Renewable Fuel

- Cooking / Cloths Drying with Renewable Natural Gas
  - Savings ~ 50% to 60% verses other renewable energy options

- Lifestyle / Societal Benefits
  - Consumers reduce their exposure to Time-of-Use rates
  - Reduce need to oversize PV, inverters, batteries, etc. under net-metering
  - Reduce home's contribution to bulk power grid system peaks

Buildings Become Part Of The Solution

Renewables, Energy Storage and Hybrid Heating Can Support Virtual Power Plant (VPP) Capability Within The Community



Original Source Image: CGA, "Natural Gas, our Place in Canada's Sustainable Energy Future

Questions?

—

David Teichroeb - Business Development; Low Carbon Energy Strategies

David.teichroeb@enbridge.com (416-495-5355)

Presentations by Technology Developers

Paul Pauze

Vice President

Business Development & Sales

Innovus Power

INNOVUS POWER

The Innovus Power Platform

The Future Backbone for Distributed Generation

‘We make all power dispatchable’

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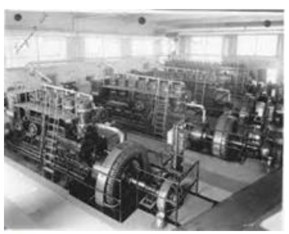
MicroGrids trying to operating with 125 year old Technology

Imagine your Car Engine Running at full speed all the time…., even when your stopped!

This is exactly how Generators operate today with 125 year old technology

1920



Today

Generators run at one speed, 100% of the time regardless of the load.

Innovus is about to bring Power Generation into the 21 Century

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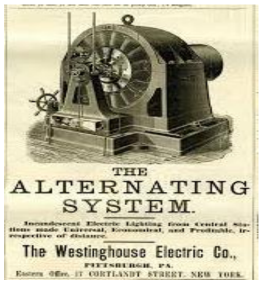
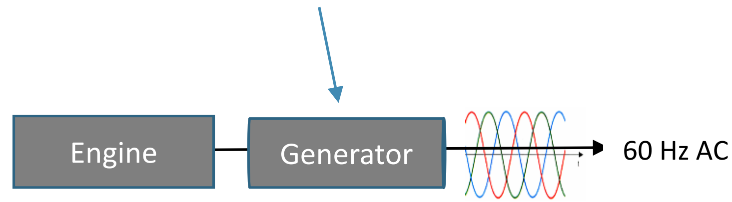
Understanding **Synchronous Generation**
The foundation of electric power



1890
First AC Synchronous Generator

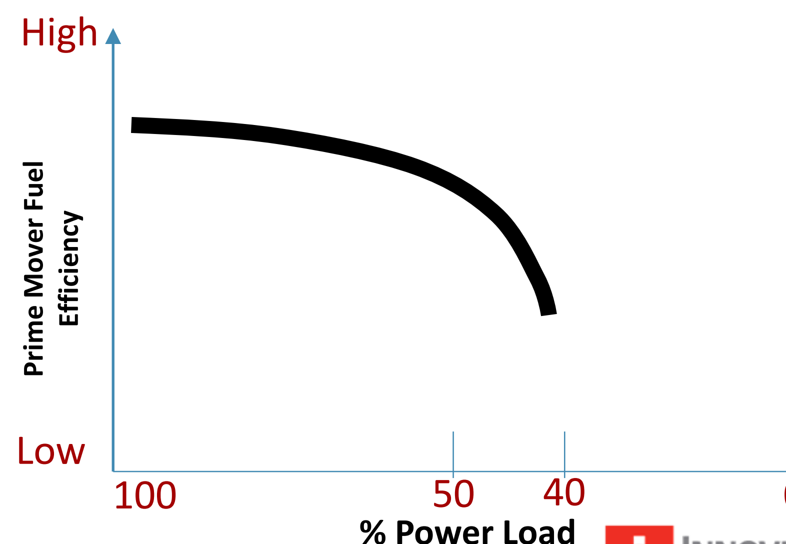
Today

Synchronous Generators are designed to only run at **'1 speed'** to control power frequency



Synchronous Generation and today's needs

- Poor fuel performance at <50% loads
- Unable to effectively integrate renewables
- Limitations drives high system complexity
- Large hurdles in further emissions reductions
- Engine Damage <40% loads



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The Innovus Breakthrough

Decouple Alternating Current (AC) frequency control from Synchronous '1 Speed' Generation

How:

By using an **Innovus** enabled **Power Electronics** and proprietary **Software Controls**

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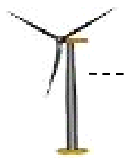
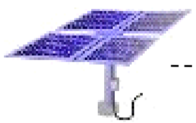
Software and Electronics for Power Generation



Wind



SolarPV

- Low Cost
- Highly reliable
- Extremely efficient
- Proven & Bankable
- Programmable and controllable

Why Not for Gen Sets?

- Variable Speed Engine operation
- Enables Highest Engine efficiency
- Integrates 100% renewables
- Programmable and controllable
- Components Proven & Bankable

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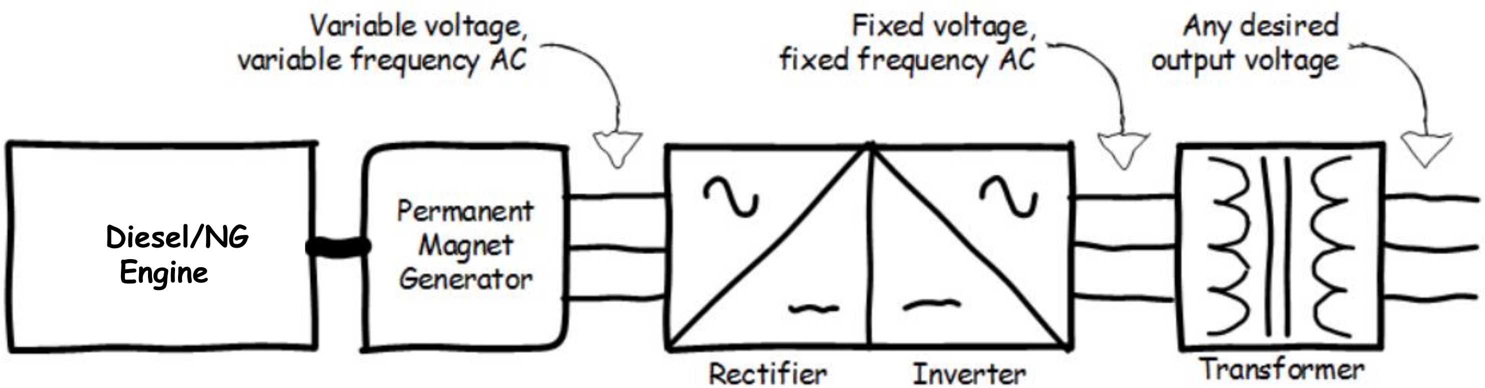
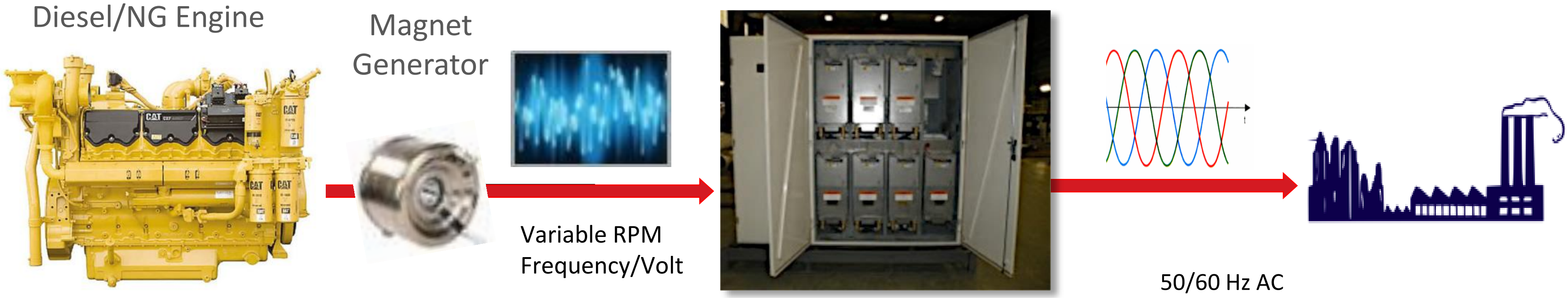
Innovus Architecture- the future of Power Generation



Cat/MTU/Cummins
Diesel/NG Engine

Permanent
Magnet
Generator



Power Hub

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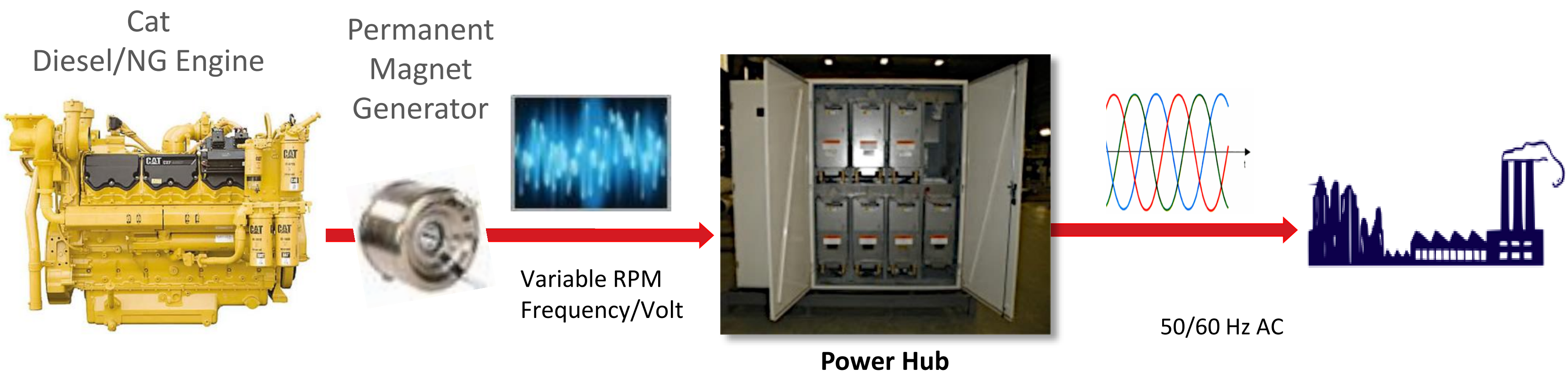
Innovus Architecture- Unlocking the Benefits



- **Efficiency- Decoupling** Engine Speed from Frequency allows the engine to operate at Optimal efficiencies at **all Loads**
- **Power Quality** - Producing Power Via converter provides **100% stable frequency** regardless of transients
- **Maintenance- Increased torque** at low loads creates **heathy** engine operation down to 10%
- **Renewables**- Converter Generation allows **100% renewable** integration

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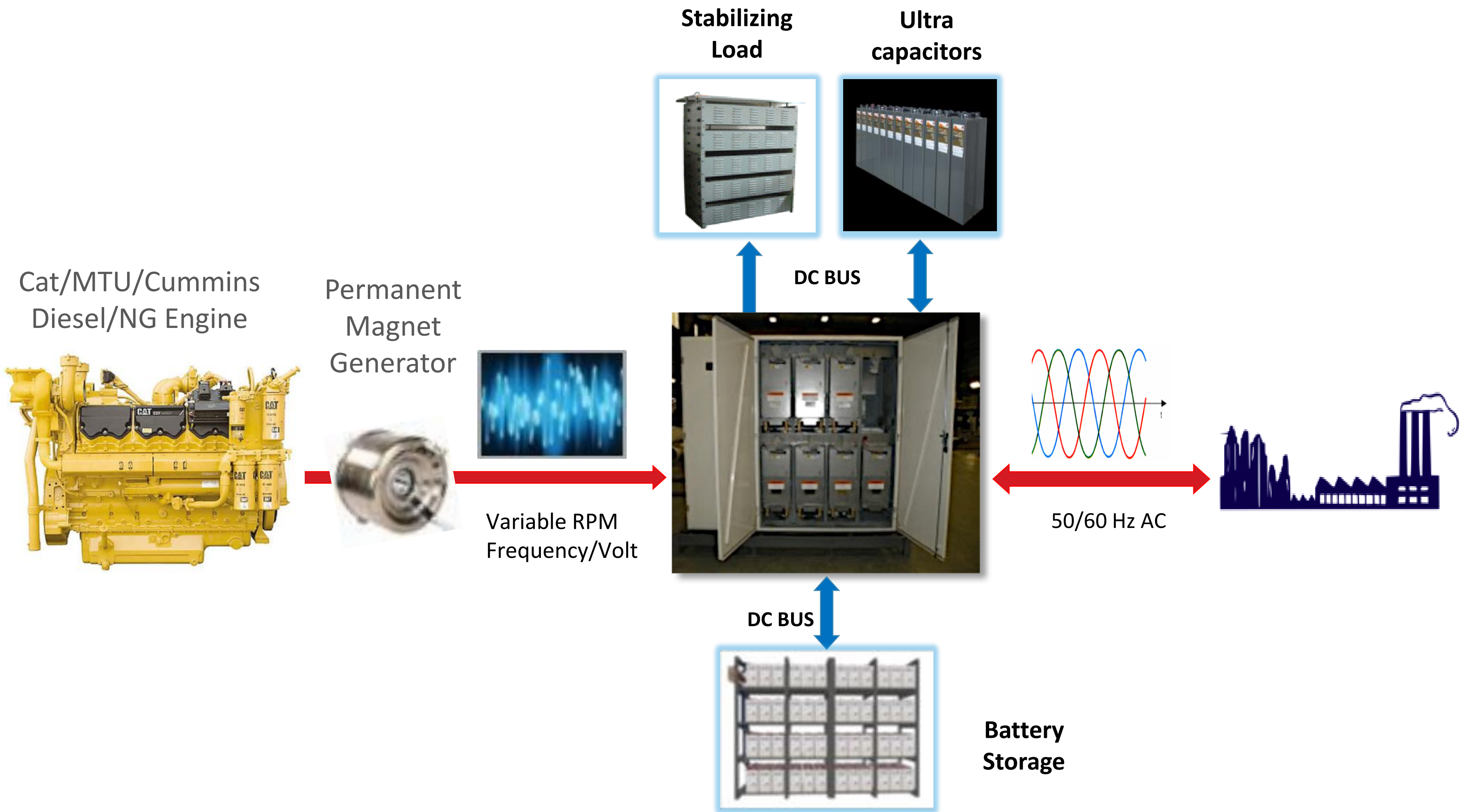
PowerBridge- Stabilization and Storage at the Source



Stabilization is unmatched

- patented integrated engine and DC Bus Energy balancing control

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Benefits of Innovus Technology- efficiency

Fuel and Emissions Savings vs FSGs

- up to 41% fuel savings compared to low loading on FSG,
- up to 83% when paired with high penetration of renewables -WISE report findings

Reduced Operating Costs and Extended Operating Life

- 25% reductions in OP costs, and increase in **engine life**

Simplification and Flexibility

- our industry leading fuel efficiency coupled with our ability to generate at nearly **constant efficiency from 100% down to 10%** removes the need for multiple generator sizes with all the related logistics advantages

Fuel & Engine Flexibility

- **Diesel or Natural Gas** engines to manage **100% transient loads** while maintaining stable voltage and frequency

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Benefits of Innovus Technology – Renewables/Storage

High Penetration of Renewable Energy Sources now or in the future

- up to 100% renewables without the need for complex microgrid controls, flywheel or battery storage for grid stabilization

Virtual Spinning Reserve

- PowerBridge integrated technology allows **100% reserve capacity** with engine off, zero fuel burn operation

Low Cost Storage Integration

- as storage for time shifting becomes economical, our Converter platform **enables seamless integration without the need of additional converters** or complex microgrid controls

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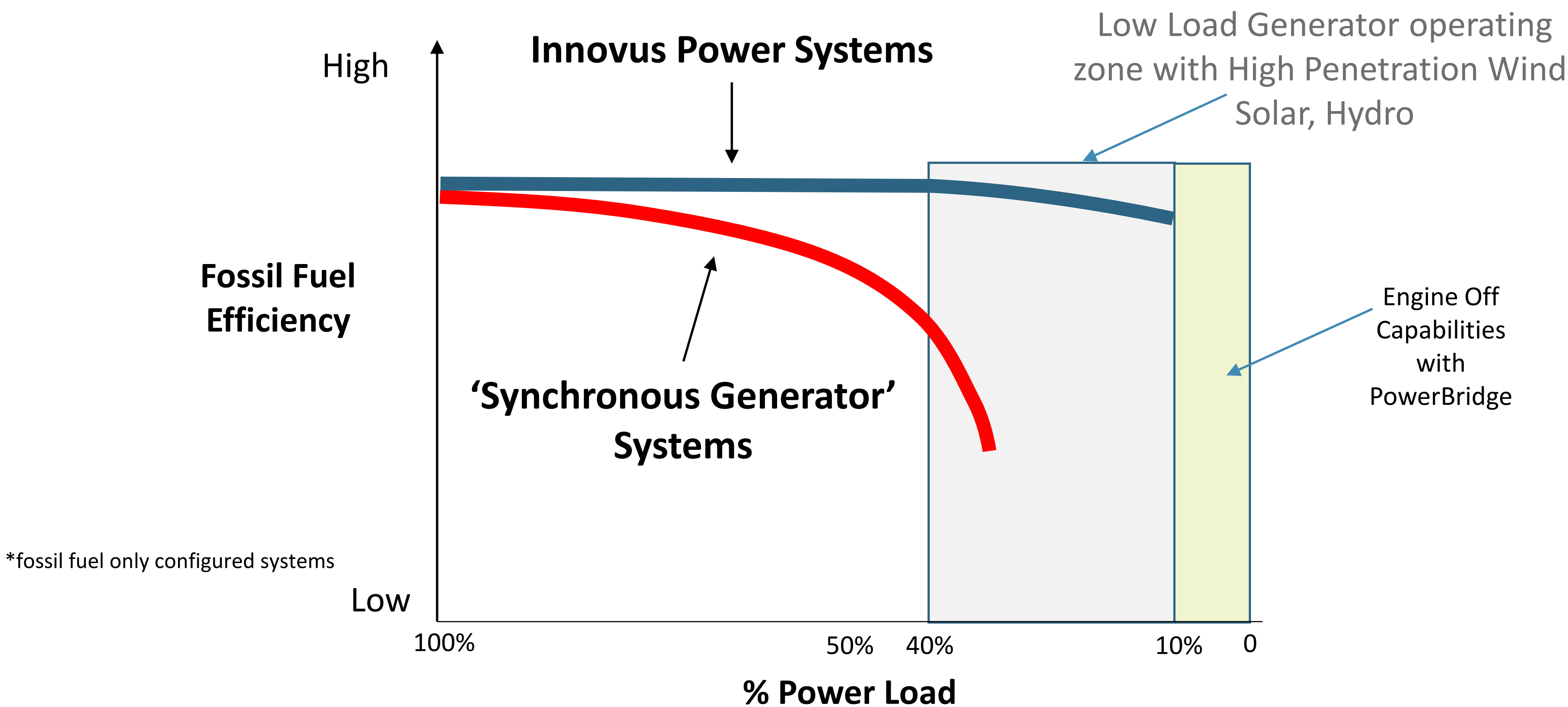
Innovus Platform- Disruptive Generator Performance



