Conception and Operation of a Unique Large-scale PV Hybrid System on a Hebridean Island

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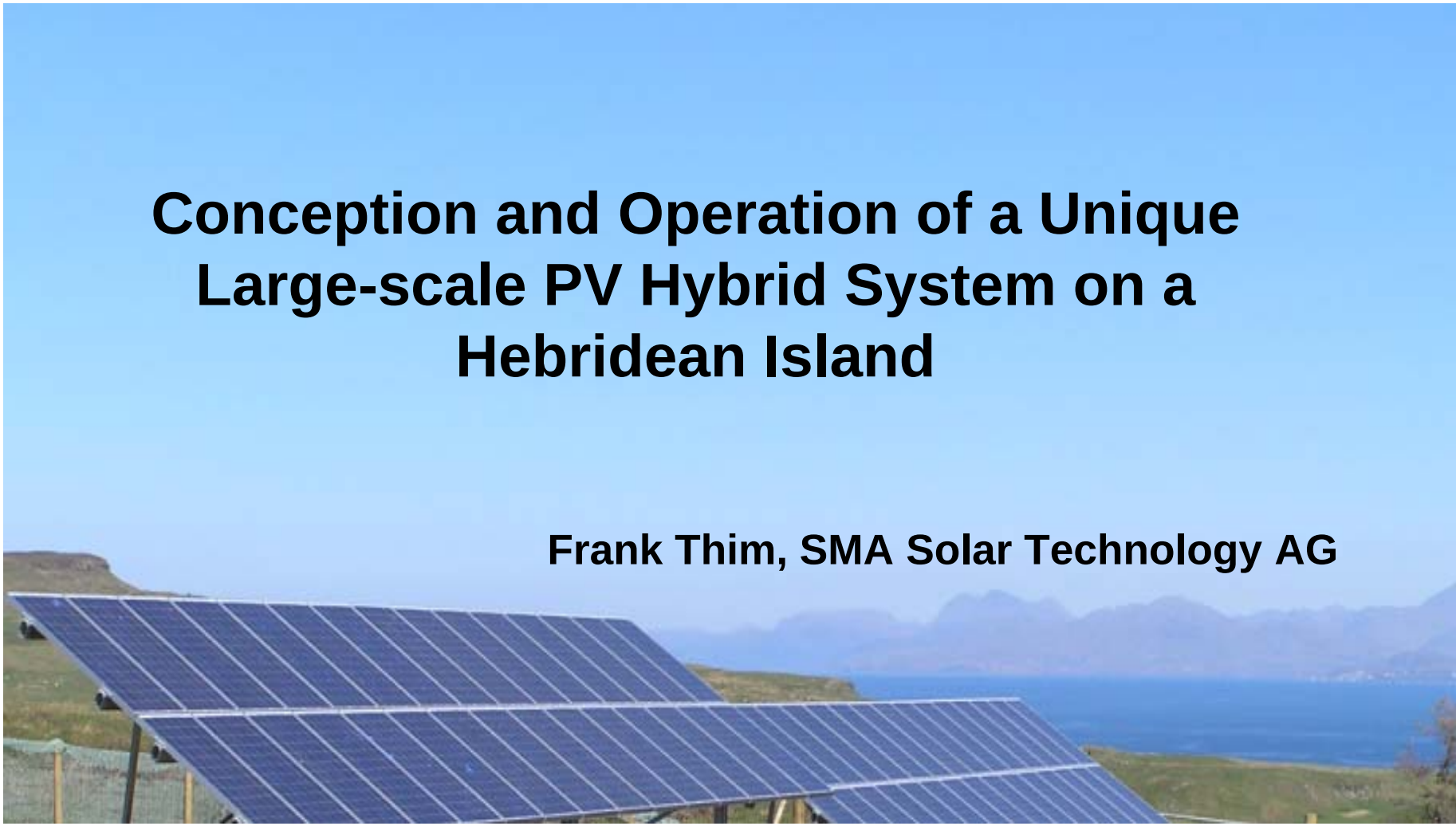
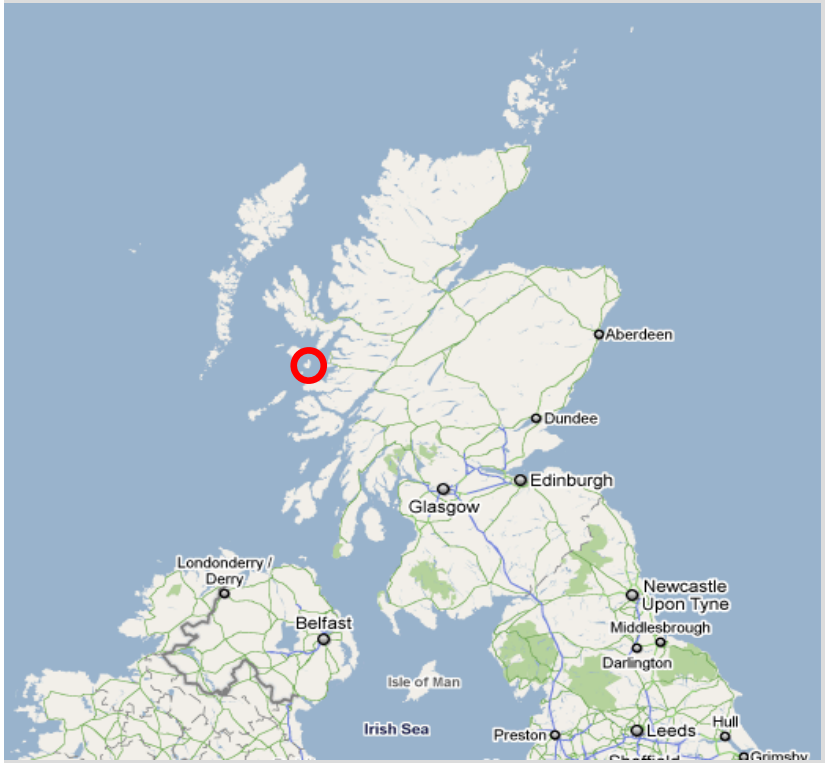


