



Power Storage

Benefits of Using Hydrogen in an Off-Grid Power System

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Agenda

❖ OFF-GRID POWER SYSTEMS

- Market Pain
 - *Marginal Costs*
 - *Performance Limitations*

❖ SEASONAL RENEWABLE POWER GAP

- Design for Worst Case
 - *Waste Space*
 - *Waste Energy*

❖ HYDROGEN POWER SYSTEMS

- Store Excess Energy
 - *Smaller Footprint*
 - *Secure Power*

❖ IMPLEMENTATION

- Fuel Cells and Electrolysers
 - *Autonomous Characterisation and Operation*



Off-grid Power Systems

- Example Case : Mobile Phone Base Station

Energy per Day : 20 kWh

Remote Location : No Infrastructure

- SOLUTION – DIESEL GENERATOR WITH > 250 Gallon Tank

- Fixed Costs : Generator ~ £5000

UPS ~ £1000

- Marginal Costs : Refuel ~ £750 to £5000 every 1-4 Weeks

Maintenance



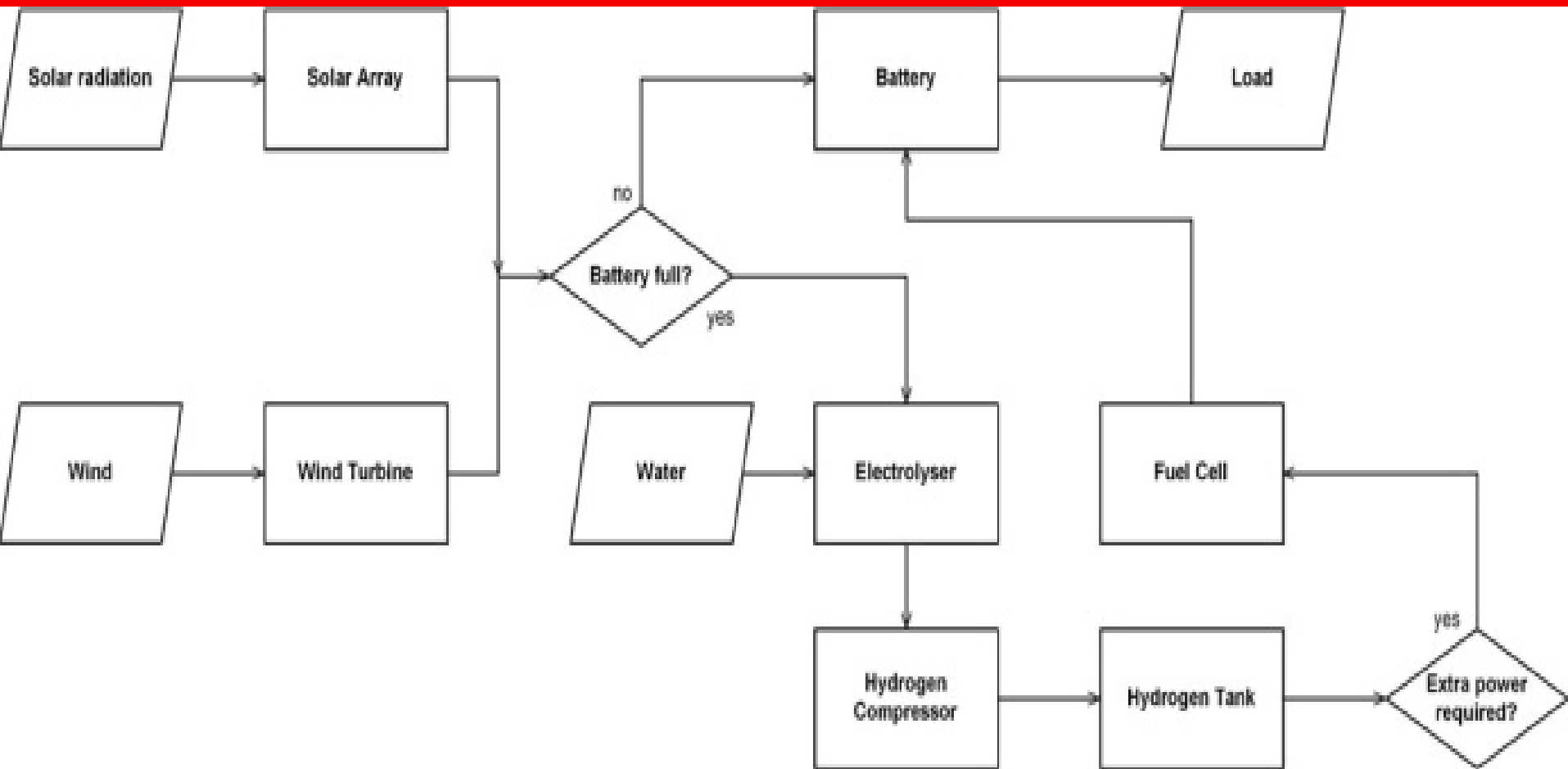
Renewable Generation

No infrastructure required

Fit and Forget

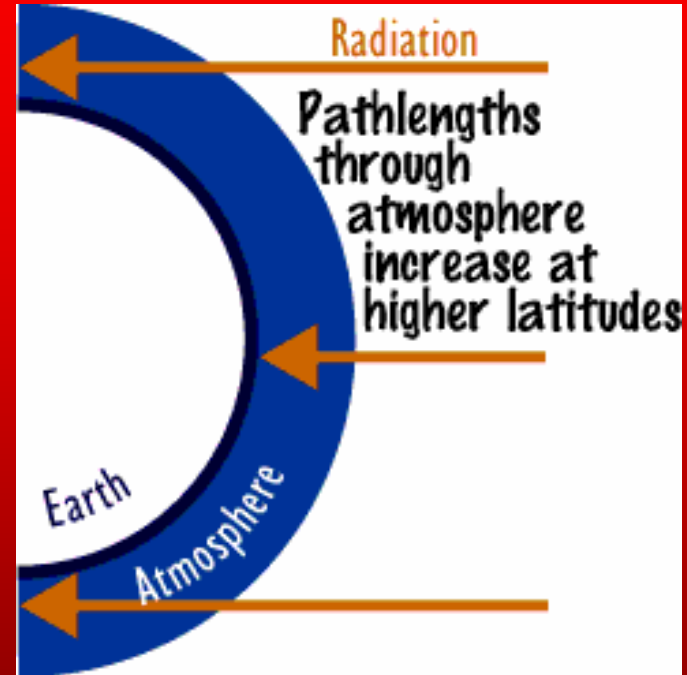
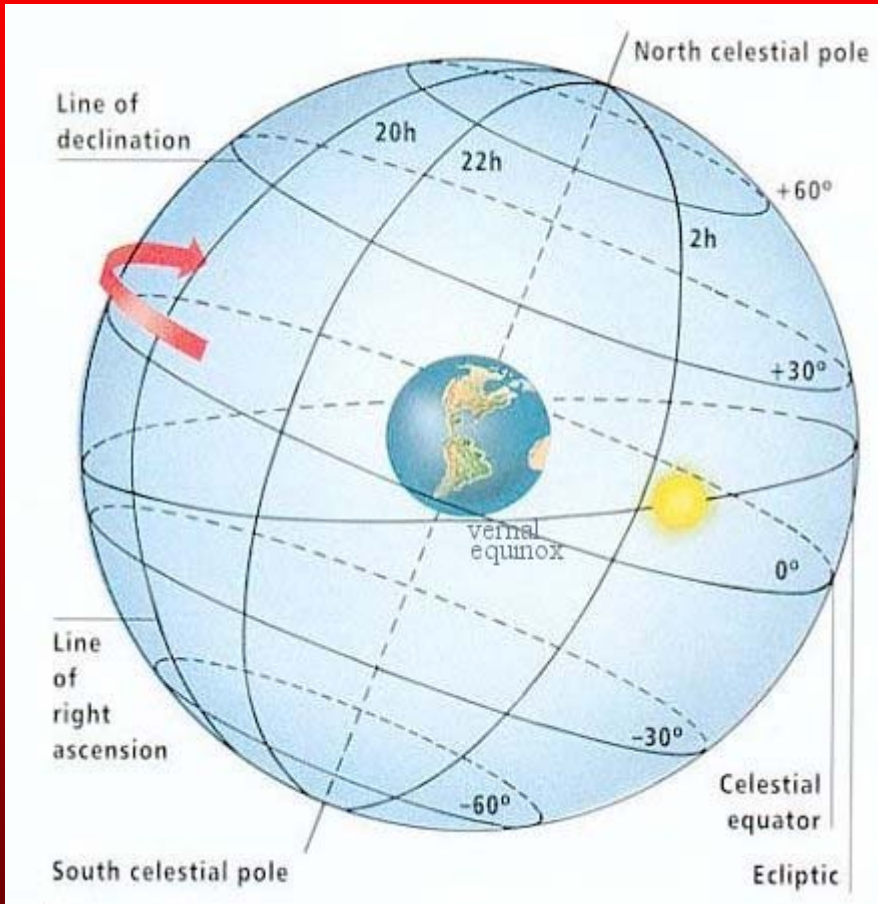