- Low loading 10% reduces storage requirements
- Innovus is highly fuel efficient at all power loads
- Capital needs drop by 60-70% compared to Battery based systems
- Perfect compliment for Renewables

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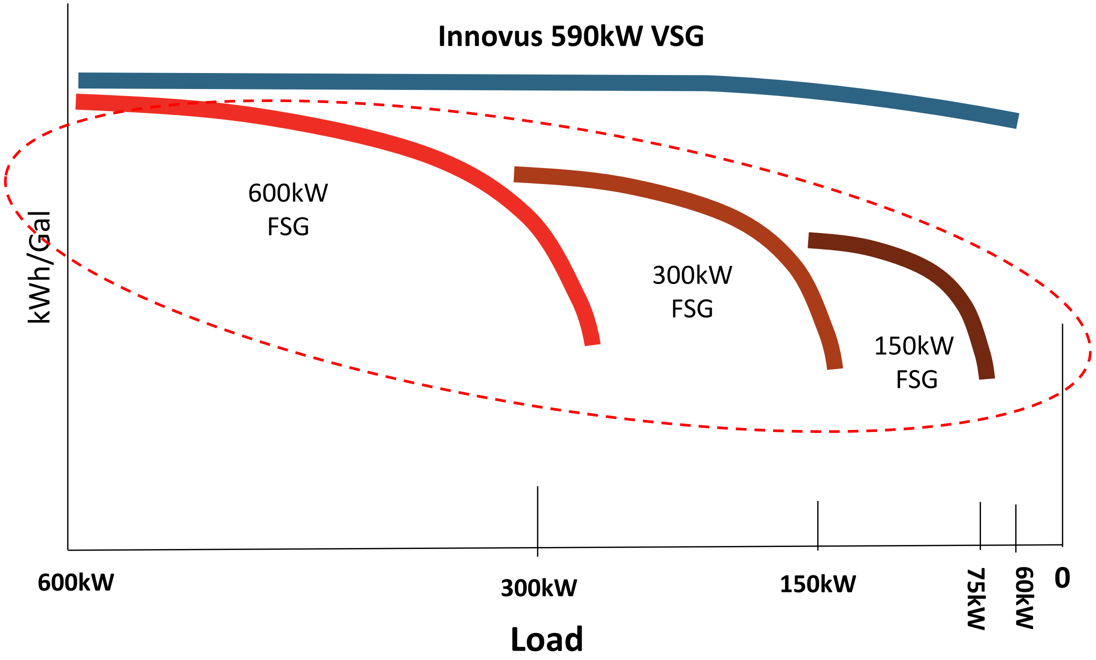
Innovus Platform - Disruptive Capability & Simplicity

No need to operate multiple generators to manage Peak efficiencies

- **VSG does the job of 3 FSGs**
- **Fleet simplification, reduced sku, training, parts**



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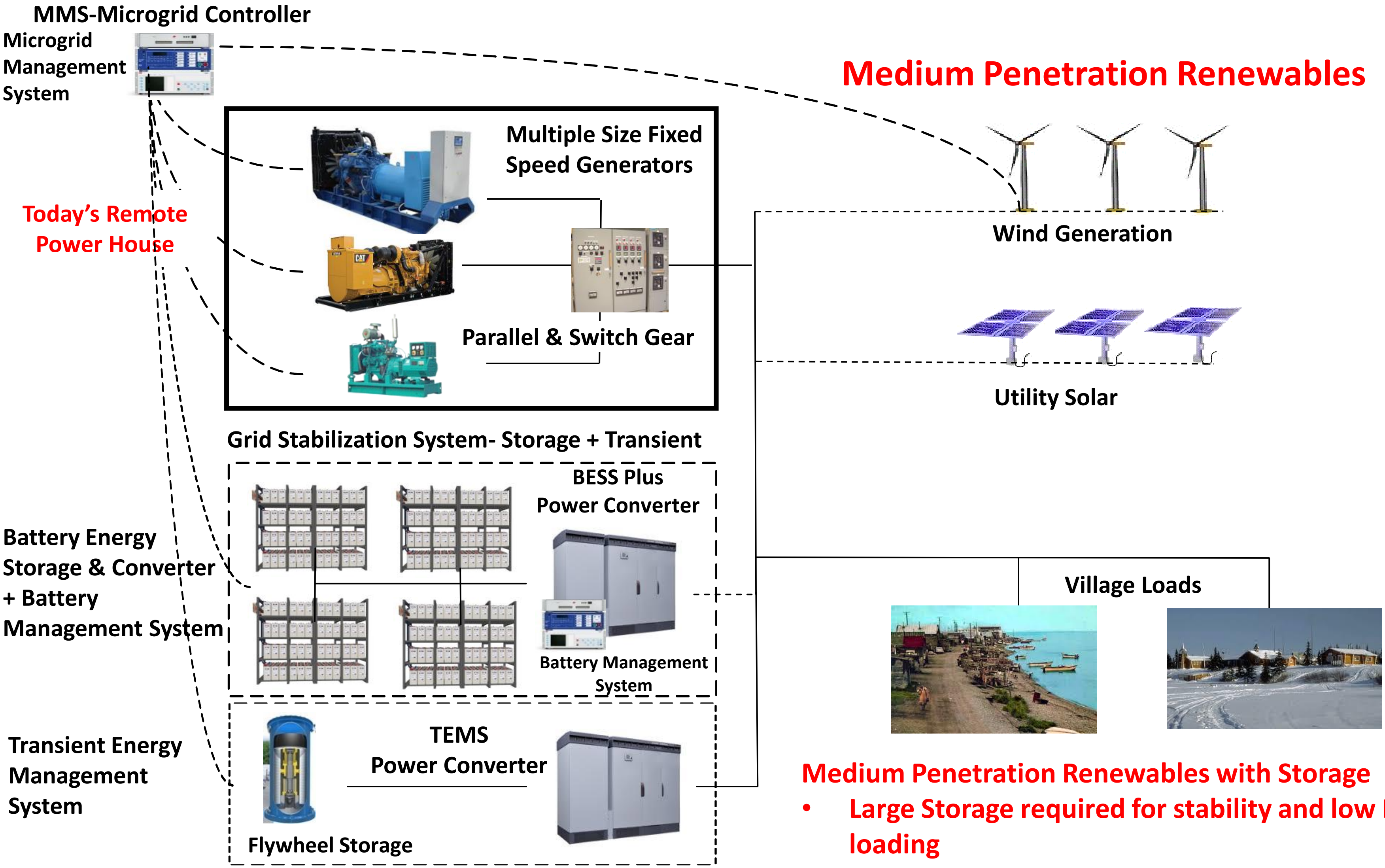
Status Quo- High Cost Complex Renewable Microgrid



Medium Penetration Renewables with Storage

- Large Storage required for stability and low FSG loading
- BESS, BMS, TEMS & MMS extremely Costly
- 5-8 Vendors, system custom built at site
- Who owns power delivery?
- High Cost, High LCOE
- Complex system

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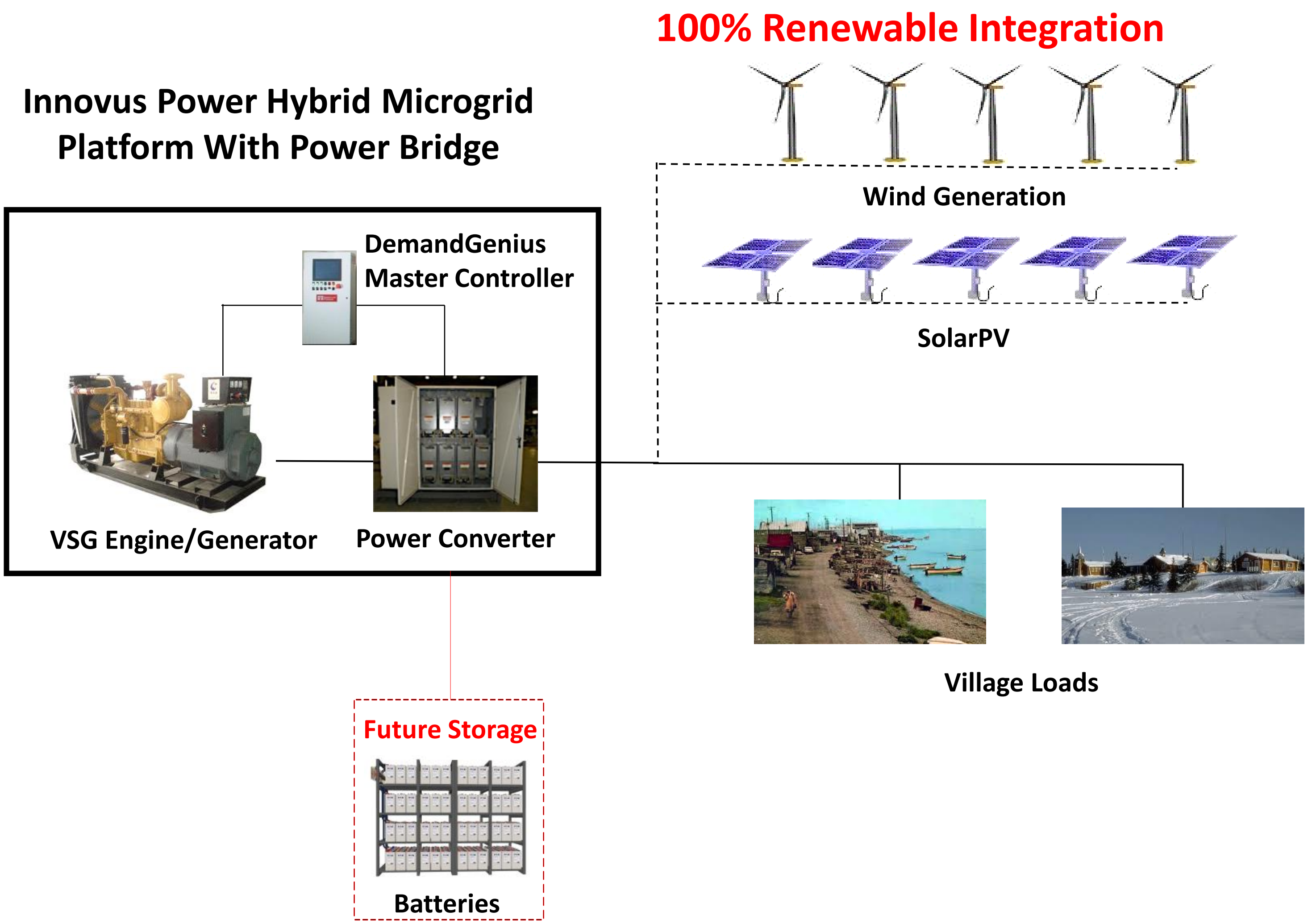
Innovus Enabled with High Penetration Renewables



Innovus Microgrids deliver the lowest LCOE and Emissions

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WISE Follow up and Comparison to WWF Report

- WISE completed follow up Study utilizing Innovus Power technology
- Results are Convincing

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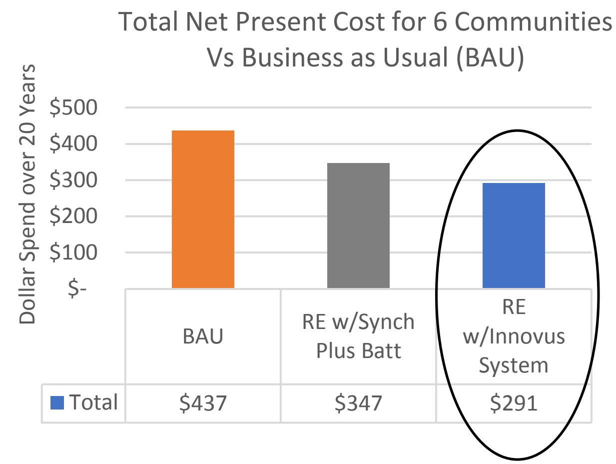
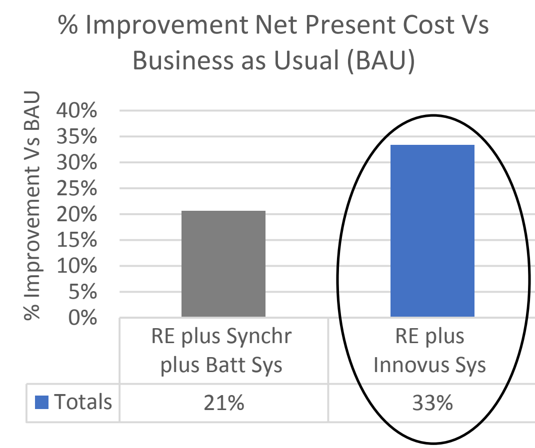
Innovus – Optimal results

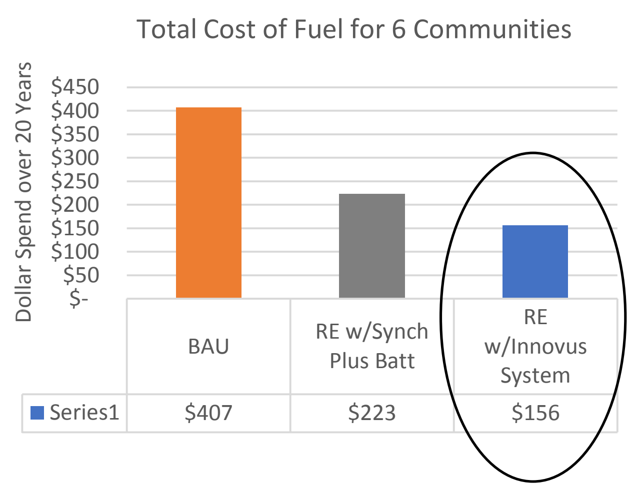
The Innovus System with Renewables cuts Fuel Burn by 62% Vs Business-as-Usual (BAU) and Superior to Synchronous Generator Based Microgrids

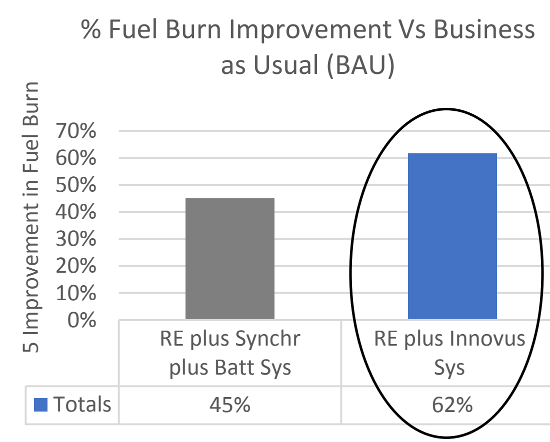
In addition to NPC and Fuel Cost Superiority, the Innovus Advantage includes:

- Up to 30.37% more GHG Reduction
- $56M Less NPC
- $67M Less in fuel
- 3392 kW more Renewables integrated
- 385kW less generation capacity required
- No Storage required unless Time Shifting can be economically justified









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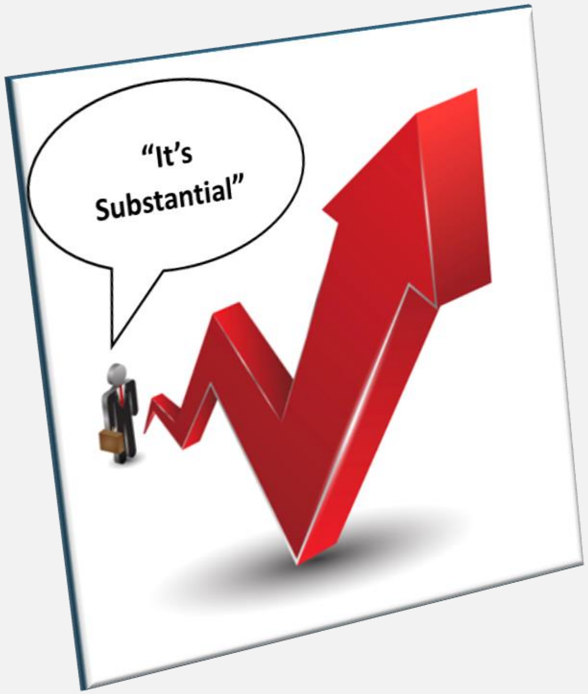
The Market: Large and Growing Rapidly

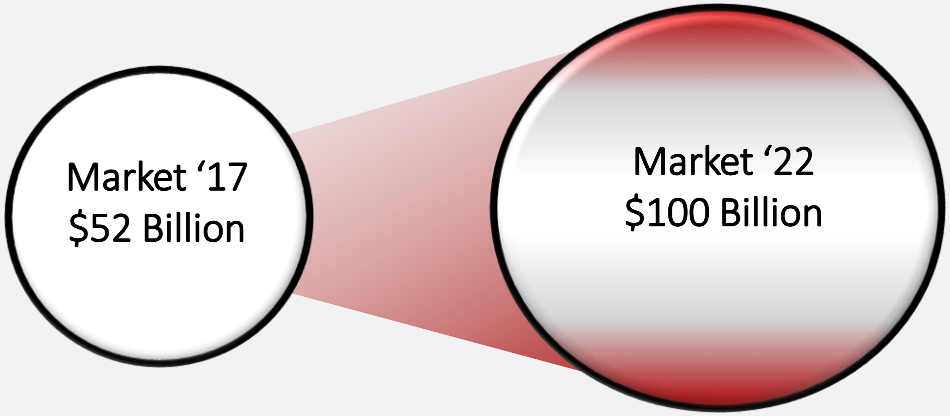


Generator Sales (‘17 & ‘20)