Overview

1. Introduction
2. The electrification program
3. System overview
4. Power control and power balance
5. Benefits for the inhabitants
6. Summary of the field experience

1. Introduction



> Scottish Inner Hebrides

> 16 km distance to the coast

> 9 km north to south extension

> 5 km east to west extension

> Harboring around 100 residents

> Community: 45 households, 26 business, 6 community buildings

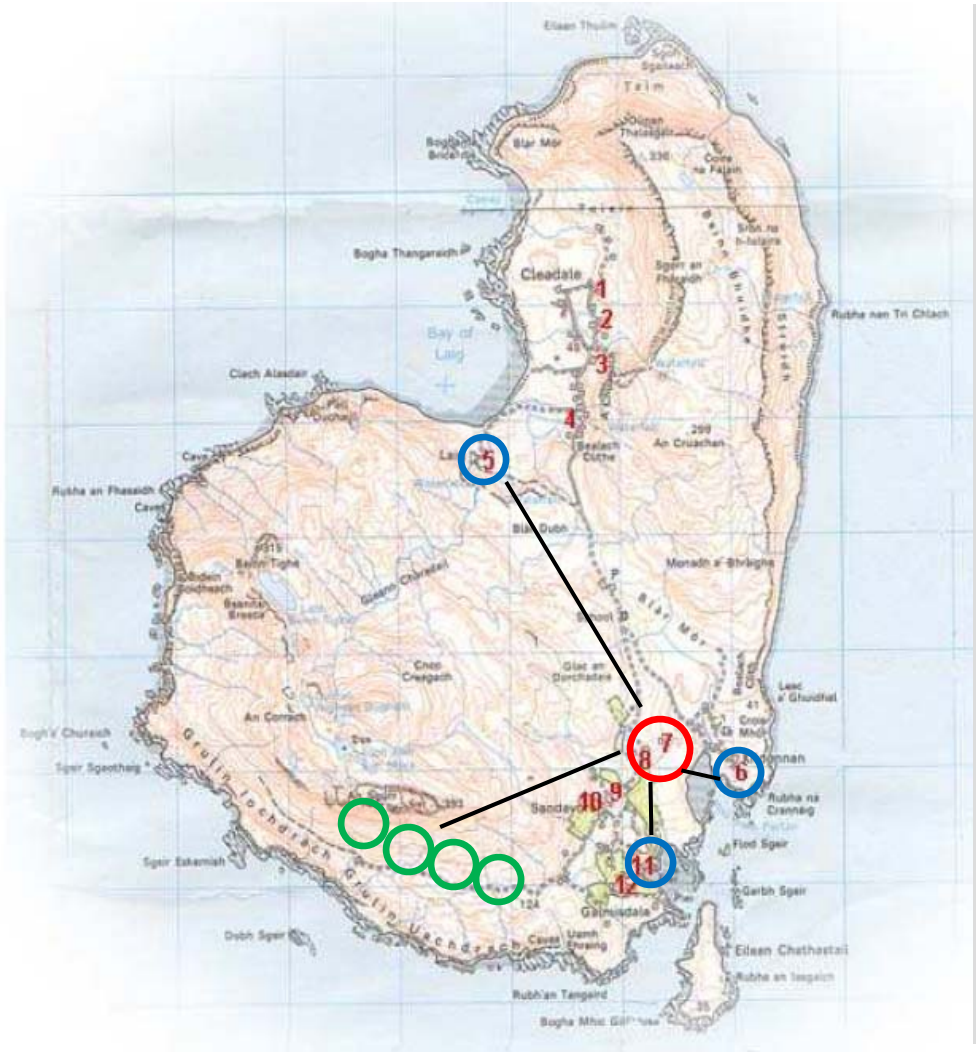
> Population is growing

2. Before the Electrification Program

> Depending on their own produced energy
> Mostly diesel generators
> Maintenance of own systems
> Systems switch off at night (candles)
> Never served by electricity from the mainland

- On 1st February 2008, the Isle of Eigg Electrification Project for whole Community switched on for the first time!

3. System Overview



This system integrates multiple renewable power sources

> Hydro (110 kW)
> Wind (24 kW)
> Solar (10 kWp)

- These power sources are distributed and coupled by a **medium voltage grid** over several kilometers

3. Power Sources: Hydro Electric Generators

> 3 Hydro generators

> 110 kW (major renewable energy source)

» Provides enough power most of the year – except in summer months!

3. Power Sources: Wind Turbines

> 4 Proven wind turbines connected to Windy Boy 6000 A

> 24 kW (Second largest renewable resource)

⏩ Provides power all over the year (– but lowest yield in summer)

3. Power Sources: The PV Array

> PV array with 165 W modules with 3 Sunny Boy 3000

> 10 kWp (Smallest renewable resource)

