Energy sources for the energy supply of remote and inaccessible areas

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International Renewable Energy Congress – XXI, October 2016

Increasing numbers of microgrids

- **Factors**
  - New facility with no grid connection
  - Existing facility expanding beyond utility service limit

- **Powering concerns**
  - Cost of diesel fuel (including handling to remote locations)
  - Poor environmental image
  - Maintenance costs

Types of microgrids

- **Grid-connected**
  - Single point of common coupling
  - Can disconnect as needed and operate autonomously
  - Resiliency / energy security
    - Storm-prone areas
    - Military - Security - Border bases
- **Remote**
  - Village power
  - High cost of generation

- **Military forward operating bases**
  - High cost of fuel delivery

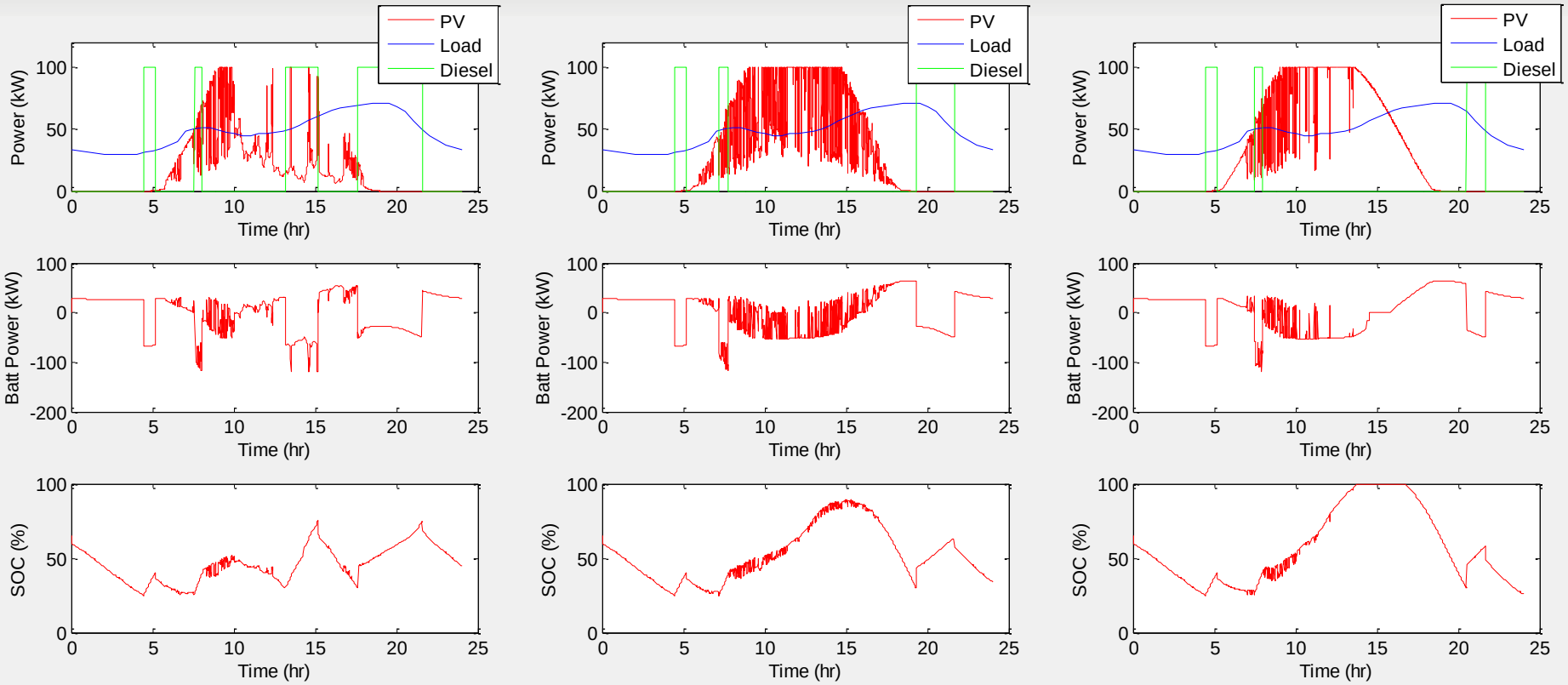
Adding renewables to microgrids

- **Solar and/or wind can substitute for diesel power**
  - But without storage, diesels still have to supply spinning reserves

- **Typical penetration of PV**
  - 20-30% of diesel power with standard power electronics
  - 50-60% of diesel power with dedicated software

- **Energy storage allows maximum contribution of renewables**
  - Fuel savings can easily be 50% to 75% or more
  - Load varying from 30kW to 70kW /100kW diesel /24-hour fuel consumption 730 l