(100kW to 25MW)

2016 (Estimated)

2020 (Estimated)



Multiple Addressable Verticals

Communities

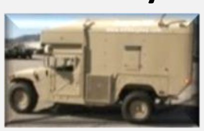
C&I

Mining

Oil & Gas

Construction

Military



US & EU Grid

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The Revolution in Power Generation starts in 2017

Northwest Territories Power Corp is replacing their Synchronous Generation System with the Innovus Power Platform in Aklavik, NWT Canada

Peak Rating: 590 kW Prime Power

Installation: November 2017

System Configuration: Diesel Generation with Solar

Solar: Low Penetration 1st Phase

Planned Renewable additions: Solar will be added to full Penetration as funding available

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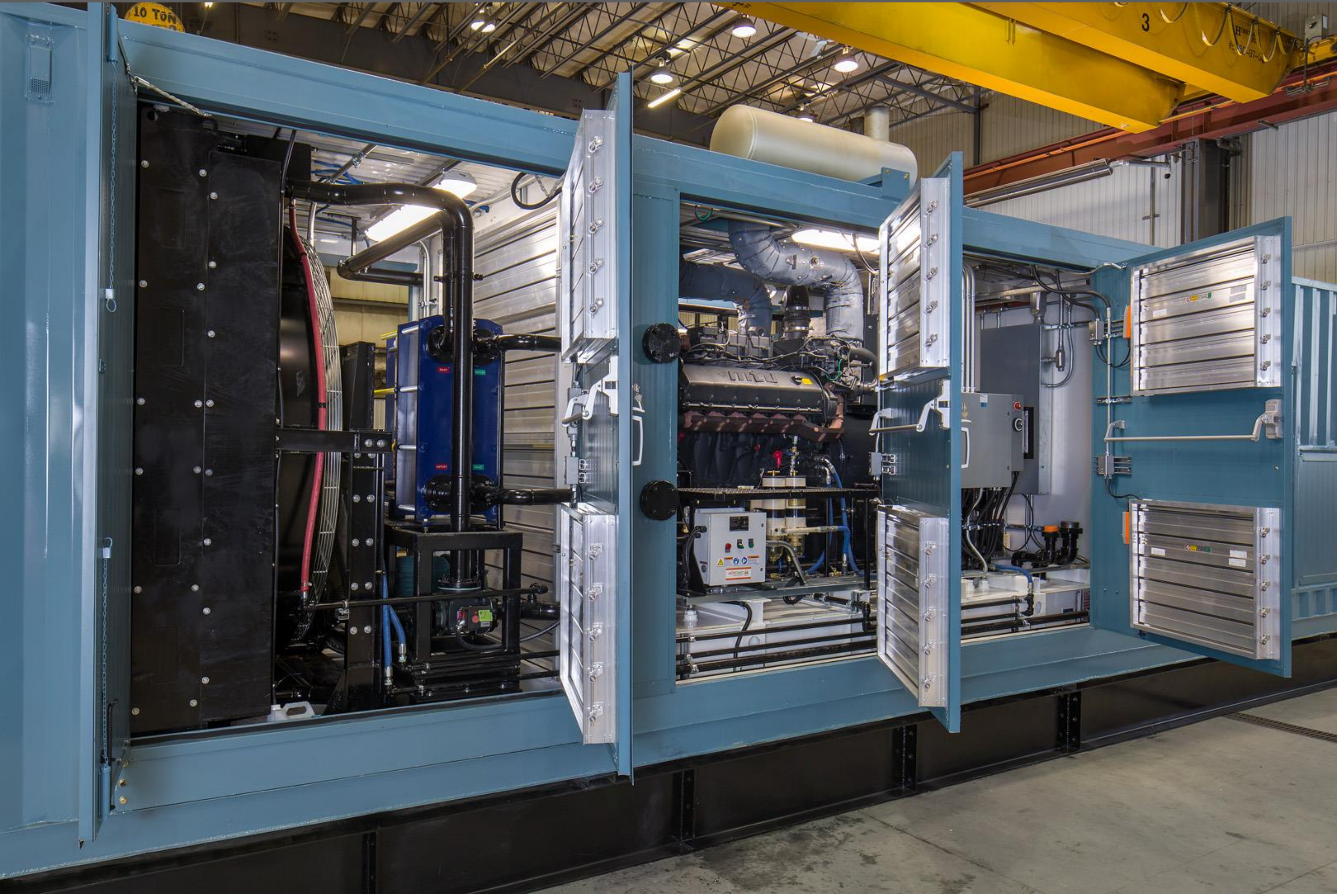

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The Future Backbone for Distributed Power

Thank you
Paul Pauze

Presentations by Technology Developers

Julie Morin

Internet of things

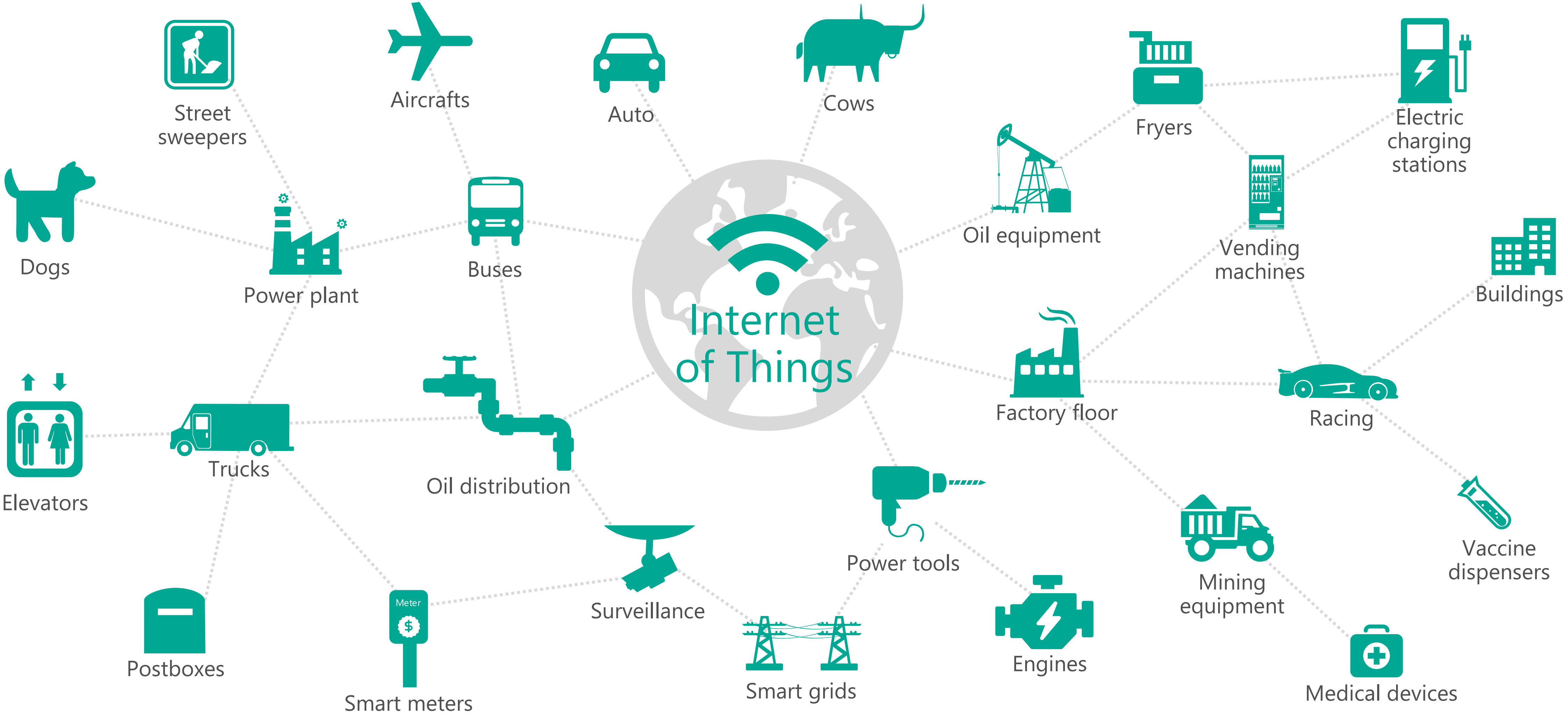
Global Black Belt Team

Microsoft Canada

Digital Transformation with Azure IoT

Julie Morin
Solution Sales Professional – Julie.Morin@Microsoft.com
IOT Sales Lead Canada- Global Black Belt Team
Julie.morin@Microsoft.com

Innovation at work – real world IoT use cases



Microsoft Confidential

IoT is already delivering tangible results

Johnson Controls

Chillers now run **9x faster** than unconnected equipment, avoiding more than **$300,000** in hourly downtime costs

thyssenkrupp

Gathers data from sensors and systems to create valuable business intelligence and **reduce downtime by 50%**

Rolls-Royce

Cutting fuel usage by 1% could save **$250,000 per plane per year**

Rockwell Automation

Improves **access** to production and supply chain **data** worldwide, reducing downtime costs by as much as **$300,000 per day**

Leading organizations empowering their businesses

Turning Data into Insight at massive scale

TransAlta was looking for more effective and scalable ways to turn the massive volumes of data they capture from their power generation facilities into insight. When you are dealing with the volume and velocity of data that is present in the power generation industry, you need a highly scalable data infrastructure – which is why the Azure cloud was a perfect fit for TransAlta’s roadmap.

Operational Insights from untapped resources

A large Canadian based heavy equipment dealer wanted to do was help their clients improve efficiency and utilizations of their operations. They have access to a vast amount of data from machine sensors on their customer fleets, so they leveraged IOT and advanced analytics capabilities to build a digital service around this data. then offer to their customers this in addition to the physical assets themselves

Data processing at massive scale

NavCanada is Canada’s Air Navigation Service Provider, managing over 12 million aircraft movements per year over a territory of 18 million square kilometers. NavCanada is leverage IoT and advanced analytics capabilities to derive new and innovative insight from the aircraft they monitor and guide safely through Canadian airspace at massive scale.

Azure IoT Suite

- Device Connectivity & Management
- Data Ingestion and Command & Control
- Stream Processing & Predictive Analytics
- Workflow Automation and Integration
- Dashboards and Visualization
- Preconfigured Solutions
  - Remote Monitoring
  - Predictive Maintenance
  - Connected Factory (new)

Microsoft Confidential

Benefits of Azure IoT Hub

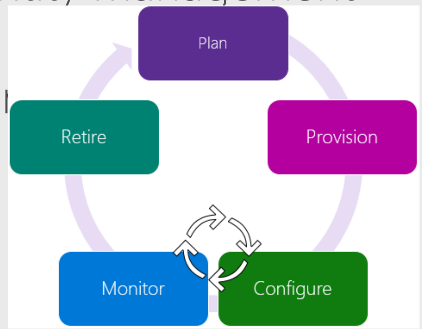
Designed for IoT to multi-scale
- Connect, monitor and manage millions of devices

Security
- Individual device identities and credentials
- Per-device security keys
- Device Identity Composition Engine (DICE)
- Hardware Security Modules (HSMs)
- X.509 via AMQPS/HTTPS/MQTTS
- IP Filter to reject/accept specific IP addresses

Cloud-scale messaging
- D2C, C2D, File transfer & Request/Reply methods
- Durable messages
- Device management: twin/methods/query/jobs
- Declarative message routing

Cloud-facing feedback
- Delivery receipts, expired messages
- Device communication errors

Operations Monitoring
- Monitor device connectivity and device identity management events
- Provision by Location, Customer, Applicatio
- Set firmware and twin state
- Zero touch provisioning



Connection multiplexing
- Single device-cloud connection for all communications (C2D, D2C)

Multi-protocol
- Natively supports AMQP, HTTP, MQTT
- AMQP/MQTT over WebSocket
- Designed for extensibility to custom protocols

Multi-platform
- Device SDKs available for multiple platforms (e.g. RTOS, Linux, Windows, iOS, Android)
- Multi-platform Service SDK

Azure IoT: Ready for the enterprise

Secure
End-to-end

From the endpoint, through the connection, to data, applications, and the cloud

Fast
Start in minutes

Preconfigured solutions for the most common IoT scenarios

Open
Connect anything

Any device, OS, data source, software, or service

Scalable
Grow effortlessly

Millions of devices, terabytes of data, on-premises, in the cloud, in the most regions worldwide

Things — Control — Insights — Action

From endpoint to insight to action, across the enterprise, and around the world

Recognized as a **leader in Business Intelligence and Analytics Platforms**
Recognized as a the **leading visionary for Internet of Things platforms**

Built on the **industry's leading cloud**

When everything is digitally connected, how can you leverage the data that is available to …

Reduce energy consumption

Optimize Building Utilization

Improve air, water quality,

Schneider Electric uses Microsoft Azure IOT https://youtu.be/-BjV5Xf2QK4

Microsoft

Solutions for Energy Smart Buildings

Energy Consumption & Tracking

Real-time Fault Detection

Visualization & Dashboards

IoT Connected Solutions

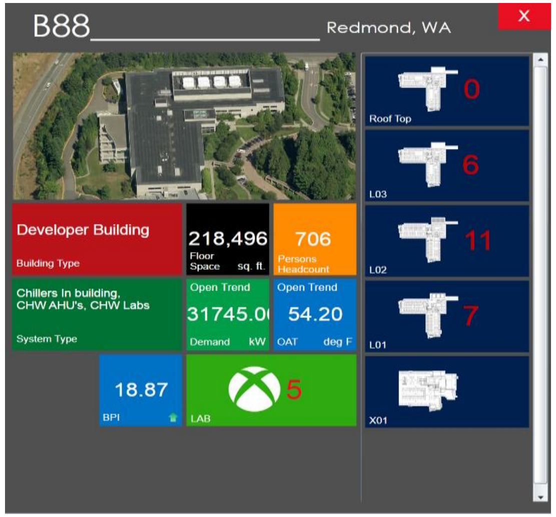
Advanced Analytics Solutions for Energy-Smart Buildings

A complete, flexible, cost-effective approach to Digital Transformation

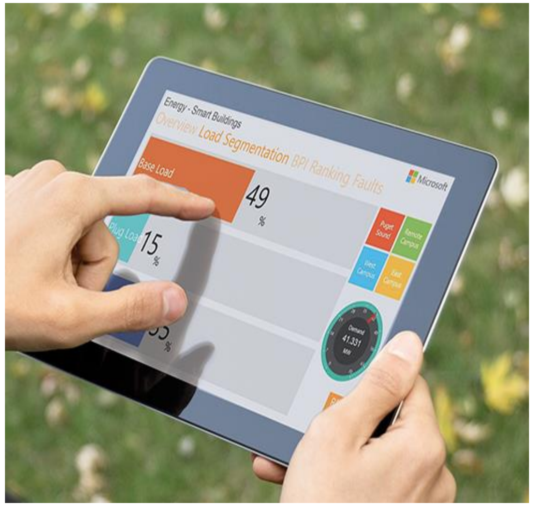
Microsoft Energy-Smart Buildings

Universal Connectivity

- **BACnet**
  - Siemens
  - Alerton
- **Modbus**
  - SquareD PowerLogic
- **SNMP**
  - Generators, PDU, UPS



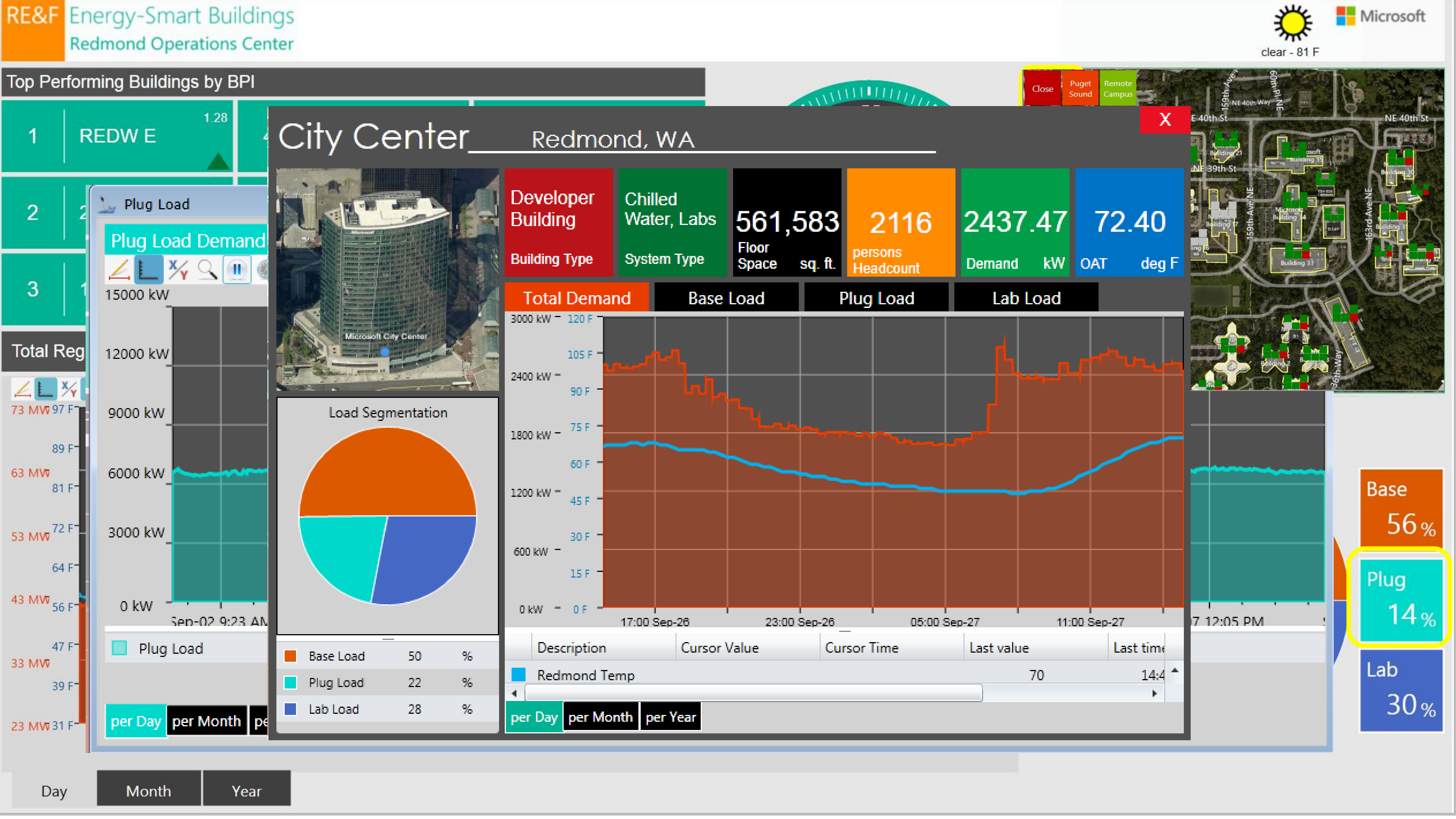
- Real-time Dashboards
- Energy Reporting
- Fault Detection & Diagnostics
- Condition Based Maintenance
- Mobile Solutions