⏩ Provides additional power in summer

3. The System Control Unit

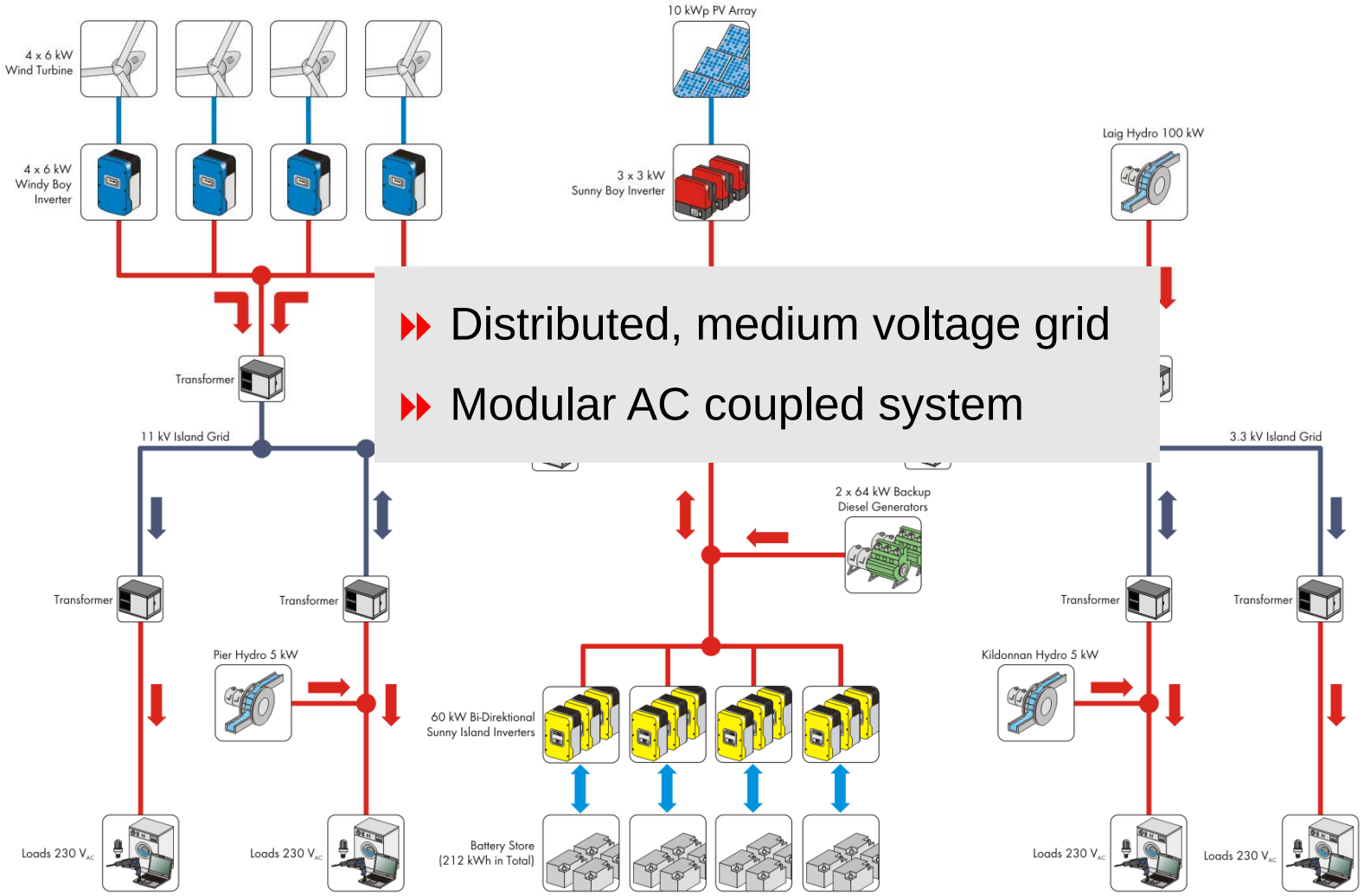
> 12 Sunny Island 5048 off-grid inverters

> 100 kW peak power

> Rolls 212 kWh battery bank

» System control

3. Electrical Schematic



- Distributed, medium voltage grid
- Modular AC coupled system

4. Battery State of Charge Control

- The Sunny Island monitor and control the **power balance** of the whole system **automatically**
- **Integrated** control parameter: State of charge (**SOC**) of the batteries:
  - **60 %**: generator is started
  - **90 %**: generator is stopped and batteries supply the loads

- Generator is only needed if available renewable power is not sufficient !