Microgrid example

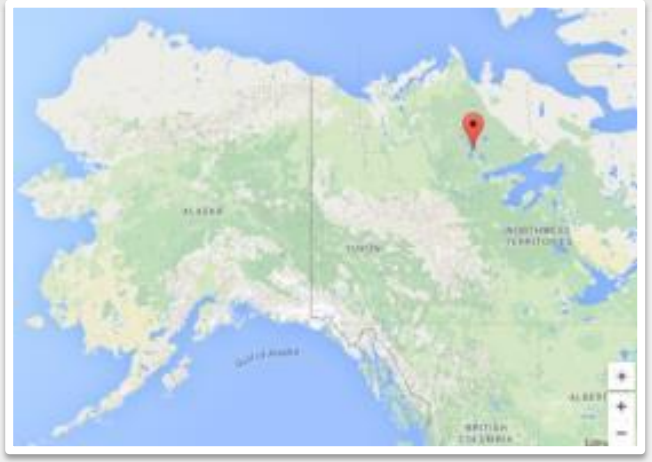


400 l (45% saved) **200 l (72% saved)** **107 l (85% saved)**

– Modeling allows fuels savings to be quantified

Colville Lake microgrid - Canada - 1/2

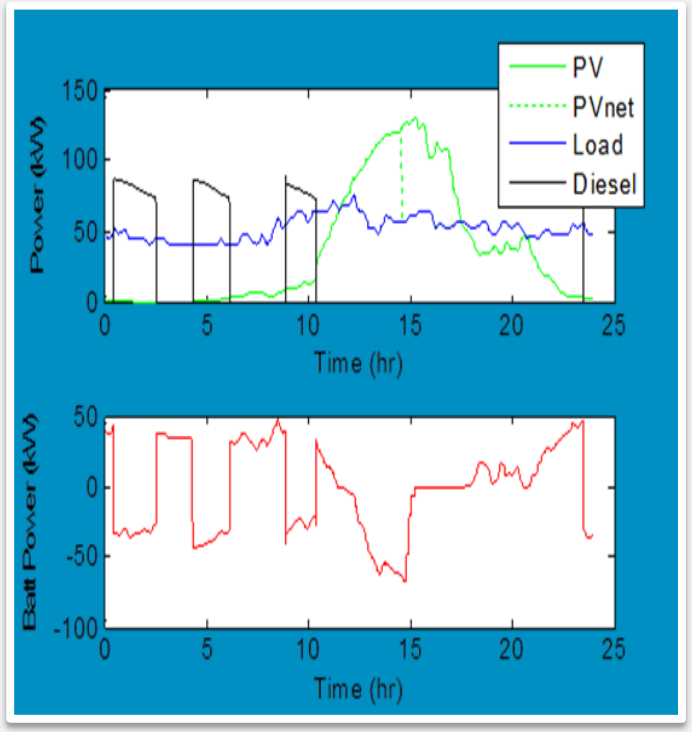
- 50 km north of Arctic Circle
  - 150 inhabitants: 150 kW peak; 30 kW base load
  - Temperatures -50°C to +35°C
  - Diesel fuel delivery only by ice road
- Cost of generation ~$2.60 / kWh
- New power station
  - 2 x 100 kW diesels + 150 kW diesel
  - 50 kW of solar to be extended this year
- IM20M container 232 kWh with 240 kW PCS
- Includes Saft's Cold-weather package
  - Insulation for –50°C performance
  - Hydronic heating coil for glycol heating



Colville Lake microgrid - Canada - 2/2

- Saft developed complete control strategy
  - Supported with Matlab modeling

- Emphasis on modeling
  - Determine optimum size for PV expansion
    - From 50 kW to 140 kW
  - Quantified fuel savings using Customer load and PV data



- Developed cold-weather package for IM20
  - Hydronic heater and extra insulation for –50°C

Cobija PV diesel hybrid power plant - Colombie - 1/3

- **Pando province, northern Bolivia**
  - Not connected to national grid
  - 65% electricity coverage