Energy-Smart Buildings

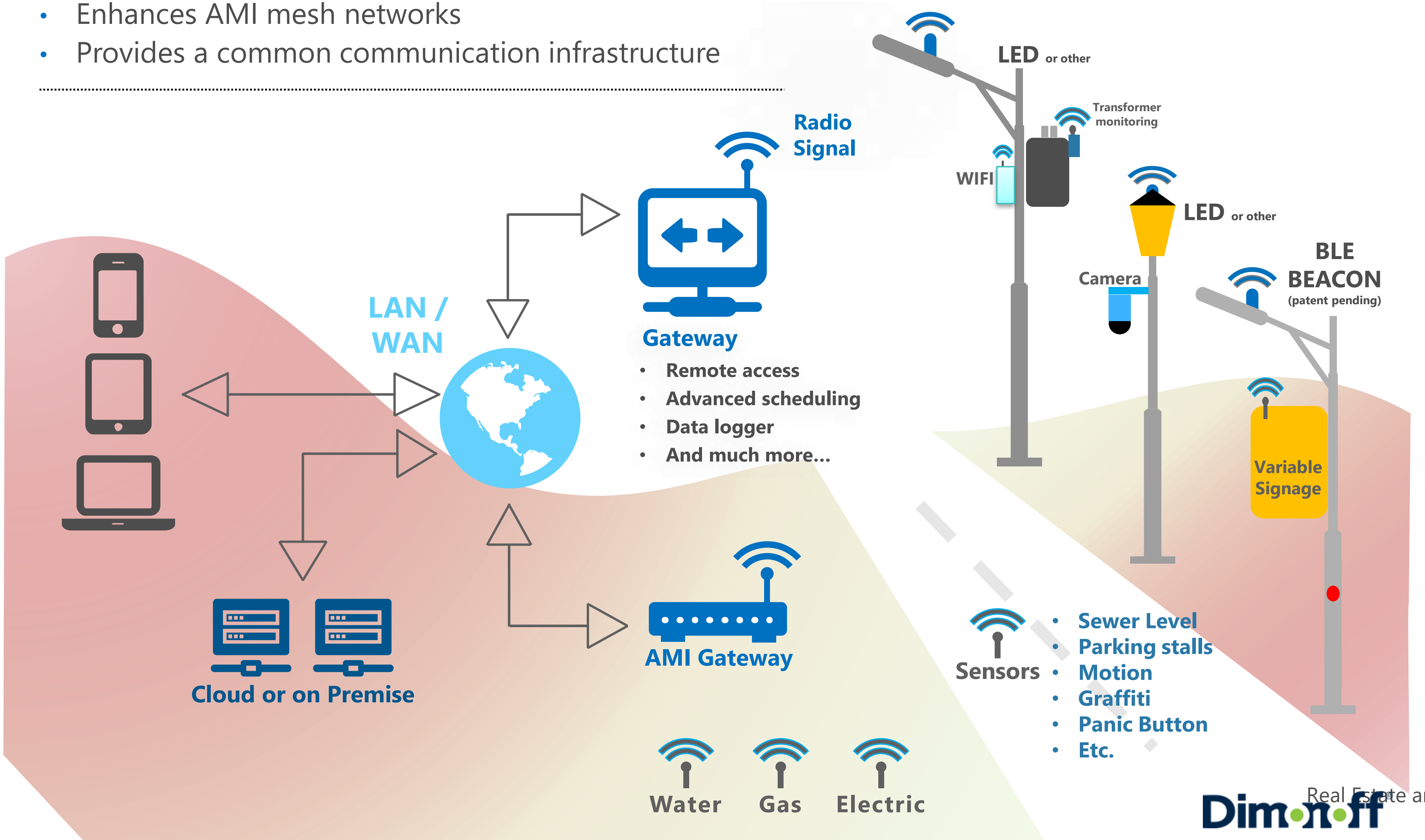
Redmond, WA

© 2017 ICONICS, Inc.


RE&F
Energy-Smart Buildings
Redmond Operations Center
clear - 81 F
Microsoft
Top Performing Buildings by BPI
1
REDW E
1.28
2
3
Total Reg
Plug Load
Plug Load Demand
15000 kW
12000 kW
9000 kW
6000 kW
3000 kW
0 kW
Plug Load
per Day
per Month
City Center
Redmond, WA
Microsoft City Center
Developer Building
Building Type
Chilled Water, Labs
System Type
561,583
Floor Space
sq. ft.
2116
persons Headcount
2437.47
Demand
kW
72.40
OAT
deg F
Total Demand
Base Load
Plug Load
Lab Load
3000 kW
2400 kW
1800 kW
1200 kW
600 kW
0 kW
120 F
105 F
90 F
75 F
60 F
45 F
30 F
15 F
0 F
17:00 Sep-26
23:00 Sep-26
05:00 Sep-27
11:00 Sep-27
Load Segmentation
Base Load 50 %
Plug Load 22 %
Lab Load 28 %
Description
Cursor Value
Cursor Time
Last value
Redmond Temp
70
per Day
per Month
per Year
Close
Puget Sound
Remote Campus
NE 40th St
NE 39th St
Base 56 %
Plug 14 %
Lab 30 %
Day
Month
Year

Typical System Infrastructure

- Access every fixture, optimizing time and lights levels
- 2-way communications, including statuses and metering
- Enhances AMI mesh networks
- Provides a common communication infrastructure



Dimonoff

Agriculture uses 70 % of the world's available fresh water

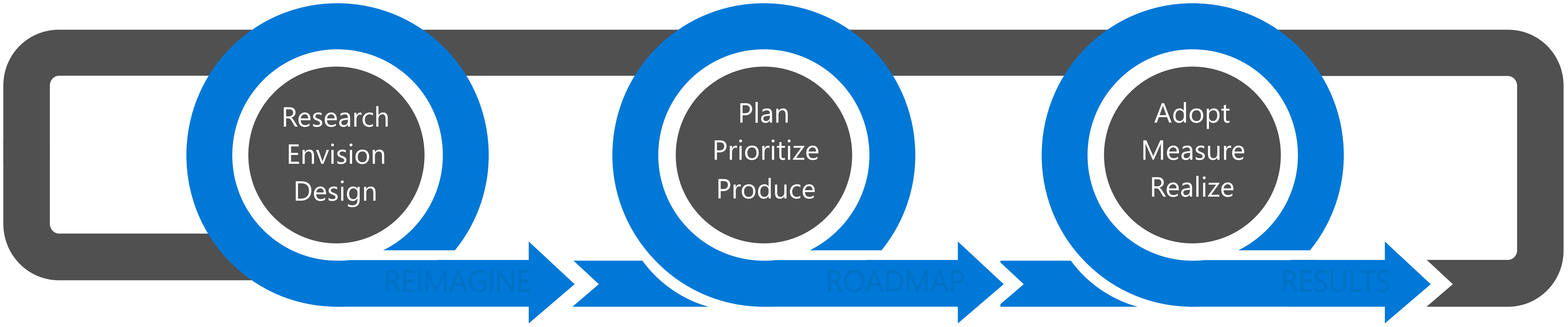
A shrinking supply with a growing demand increase by 55 % in the next three decades.

Microsoft

Microsoft Confidential

Video – https://youtu.be/1jh1qJu9_Zk

Our approach to digital transformation



Imagine and envision the art of the possible through business, technology, and experience perspectives in parallel.

Build the desired state to get from where you are to where you desire to be.

Business value and outcomes delivered that result in business performance improvement.

Microsoft Confidential

The world is now a network. Operations are transforming. How do you harness the power of digital to ...

Increase agility and reduce costs?

Innovate faster for competitive edge?

Serve your customers in new ways?

Microsoft

Thank You

Presentations by Technology Developers

Alif Gilani

Head
Engineering
Energy Management Division
Siemens Canada

SIEMENS

Ingenuity for life

The Future of the Energy System:
With Distributed Energy Resources & Microgrid Control

WISE – Nov 9th, 2017

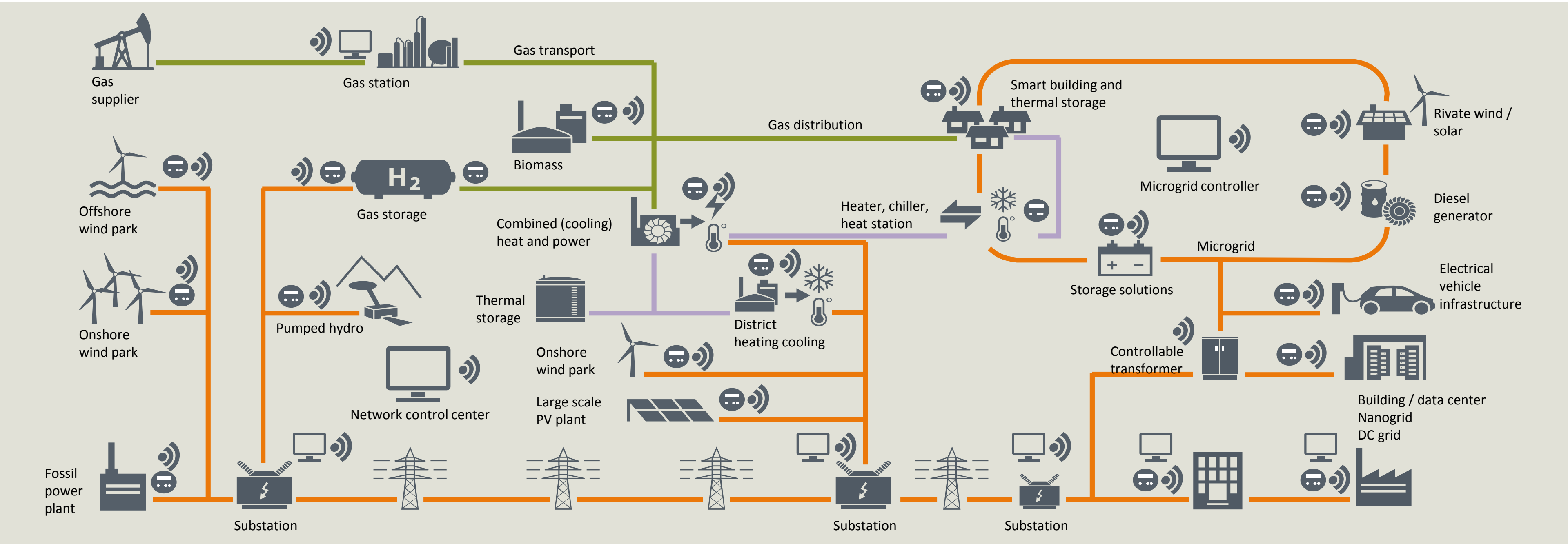
Alif Gilani

• Unrestricted © Siemens AG 2017

Agenda

1. Macro – Global Trends
2. Micro – Use Case Analysis
3. Distributed Energy System Solutions
4. Outlook

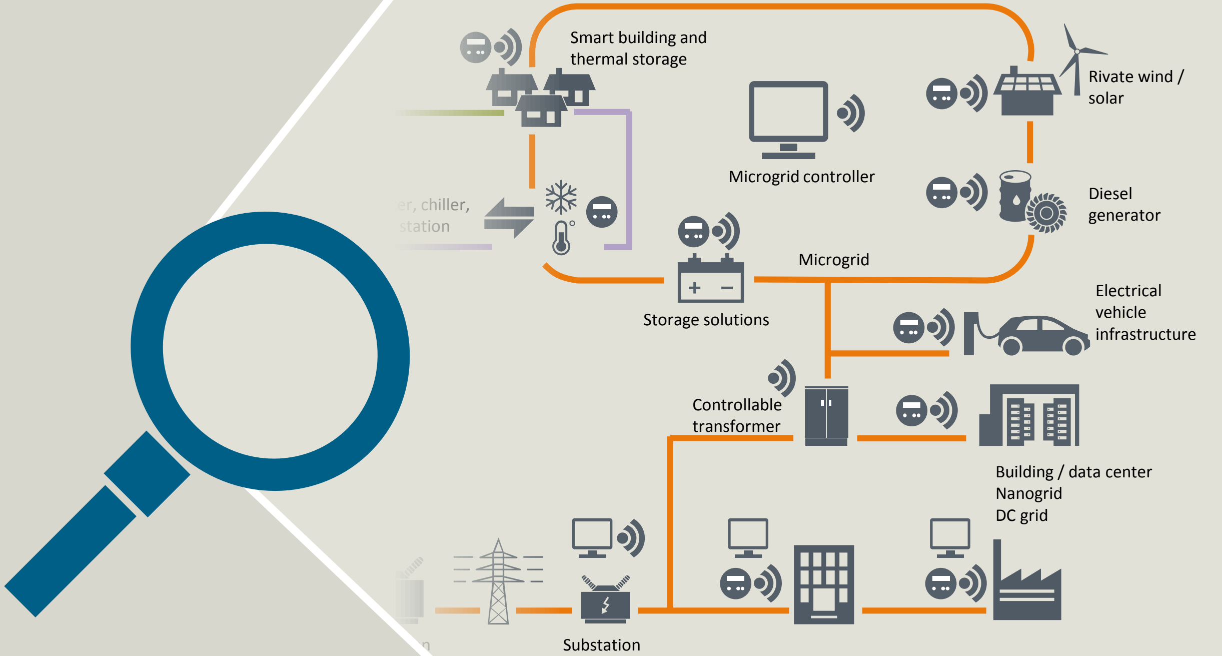
Centralized – Unidirectional → Decentralized Bidirectional



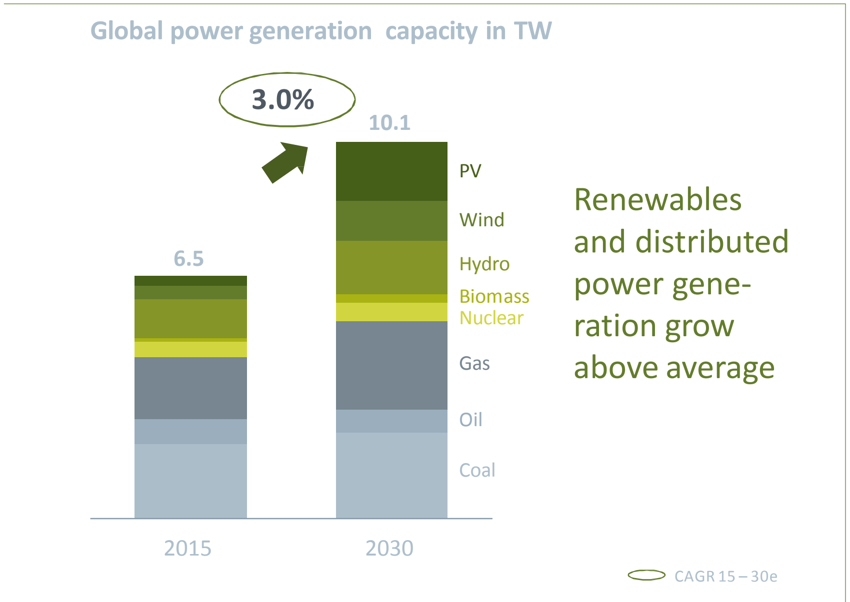
1 Changing Generation Mix	**2** Generation Capacity Additions	**3** Distance from Source to Load	**4** Decentralization (Public/Private)	**5** Refurbishment/ Upgrades

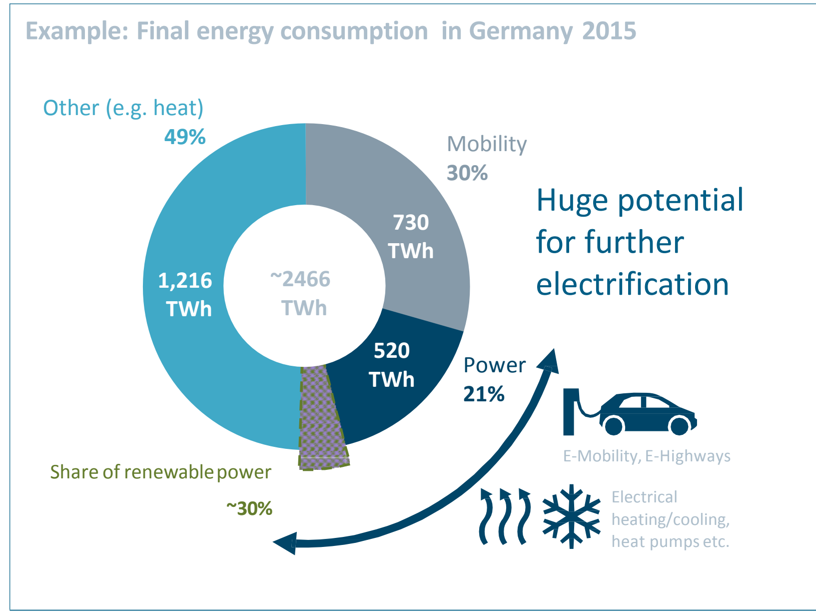
Value Propositions

- Increased Reliability
- Reduced Energy Costs
- Improved Grid Resilience
- Lower Emissions
- Enhanced Control
- Financed Solutions