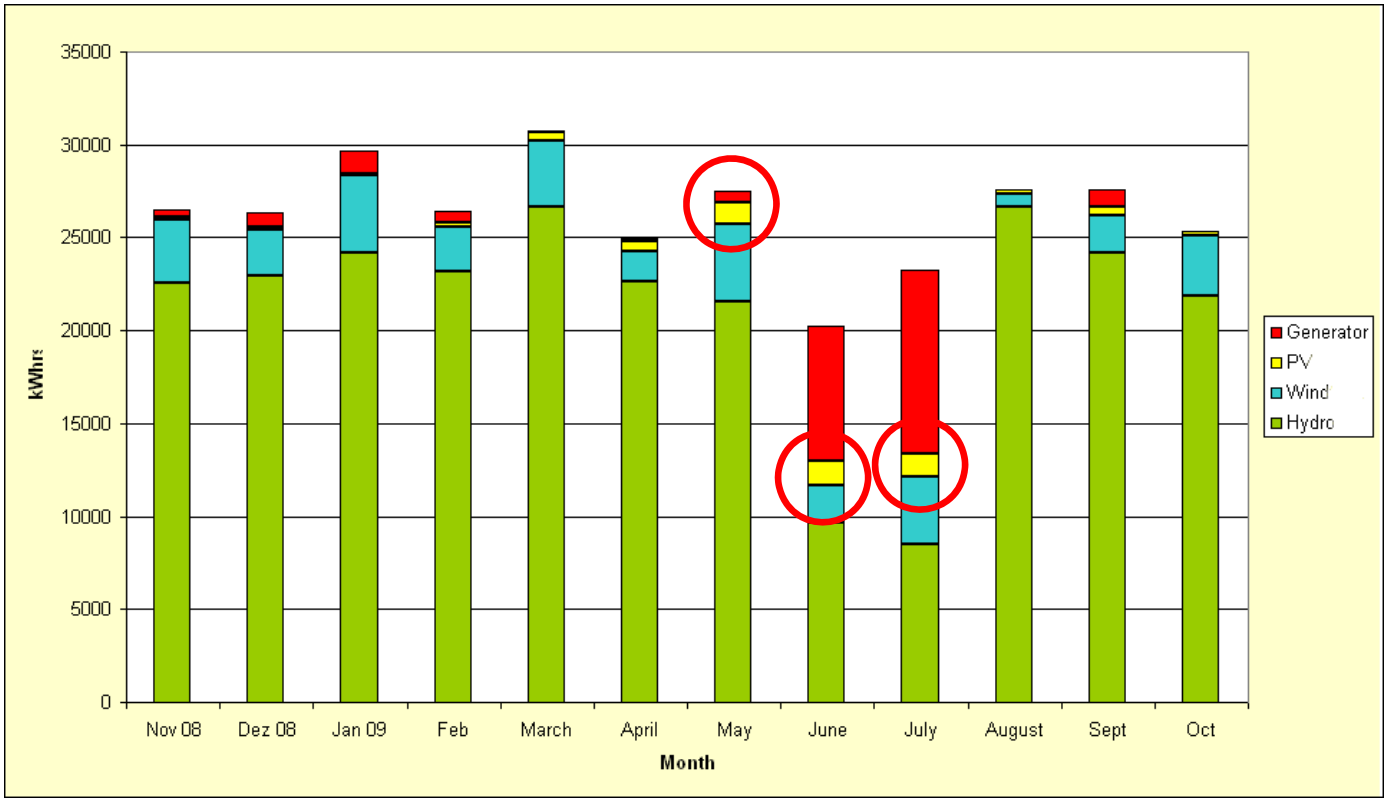
4. Frequency Shift Power Control

> Frequency is shifted if battery bank is full and more renewable power is produced than being used – Control steps:

1. Connect space heaters via frequency controlled switches
2. Connect dump loads via frequency controlled switches
3. Output power of Hydro, Wind, Solar will be limited

- System control without additional communication lines and with standard devices possible