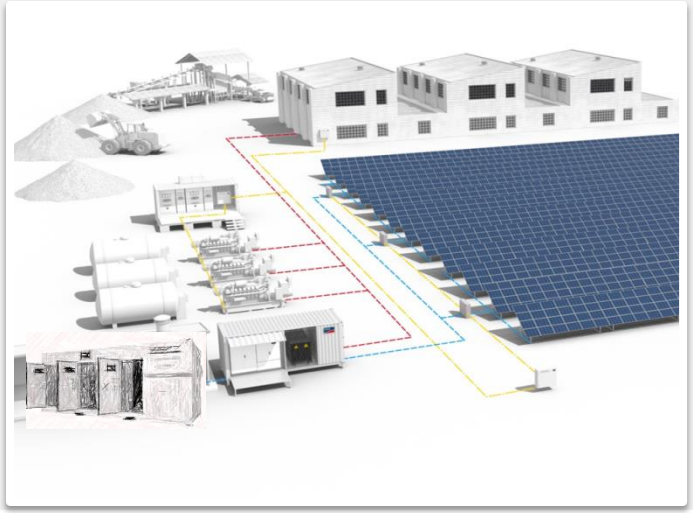
- **World's largest PV-diesel hybrid**
  - 16MW diesel generation – 8MW max load
  - 5MW PV
  - 2.2 MW Li-ion storage system
  - 50% of Cobija power needs (37 GWh/yr)
  - Main stakeholders
    - General contractor: Isotron SAU (Isastur Group))
      Owner: ENDE (Empresa Nacional de Electricidad)
      Storage System: SMA, Saft

The storage solution

- 2.2 MW – 1.2 MWh
  - 2 containers Intensium Max 20 M
  - 4 Sunny Central Storage 630 – SMA

  ➔ compensation of PV fluctuations
- Fuel Save Controller – SMA
  - Calculates maximum PV injection to grid
  - Smooth operation of gensets
- Replaces 2 gensets running @50%
- 2 mio l fuel saving
- Commissioning December 2014

Nb: SMA scope also comprises 6 Sunny Central 800CP-XT



Courtesy SMA

The storage optimum

PV & smoothing

- Optimum for Cobija project
- Replaces 2 gensets running @50%
- 2 mio l fuel saving

PV & shaping

- Significantly higher Capex
- ROI depends on fuel cost

Faroe Island - Danemark -

SEV

- Vertically integrated utility
- Max load 45MW (25MW at night)
- 6.5MW wind capacity in 2013

- Share of renewables 2011 38%
- Target Share of renewables 75%

- Why?
  - Fuel costs in 2002: 7 million euros
  - Fuel costs in 2012: 21 million euros

- New 12MW wind farm end 2014

  ➔ wind energy = 26% of energy mix

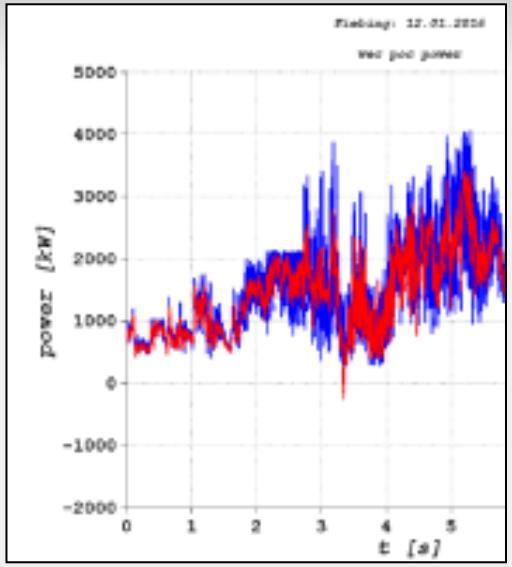
Faroe Islands: … and minimize storage

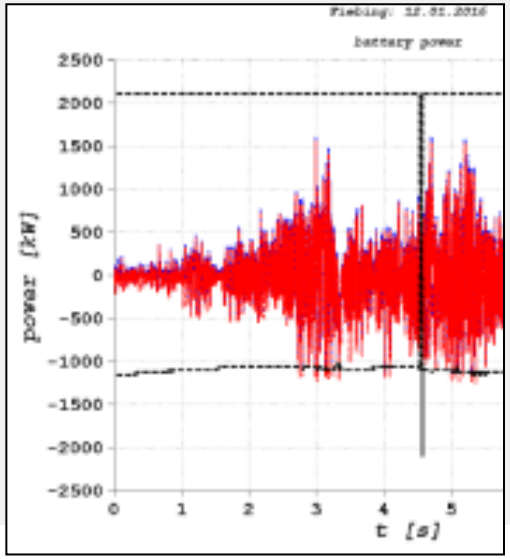
- Until now
  - Wind farm curtailed @~70% to avoid destabilizing effects on grid
- <u>This year</u>
  - Installation of high power ESS:
    2 Intensium Max 20P 2.3 MW (700 kWh)
    + 2MVA ENERCON PCS container
- Storage Functions
  - Wind ramp control at 1MW/minute
    Frequency response & Voltage control
- Expected Result
  - 30 – 40% production increase
  - 10t of fuel savings per year

Projected Results

Simuation data

- Compliance 99.5%
  (1MW / min ramp rate)
- Total efficiency losses 0.2%
  (over total energy production)
- Total wind energy curtailed <0.1%
- Avg daily battery throughput 270%
- AC roundtrip efficiency 86.2%





Thank you

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