Increasing electrification in all sectors
Heading towards an all electric world

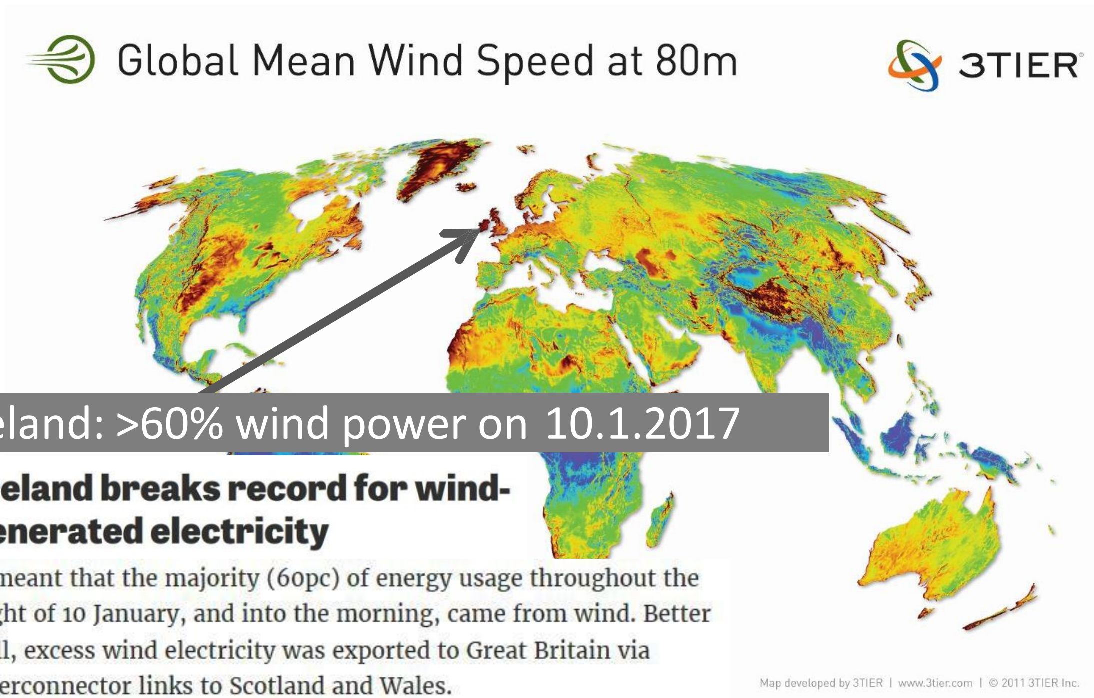




Source: Siemens Energy 2020 Project 2014 – Base Case Scenario

Source: umweltbundesamt.de/Arbeitsgemeinschaft Energiebilanzen, status 7/16; IHS

Global On-shore Wind Potential



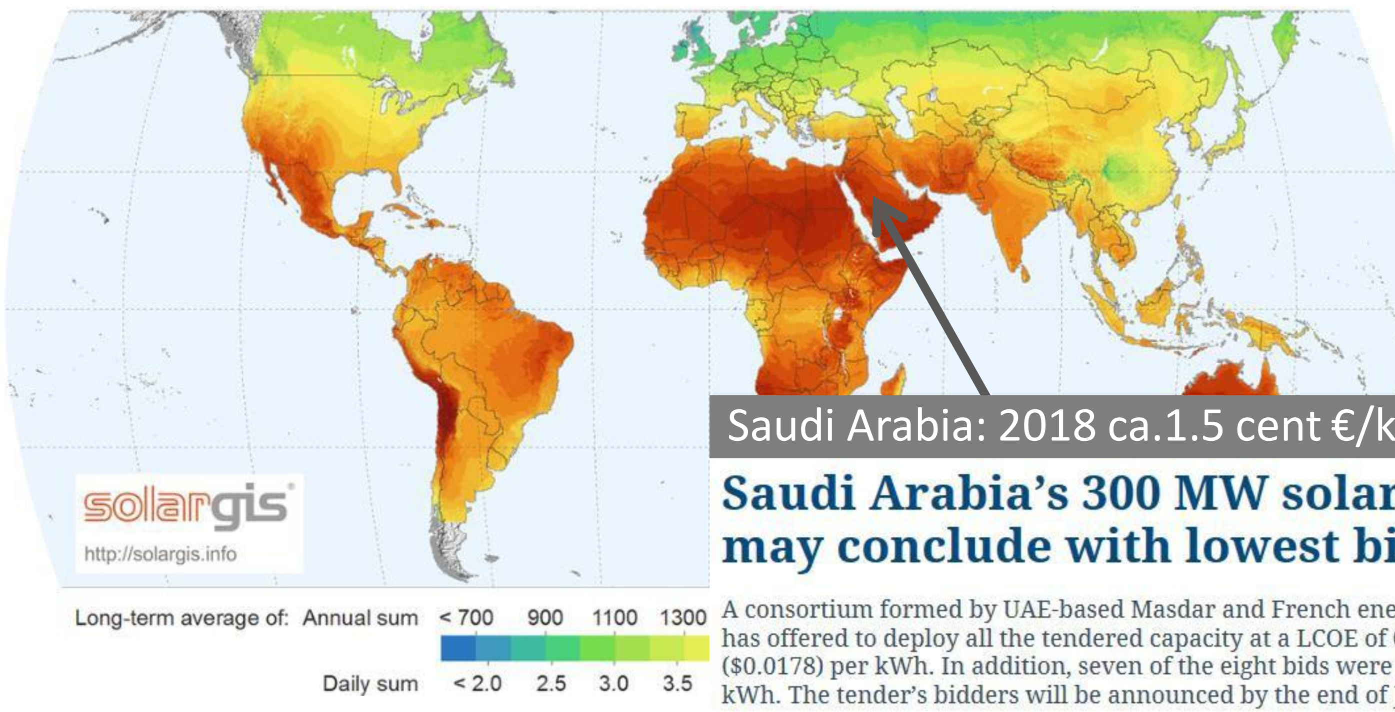
Ireland: >60% wind power on 10.1.2017

Ireland breaks record for wind-generated electricity

It meant that the majority (60pc) of energy usage throughout the night of 10 January, and into the morning, came from wind. Better still, excess wind electricity was exported to Great Britain via interconnector links to Scotland and Wales.

https://dupontconsulting.files.wordpress.com/2012/01/3tier_5km_global_wind_speed.jpg
https://www.siliconrepublic.com/innovation/irish-wind-energy-record

Global Solar Energy Yield



Saudi Arabia's 300 MW solar tender may conclude with lowest bid ever

A consortium formed by UAE-based Masdar and French energy giant EDF has offered to deploy all the tendered capacity at a LCOE of 0.06697 SAR ($0.0178) per kWh. In addition, seven of the eight bids were under $0.03 per kWh. The tender's bidders will be announced by the end of January 2018.

https://en.wikipedia.org/wiki/Photovoltaic_system#/media/File:SolarGIS-Solar-map-W orld-map-en.png
https://www.pv-magazine.com/2017/10/04/saudi-arabias-300-mw-solar-tender-may-conclude-with-lowest-bid-ever/

Agenda

Use Cases – Why build the Microgrid?

U

Grid Edge / Offgrid Load Feed
- Remote / Islanded Communities
- End of Line rural area feeds

Transmission & Distribution Capital Deferral
- Infrastructure for load extension is expensive
- End of Life Asset Replacement cost

Resiliency Play – Outage Management (I)
- Critical Infrastructure – Military Bases, Hospitals, Emergency Services
- Force Majure – Natural Disasters: Floods, Lightning, Hurricanes, Snow Storm

Ancilliary Services (R)
- In non islanded scenarios – using DERs for Volt / Var Optimization
- Frequency response
- Spinning reserve

Carbon Tax / Cap & Trade Solutions (I) (R)
- Utilizing microgrids with renewables to reduce carbon tax

Regulated Utility Business
- NPV Analysis – Recovering Against Rate Base
- Regulator Restrictions – owning DERs
- Revenue Erosion

Non-Regulated Utility Business
- New / Alternative Business Models
- Microgrid as a Service (MaaS) – PPA Agreements
- Own, Operate, Maintain (OOM) Model – DERs + Infrastructure

Demand Response (I)
- Using DERs for grid peak demand shaving / shifting
- Energy price arbitrage
- Conservation Programs – e.g. Negawatts
- Gamification

C&I Play (I) (R)
- Using PPA agreements for resiliency solutions
- Islanded operations of power critical industries

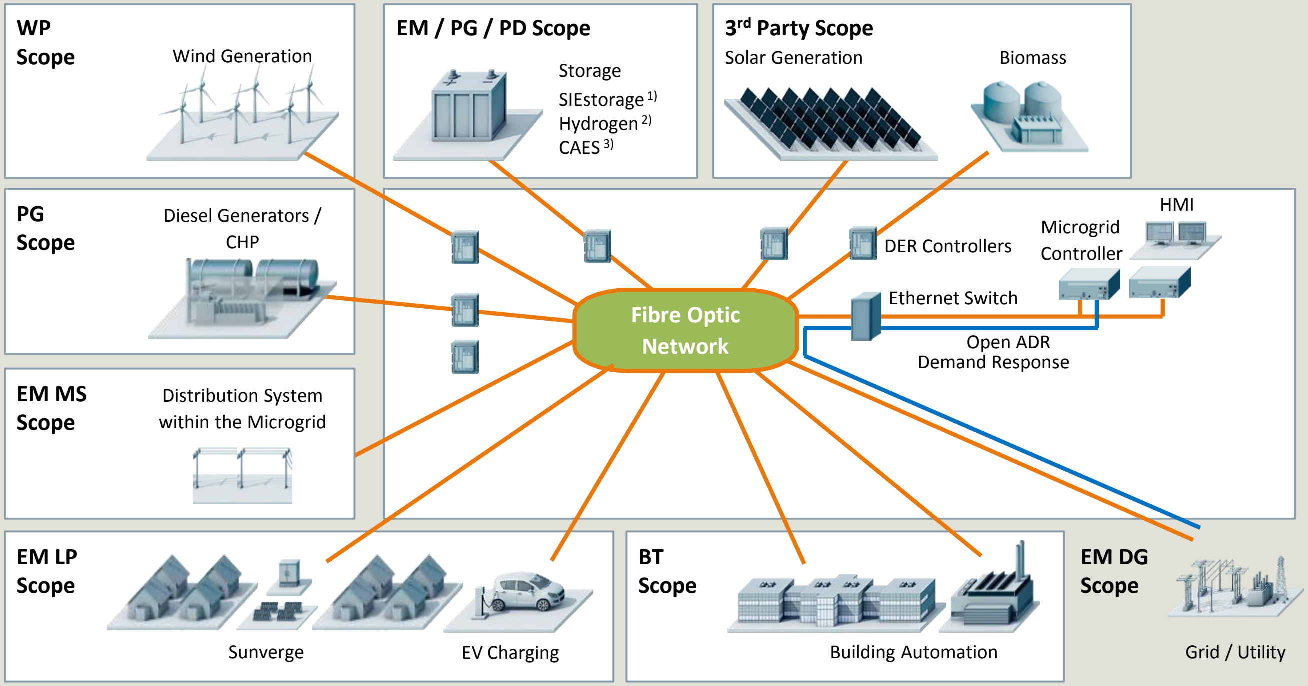
Diesel Offset (R)
- Reduction in Diesel Consumption

LEGEND U Utilities · I Industry · R Remotes · C End Customer

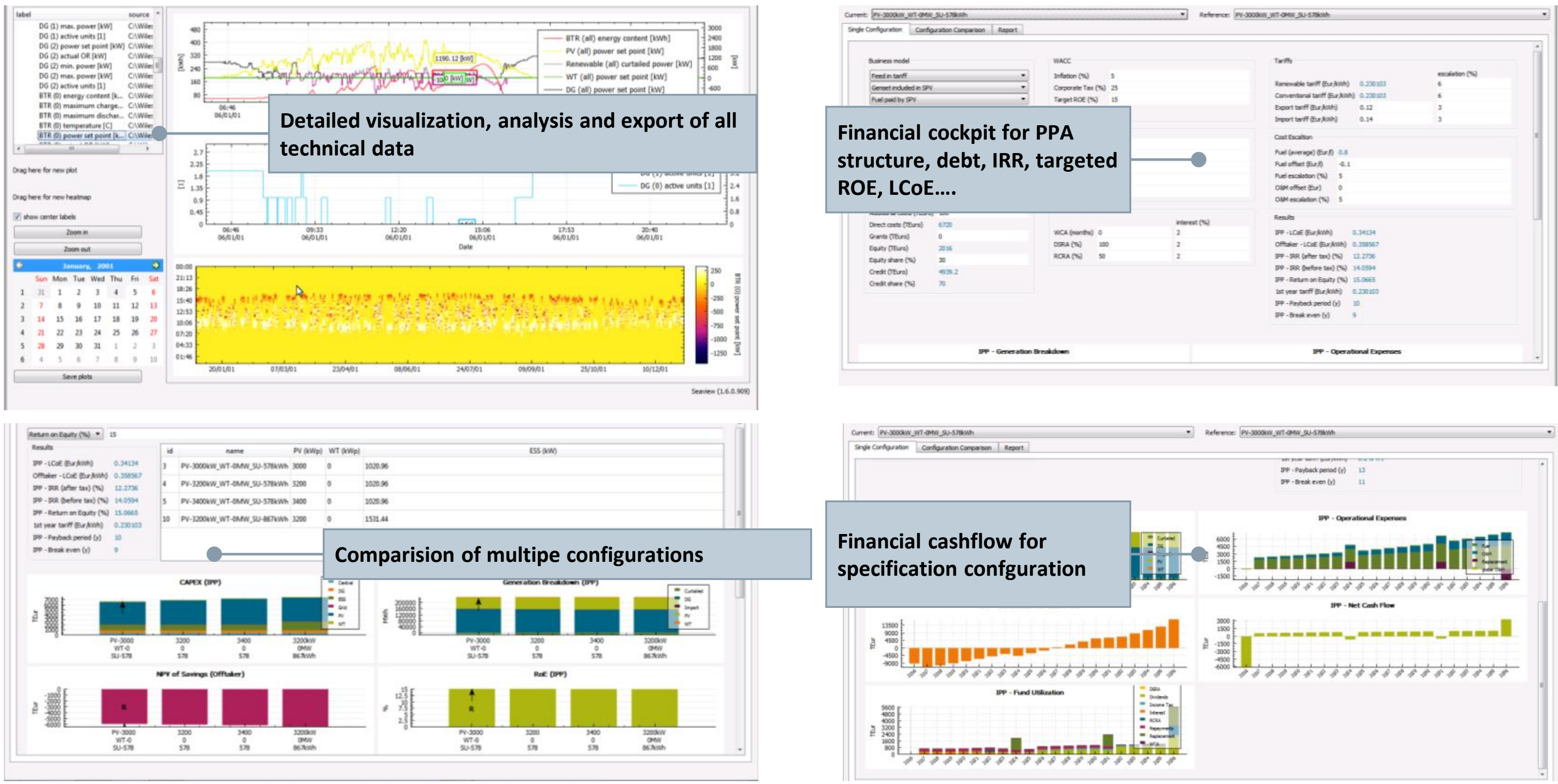
Agenda

1. Macro – Global Trends
2. Micro – Use Case Analysis
3. **Distributed Energy System Solutions**
4. Outlook

Siemens Offering – DER Portfolio



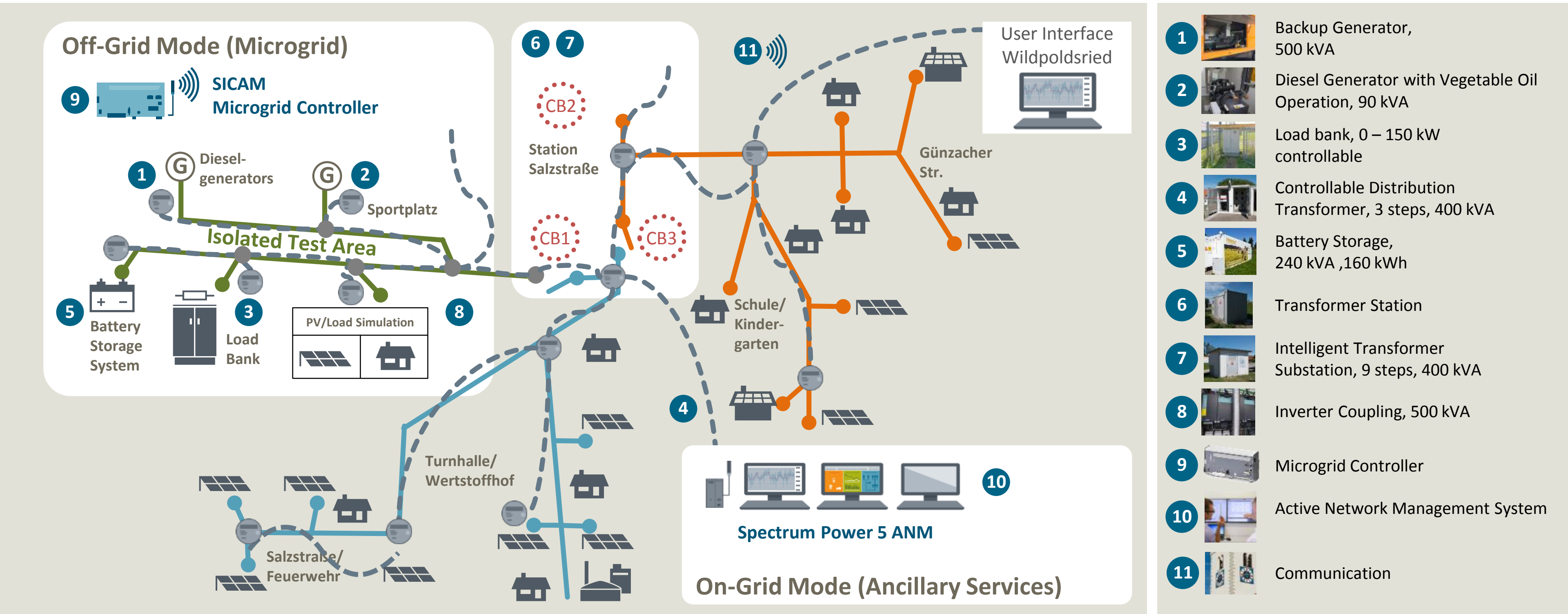
PSS DE – Energy Twin
Technical and Financial Analysis to Build Your Business Case!