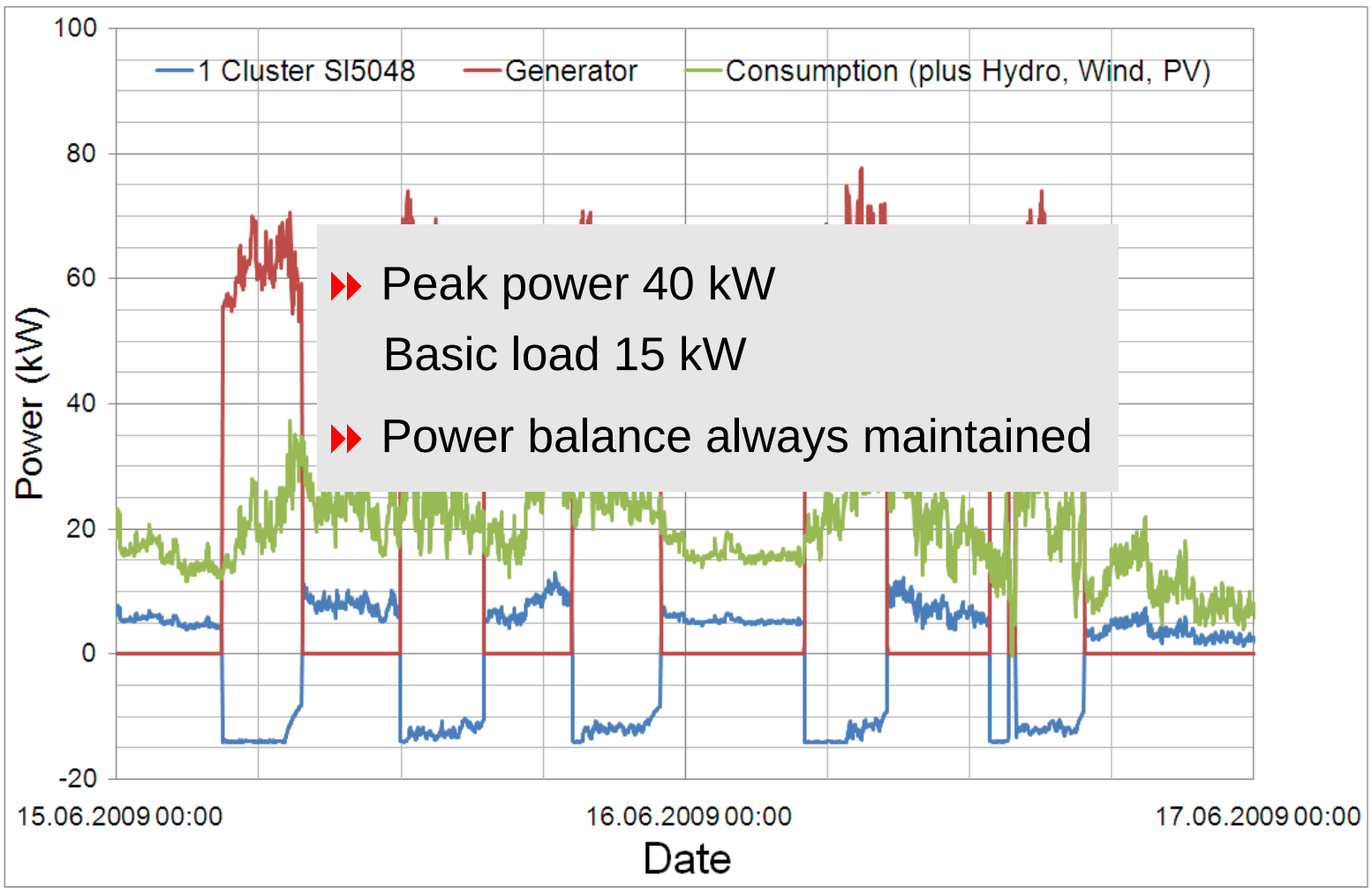
4. Power Generation



Power generated per month by the components of the system (kWh),
Data: John Booth, Eigg Island Electricity

- PV supplements Water & Hydro power during summer

4. Power Balance



5. Recent developments

> New properties on the Island

> Increasing energy demand

> In May/June 2010 very little rain on Eigg, reduced consumption & increased generator support

> New 22 kWp PV array will be installed in 2010

- The modular concept of the system ensures a flexible upgrading of the power sources and loads

6. Benefits for the Inhabitants

> Electricity available **24 hours** per day

> Repair and servicing by a trained **local maintenance team**

> (almost) **independent** from the mainland and fossil resources

» Same **quality of supply** as main grid customers!

7. Summary of System Characteristics

Large-scale modular hybrid system

> with **standard components**

> loads & generation coupled by a **medium voltage grid** over several kilometers

> Controlled by **grid frequency and SOC**

> **high reliability** achieved by using a modular concept

> **easy service** performed by local electricians

8. Summary of Field Experience

> One of the first installations with **PV, Wind and Hydro** in one community grid system!

> No problems with **critical loads**

> **95 % electricity** from **renewable** resources

> Eigg Island as best practice and proof of concept:

Modular, large scale hybrid systems are already feasible!


Thank you for your attention !
Frank Thim, Stratis Tapanlis, SMA Solar Technology AG
Steve Wade, Wind & Sun Ltd.
John Booth, Eigg Island Electricity