IRENE Project – Wildpoldsried

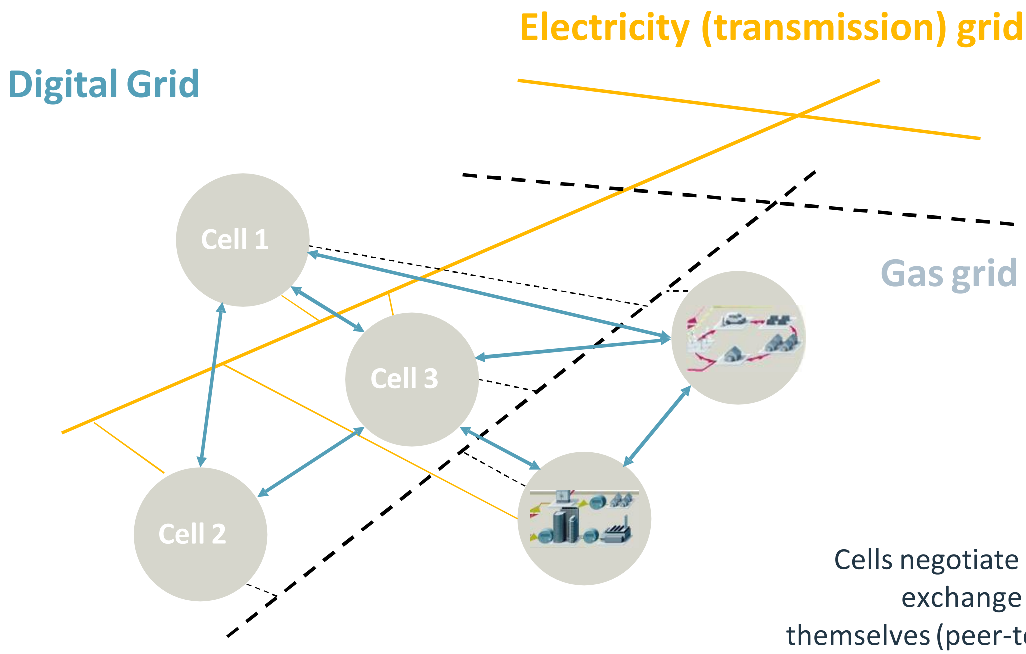
1st Microgrid of its kind outside the laboratory! 5X

LOAD



Agenda

3 Essential Grids in Context of an Energy Cell Concept



Cells negotiate energy exchange among themselves (peer-to-peer)

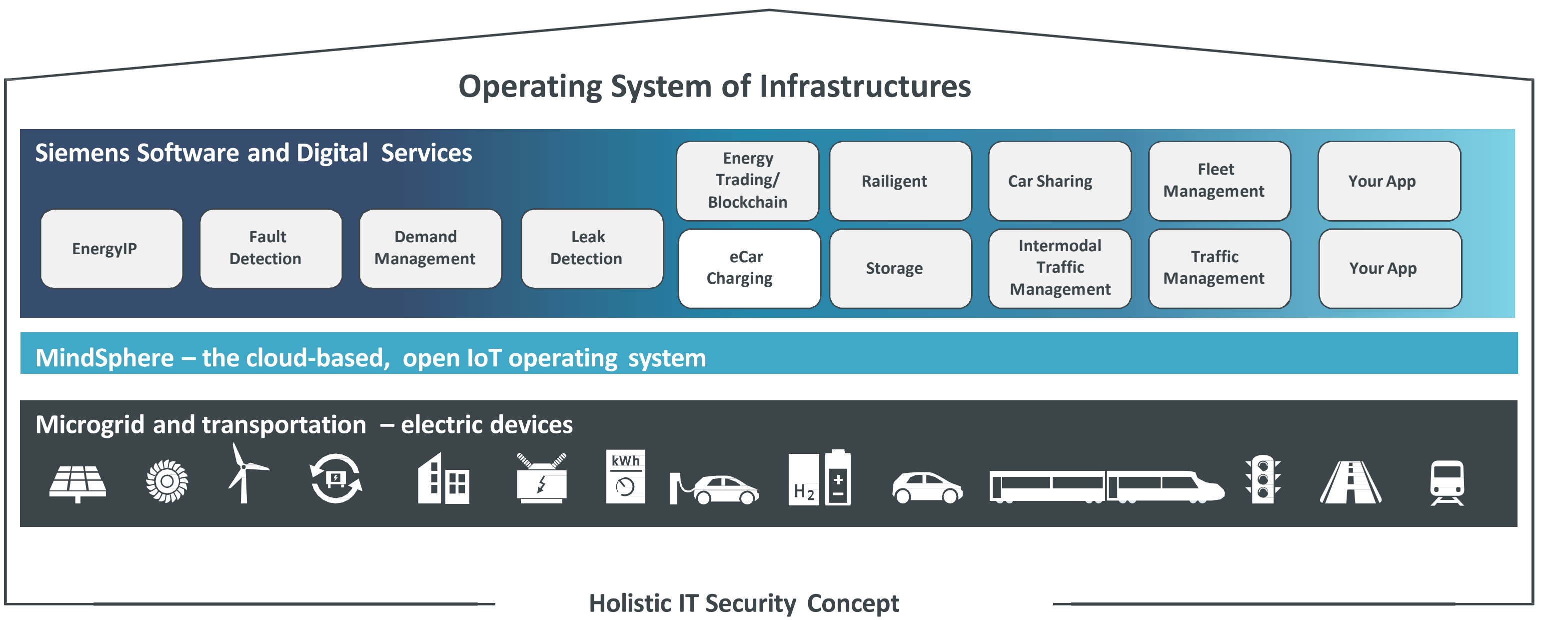
Energy cells can be

- Community
- Factory
- Power plant
- Dedicated storage facility

Energy cells contain

- Power generation
- Thermal and gas grids
- Energy storage
- Power-to-X (-value) ƒ Dynamic load control
- ƒ ICT, self-organizing, self-healing intelligence
- Resiliency
- …

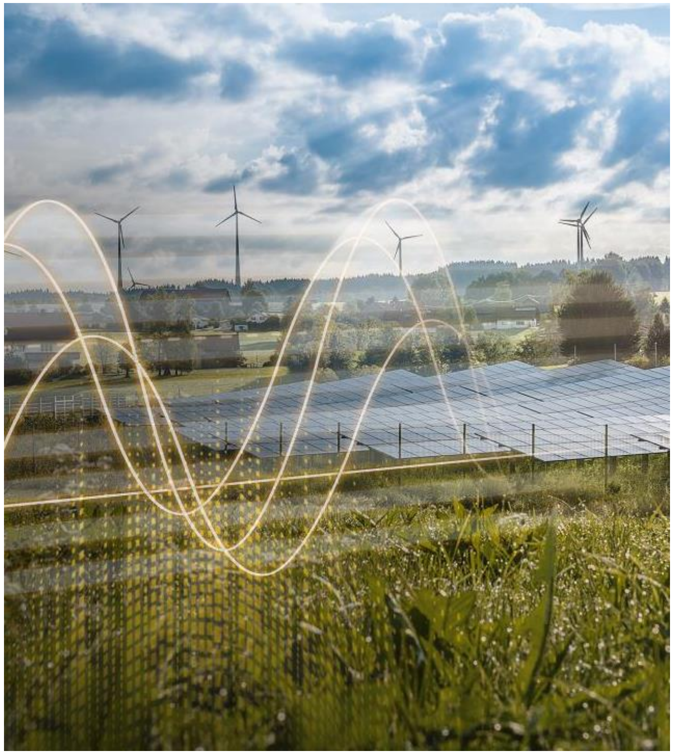
IoT Operating Systems to manage Infrastructures Example - Mindsphere



Outlook

1. More Wind- and PV, Electrification, Distributed Energy Systems
2. Sector-couplings and Energy Storage increasingly relevant
3. Digitalization key enabler (simulation, operation, market integration)
4. Emerging Sharing Economy concepts for Prosumers
5. Artificial Intelligence gaining momentum

Contact Information



Alif Gilani

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Energy Management Division

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Oakville, Ontario L6H 0H6

Mobile: (289) 208 2461

E-mail:alif.gilani@siemens.com

Backup

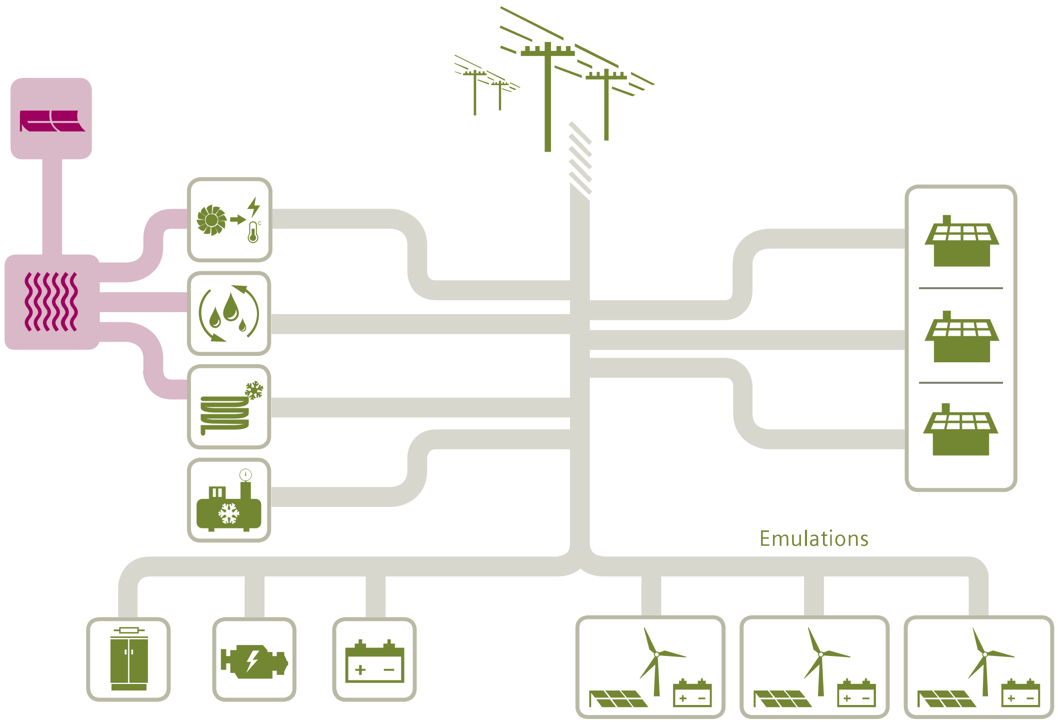
Standardizing the Microgrid Solution – Microgrid in a Box!

Microgrid in a Box Solution

Battery Energy Storage System (BESS) Inclusive of:

-Battery Management System (BMS)
-Inverter – SINACON
-Battery Racks
-Microgrid Controller Panel
-HVAC
-Fire System
-Distribution Panel

Microgrid Show Case and Test Laboratory, Erlangen / Germany

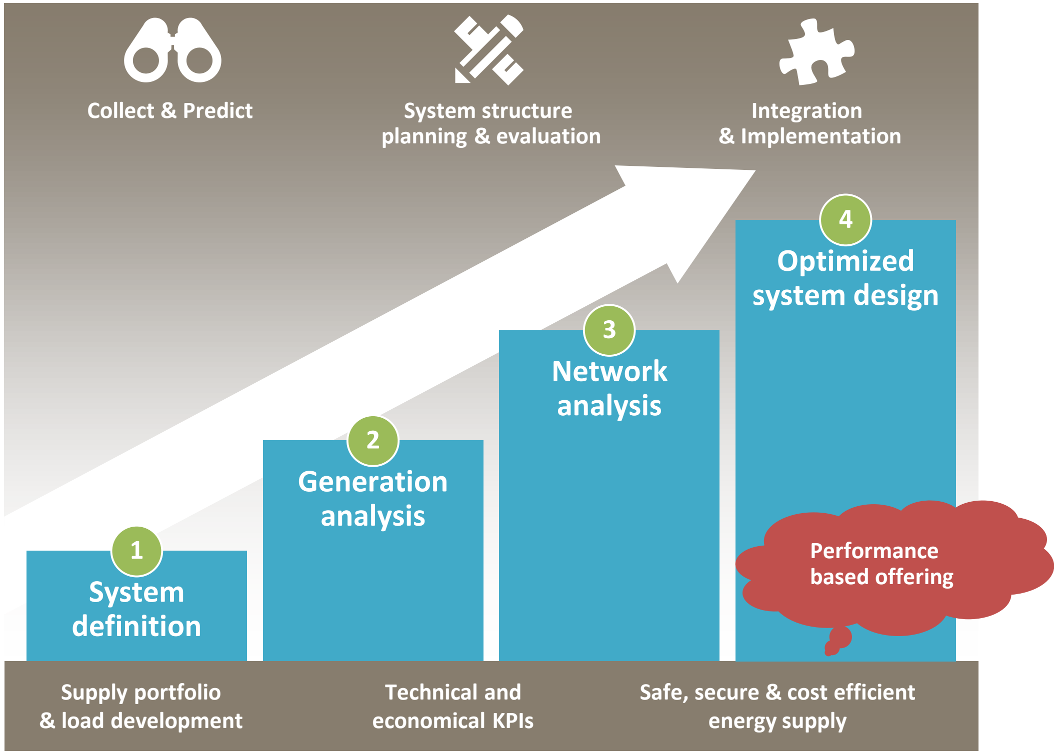


Built-in equipment for "electrical" microgrid:

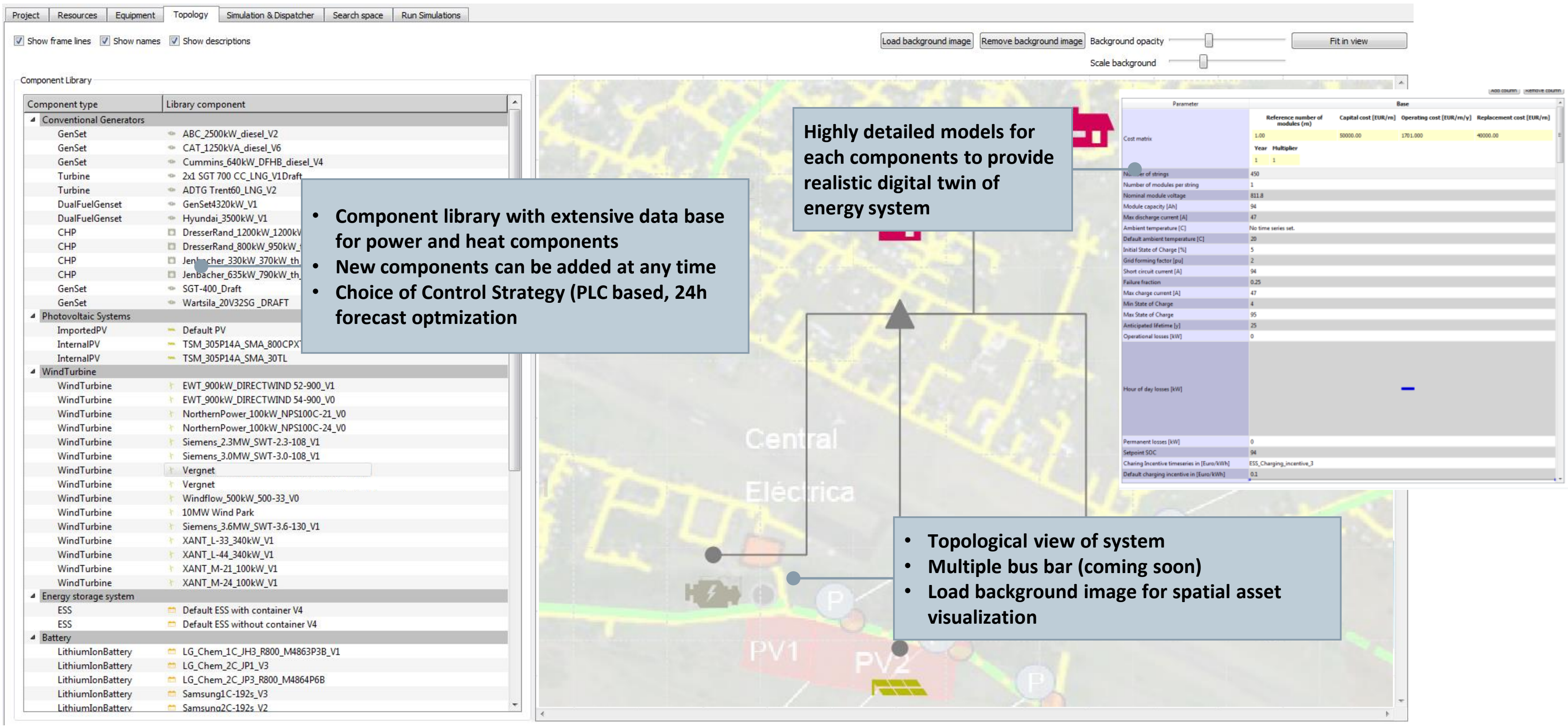
- Diesel emulation (synchronous generator)
- Battery storage systems incl. inverters
- Adjustable loads
- Inverter-based emulation systems
- Controllable distribution transformer
- Circuit breaker
- Synchronization and protection relay

PSS® DE: Proven economical distributed energy designs

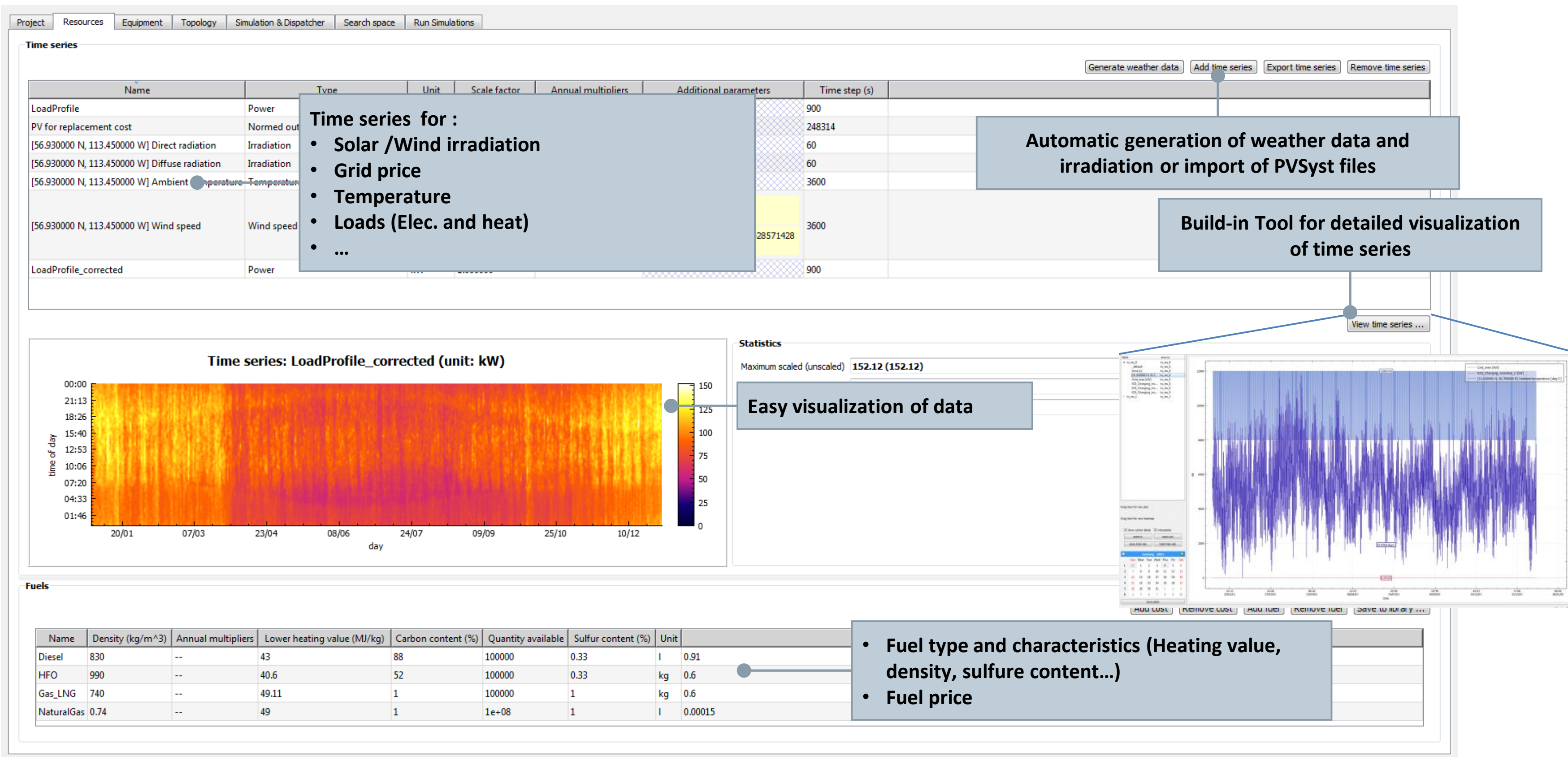
- Siemens provides an integrated approach to evaluate the technical feasibility under consideration of economical expectations
- To define an optimal, flexible and transparent solution Siemens developed PSS® DE to support planning processes from the existing system to the final optimized system design.
- This approach supports decision makers to ensure profitable business development based on technical resilience



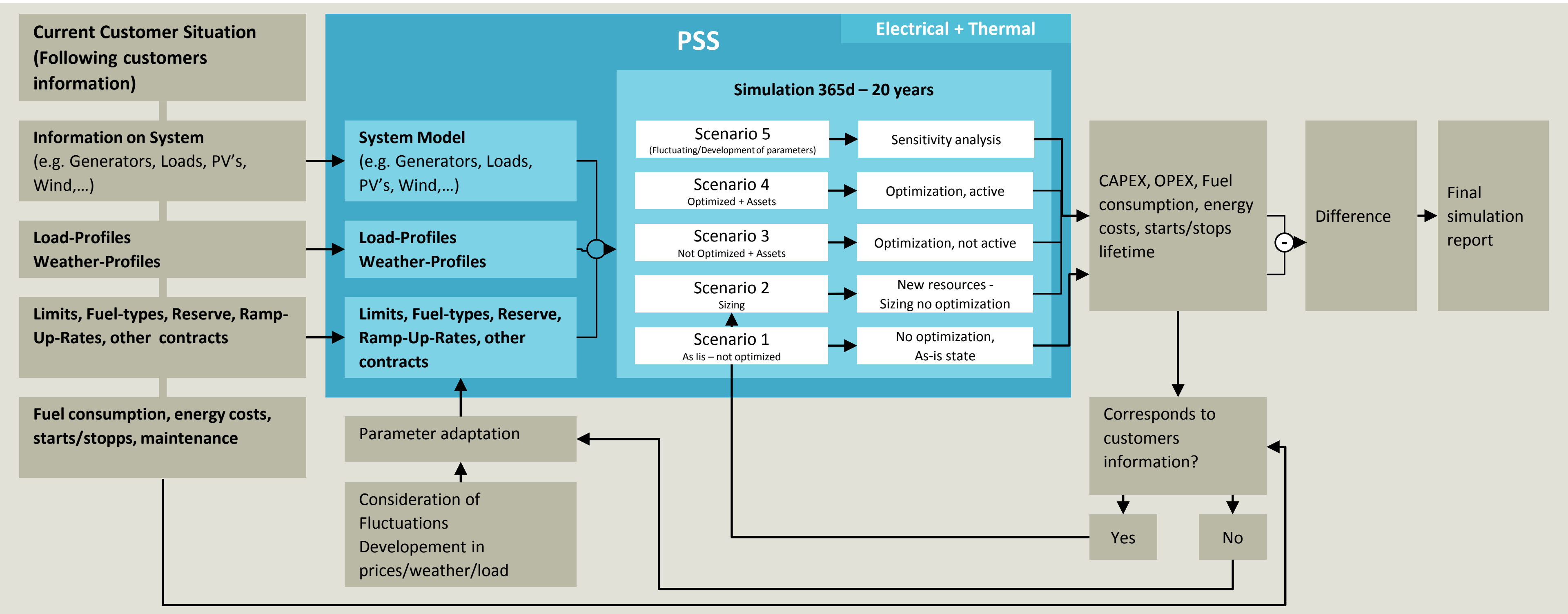
PSS DE – Energy Twin Snap Shots



Input tab offers extensive possibilities



PSS DE – Energy Twin
Microgrid Simulation Process



Results of simulation for Remote community

CAD 800k

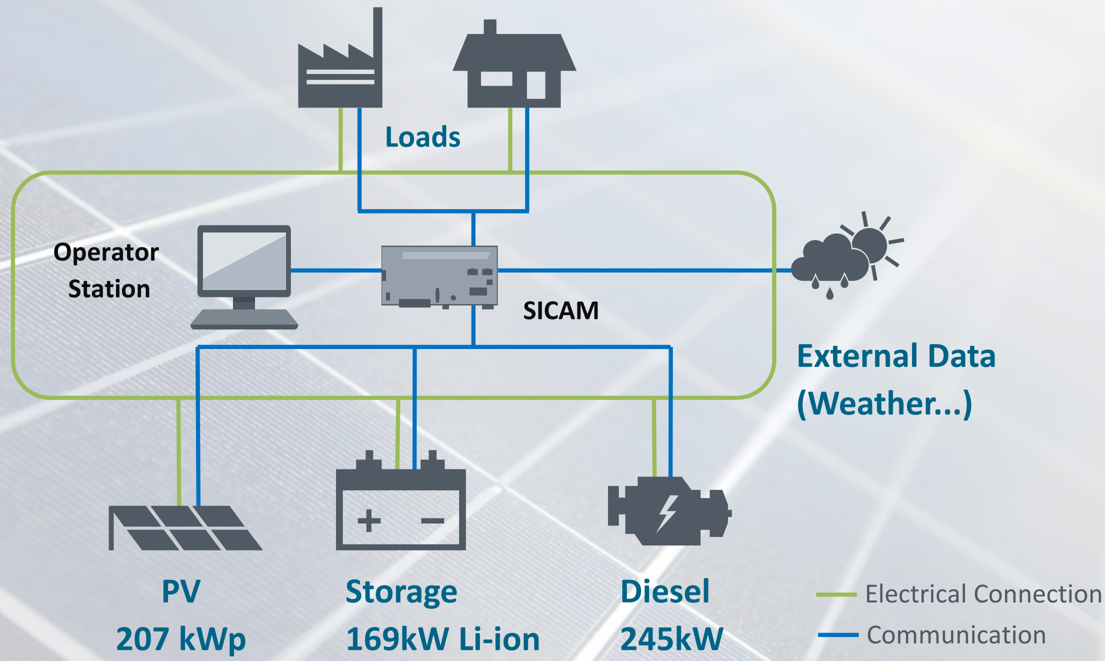
NPV of project compared to current system

-19%

Fuel consumption

22%

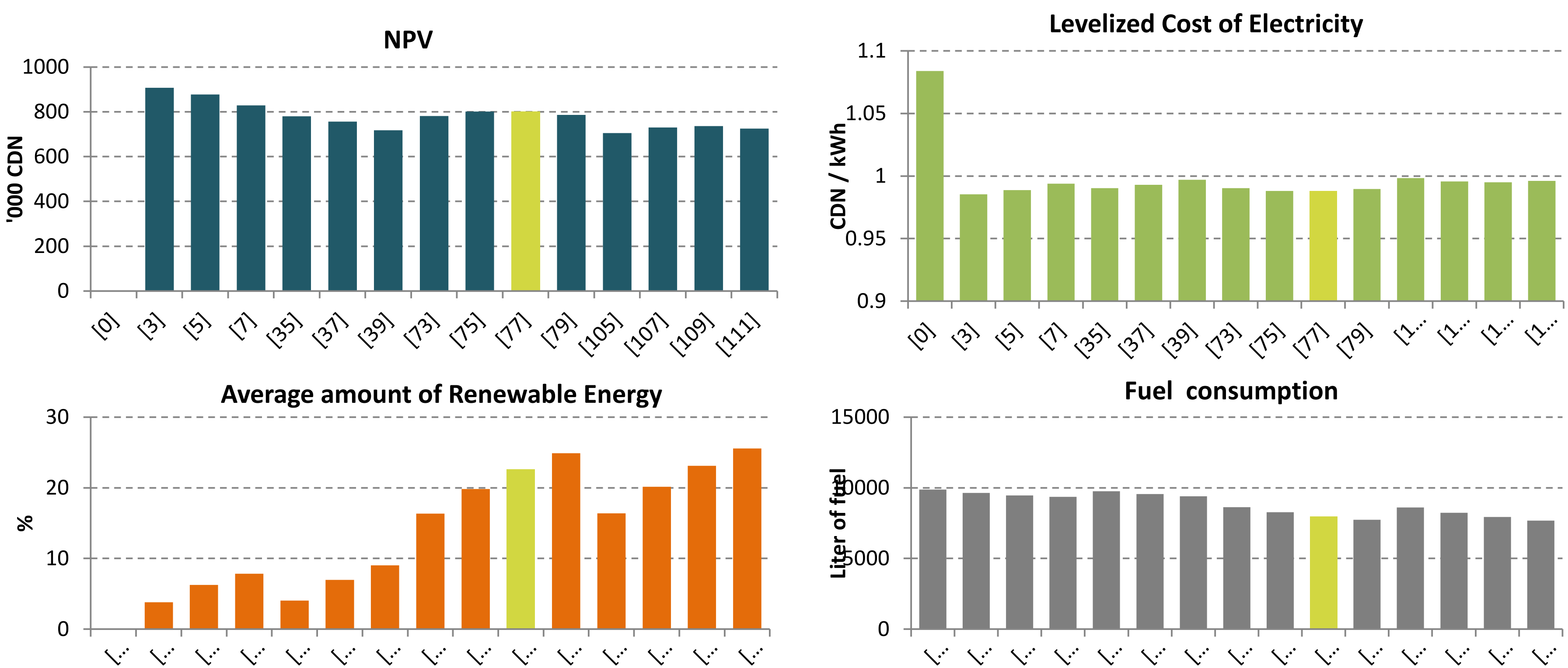
Renewable Energy



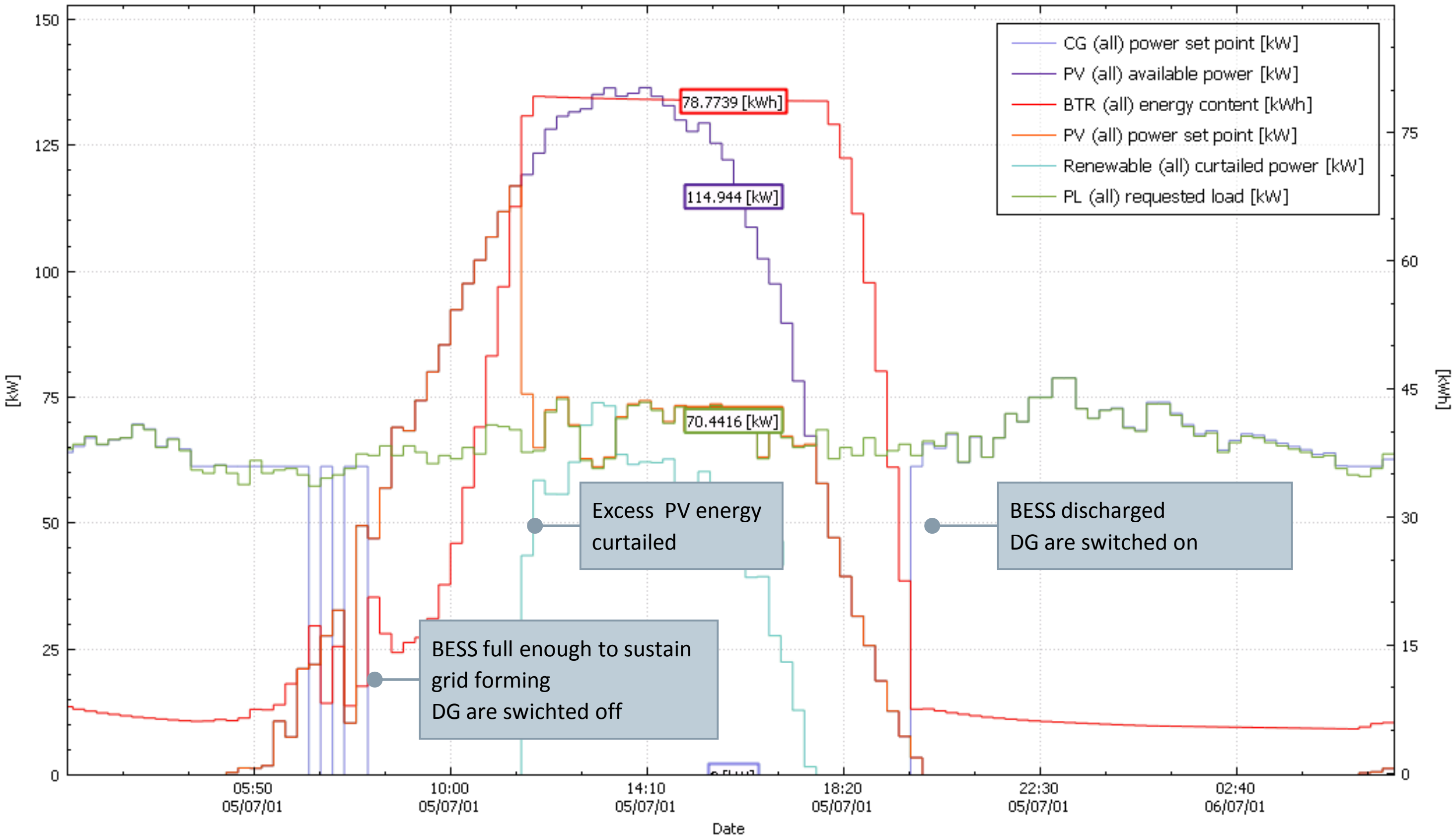
Multiple configurations compared to baseline

Solution #	Diesel	Solar	BESS	CAPEX [kCDN]	OPEX Year 1 [CDN]
[0] – Baseline	245 kW	0 kWp	0 kW	750	144472
[3]	245 kW	35 kWp	0 kW	1718	145335
[5]	245 kW	69 kWp	0 kW	1798	146197
[7]	245 kW	104 kWp	0 kW	1877	147060
[35]	245 kW	35 kWp	85 kW	1777	148310
[37]	245 kW	69 kWp	85 kW	1858	149172
[39]	245 kW	104 kWp	85 kW	1936	150035
[73]	245 kW	138 kWp	169 kW	2077	153872
[75]	245 kW	173 kWp	169 kW	2155	154735
[77]	245 kW	207 kWp	169 kW	2236	155597
[79]	245 kW	242 kWp	169 kW	2315	156460
[105]	245 kW	138 kWp	254 kW	2136	156847
[107]	245 kW	173 kWp	254 kW	2215	157710
[109]	245 kW	207 kWp	254 kW	2296	158572
[111]	245 kW	242 kWp	254 kW	2374	159435

Recommended solution based on NPV, LCoE, Renewable share and fuel consumption

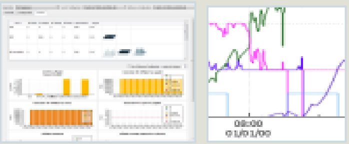


BESS and microgrid controller allows high penetration of Renewable Energy in Microgrid



Siemens' customer centric approach, combining several portfolio elements to an consistent landscape

Simulation



DESS/ Energy twin

- Determination of
  - Optimal portfolio mix ($/kWh)
  - Sizing
- Scenario simulation
- Stability check
- Protection setting

- Integrated simulation tool chain for determination of optimal portfolio mix

Real-Time Monitoring

Monet

- Real time data collection
- Visualization and benchmarking
- Simple control modules

- Monitoring
- Performance monitoring and benchmarking
- Performance contracts, SaaS

Reliability

SICAM Microgrid Controller

- Rule based algorithms
- Electricity only
- Islanding of local network
- Resynchronization
- Load shedding
- Automated generation control

- Enabling off-grid operation without interface to external communication
- Cloud enabled

Market Interaction

Spectrum Power 7 MGMS

- Generic algorithms
- LINUX based
- Monitoring and control
- Optimise energy mix
- Generation and load forecasting
- Optimal unit commitment
- Interact with the market

- Focus on off/ on-grid applications with market interaction
- Local installations with advanced functionality

Ottawa, Ontario, Canada: Algonquin College benefits from Siemens comprehensive Energy Services

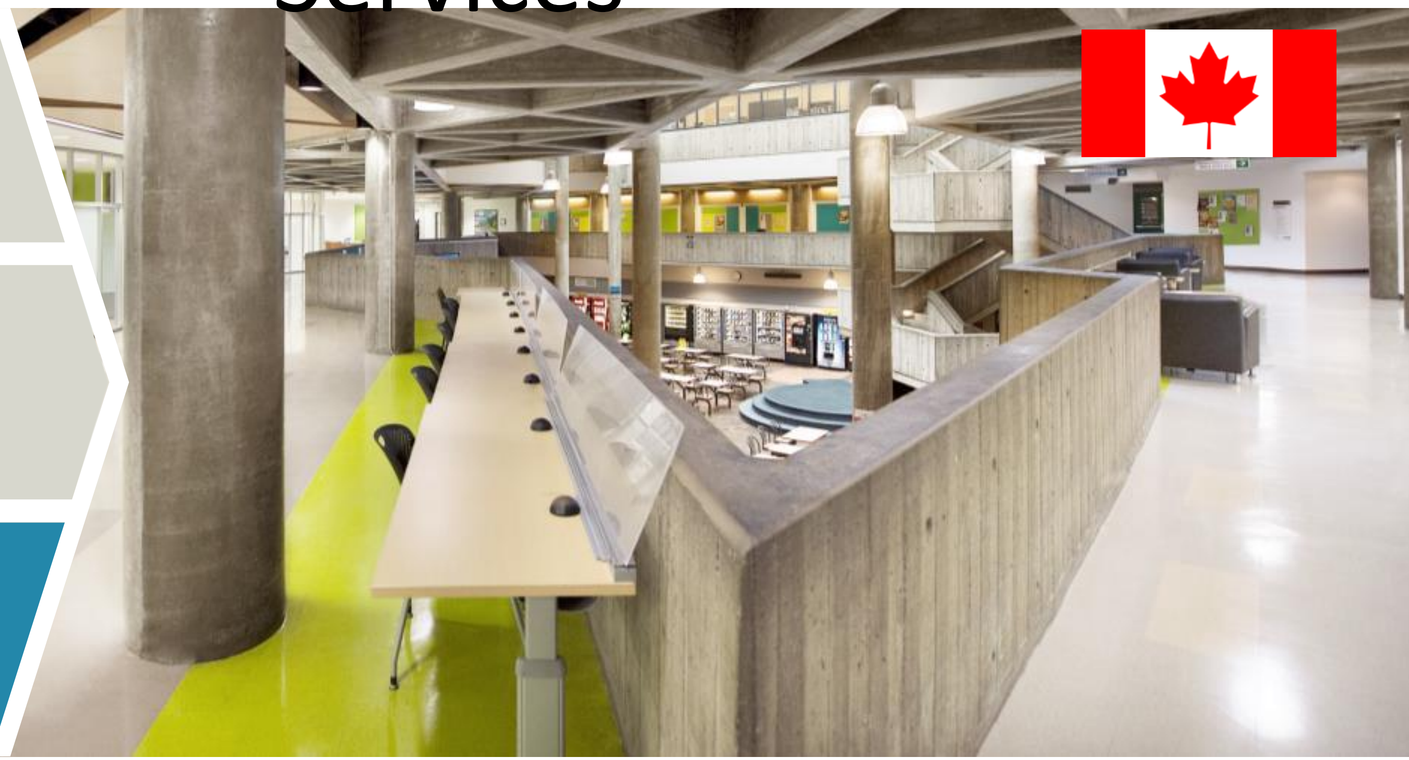
4MW

Energy Centre (Cogeneration)

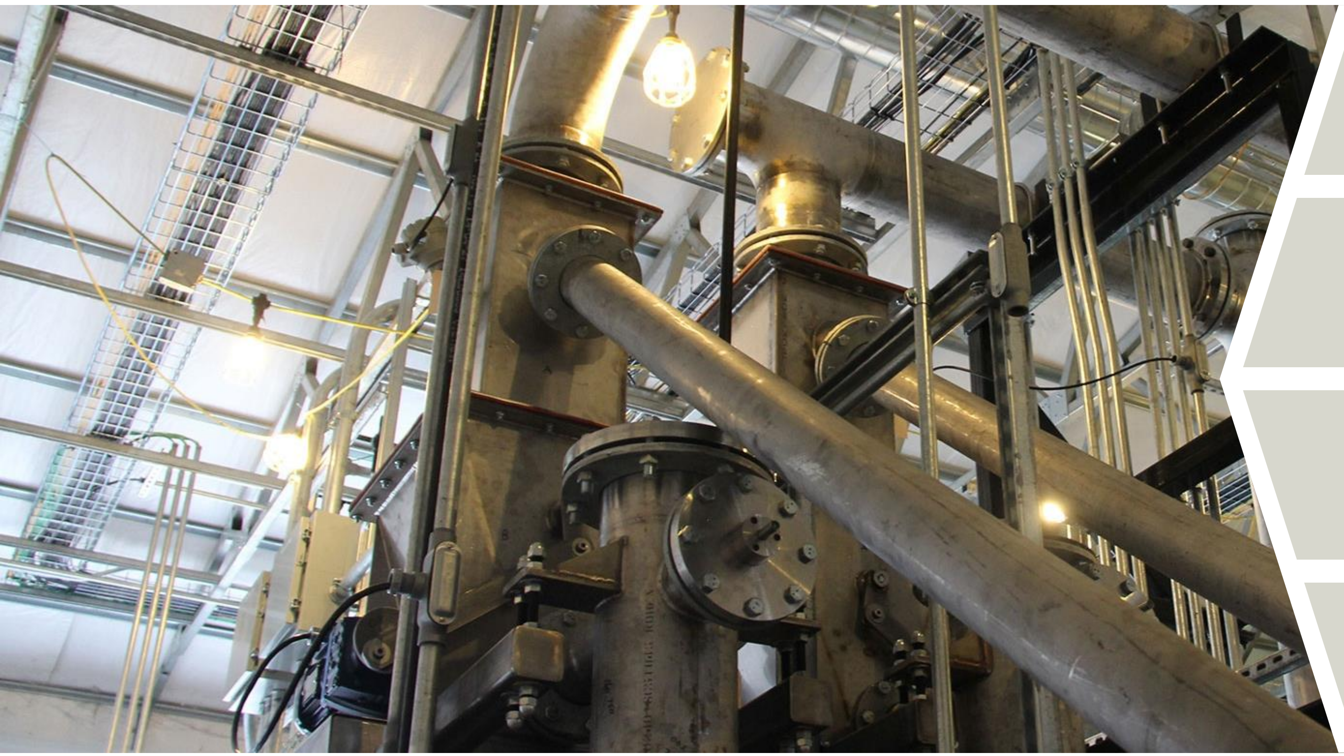
200 k$

annual savings through DG Control integration

Replicability



Intelligently managed distributed energy resources: optimized low-carbon microgrid on Native American reservation Blue Lake Rancheria



4
partners: successfully managed ecosystem

1MW
Indian reservation powered by Microgrid

150 tons
carbon reduced per year

$5M
grant from California Energy Commission

Arizona Public Services Electric Company: Microgrid Controller integrating Low Voltage Distributed Energy System

10MW

combined solar power from residential roofs

1500 s

integrated into active load management

360$

reduced from annual energy bill per customer

Isle Italy: SICAM Microgrid Controller/ SIESTORAGE enable stand alone electricity for a renewables integrated micro grid

10-15%

Oil / CO_2 savings

Reliability

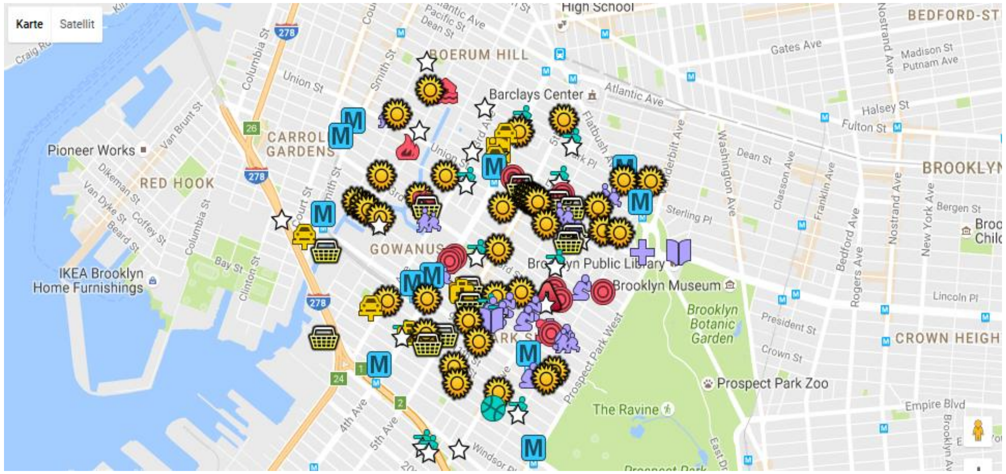
…Performance and reliability of control is very high and consists reference for future projects. Can be considered as business excellence…

ENEL, Customer

Brooklyn Microgrid

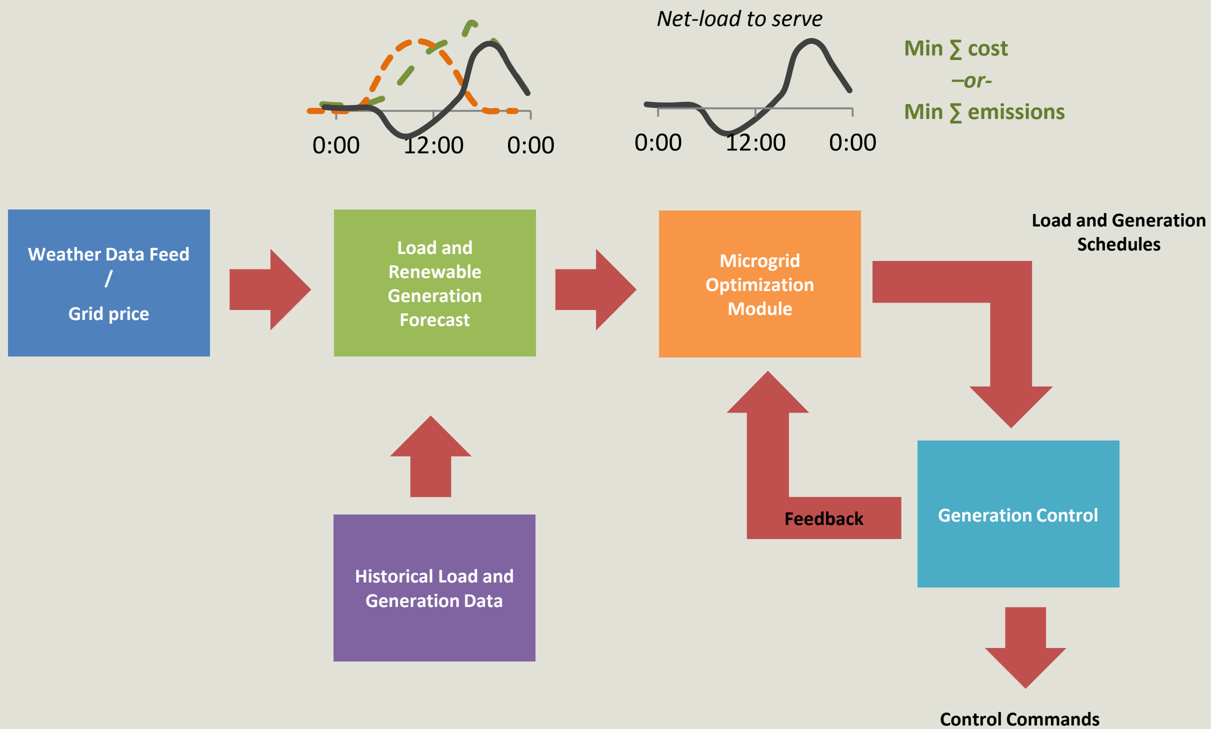
B R O O K L Y N MICROGRID

About us: We are a team of energy services professionals including engineers, software developers, analysts and makers who are dedicated to building out a resilient, clean and renewable, locally generated microgrid in Brooklyn, N.Y.

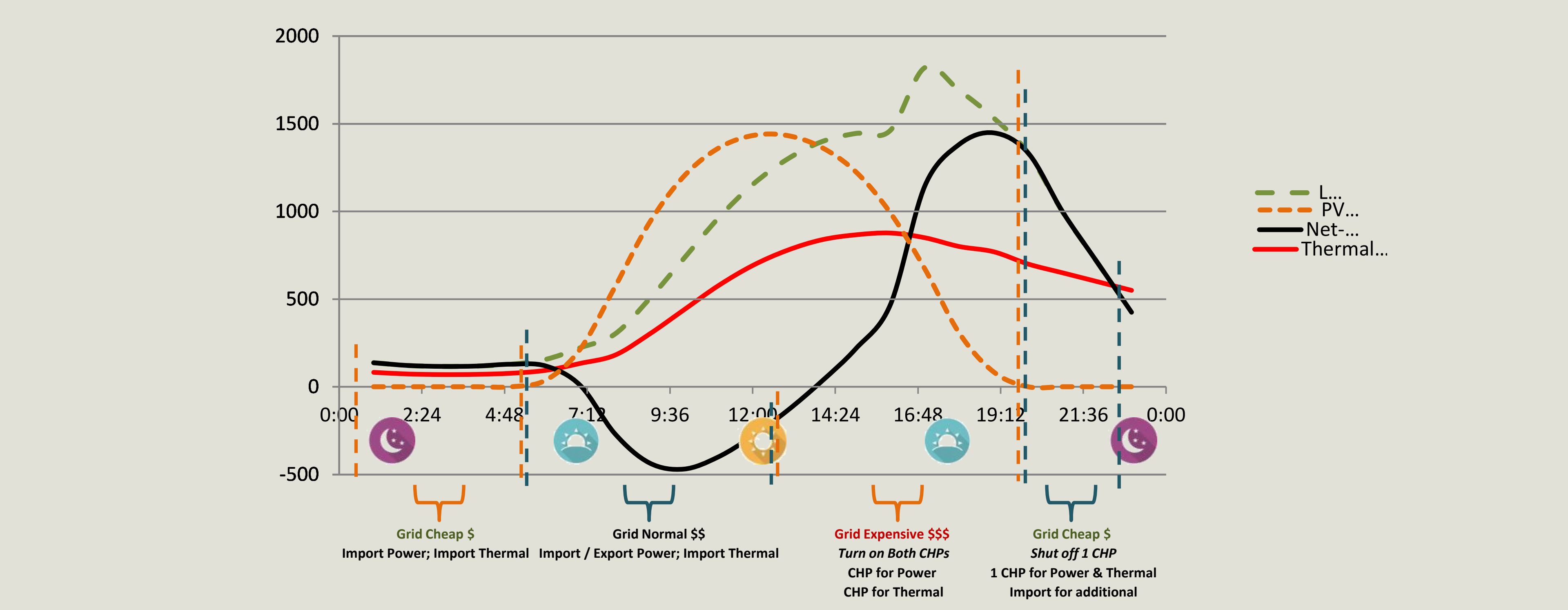


https://www.enbw-solarplus.de/ http://brooklynmicrogrid.com/

Operation in a Nutshell

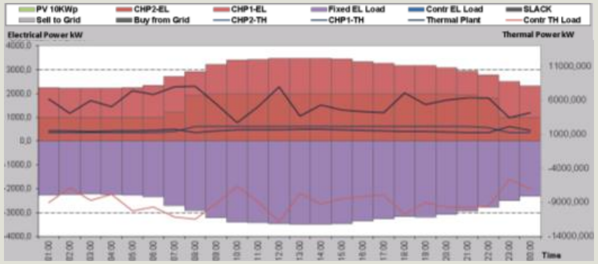


Day-ahead Forecast and Scheduling based on Optimization



Value of MGMS Optimization – Campus Simulation

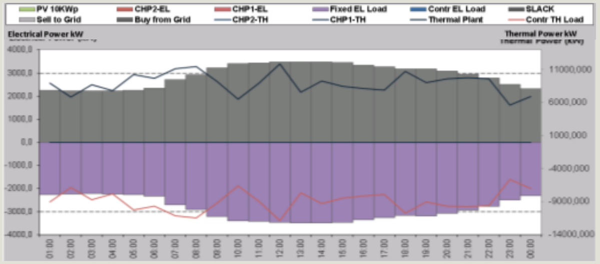
Scenario 1: Base Case



Simple campus energy model – Entire Campus is supplied from the grid and thermal load is provided by a gas powered plant.

Energy cost: $3M per year

Scenario 2: CHP

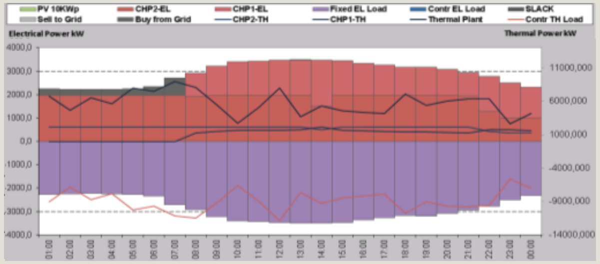


Full CHP utilization – Savings through maximum CHP utilization and simple MG controller without optimization

Energy cost: $2.2M per year

Savings: $800K per year

Scenario 3: CHP & MGMS



Microgrid optimization – Additional savings through optimizing energy intake from either CHPs or grid with the MG manager

Energy cost: $2M per year

Savings: $1M per year

$200K additional savings due to MGMS

Considering all equipment technical data, **estimated ROI for microgrid manager** depending on microgrid size, electricity, and gas prices is **2 - 4 years.**

Disruptive Innovation over the Wires: Business Models for Success

Thursday November 9 | Federation Hall | University of Waterloo

Lunch

*Explore the **Innovation Showcase**, located at the back of the Hall and Outside!*

Council for Clean & Reliable Energy — transforming the way we think about power | ENBRIDGE | WISE Waterloo Institute for Sustainable Energy | Canadian Electricity Association | Association canadienne de l'électricité | Power Workers' Union | NSERC CRSNG | University of Waterloo

Disruptive Innovation over the Wires: Business Models for Success

Thursday November 9 | Federation Hall | University of Waterloo

Lab Tours

For pre-registered guests only, thank you!

Council for Clean & Reliable Energy — transforming the way we think about power
ENBRIDGE
WISE — WATERLOO INSTITUTE FOR SUSTAINABLE ENERGY
Canadian Electricity Association | Association canadienne de l'électricité
POWER WORKERS' UNION
NSERC CRSNG
UNIVERSITY OF WATERLOO

Panel 2

Financing Business Models: The Good, The Bad & the Ugly

Moderator

David McFadden
Counsel
Gowling WLG (Canada) LLP

Speakers

Ron Dizy
Managing Director
Advanced Energy Centre
MaRS Cleantech

Colin Kelleher
CEO
Kelleher Group

Michael Nobrega
Chair of the Board
Ontario Centres of Excellence

Panel 2

Financing Business Models: The Good, The Bad & the Ugly

Audience Question & Answer Session

Please use the microphones provided, thank you!

Disruptive Innovation over the Wires: Business Models for Success

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Reception

Please join us for drinks and hors d'oeuvres as a ***thank you*** *for your participation*