Fuel Cell Off-Grid Power System

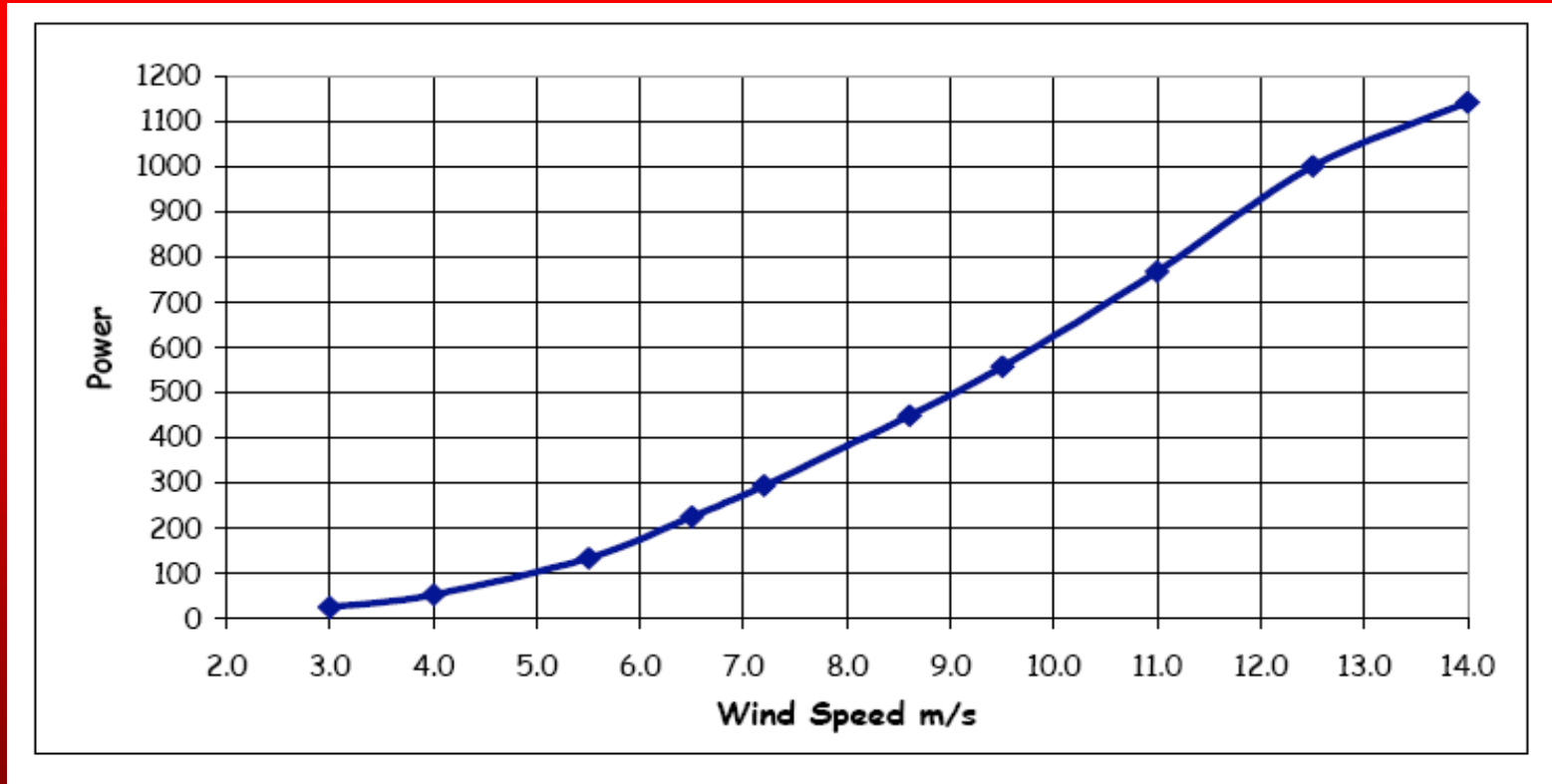




Estimating Solar Resource



Estimating Wind Resource



- <http://www.metoffice.gov.uk/education/data/index.html>



Macros Enabled Spreadsheet

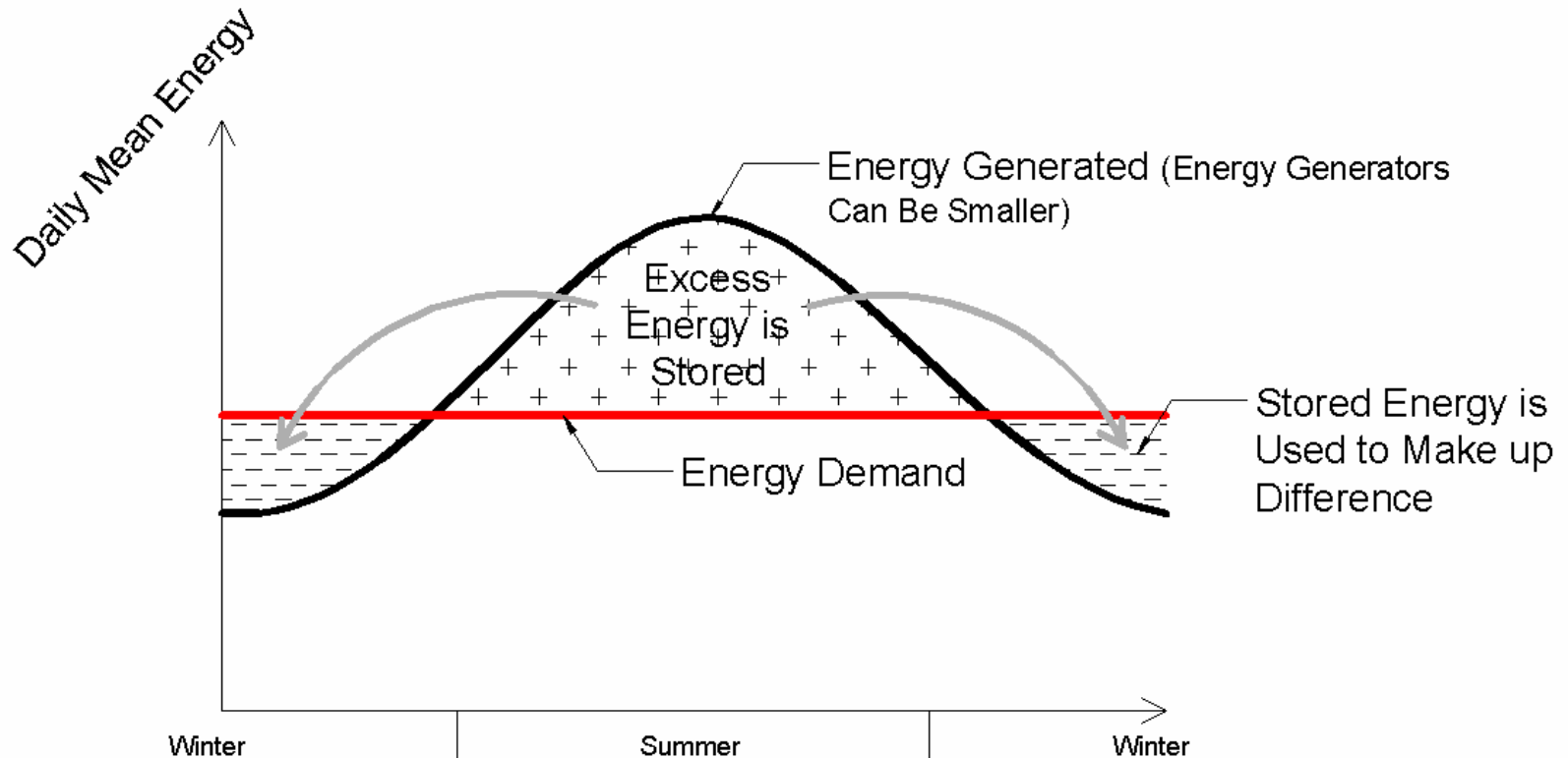
For Location, Obtain:

- Daily Mean Windspeed or Monthly Mean Daily Windspeed
- Daily Hours of Sunshine or Monthly Mean Daily Hours of Sunshine
- Enter Longitude And Latitude For Location
- Enter Met Office Data (Windspeed, Sunshine Hours).
- Enter Solar Array Data (Size, Efficiency, Mounting Angle) and Windturbine Data (Power/Windspeed Curve).
- Enter Efficiencies Of Battery, Charge Controllers, Electrolyser, Hydrogen Storage, Fuel Cell.



+ Smaller Energy Generators

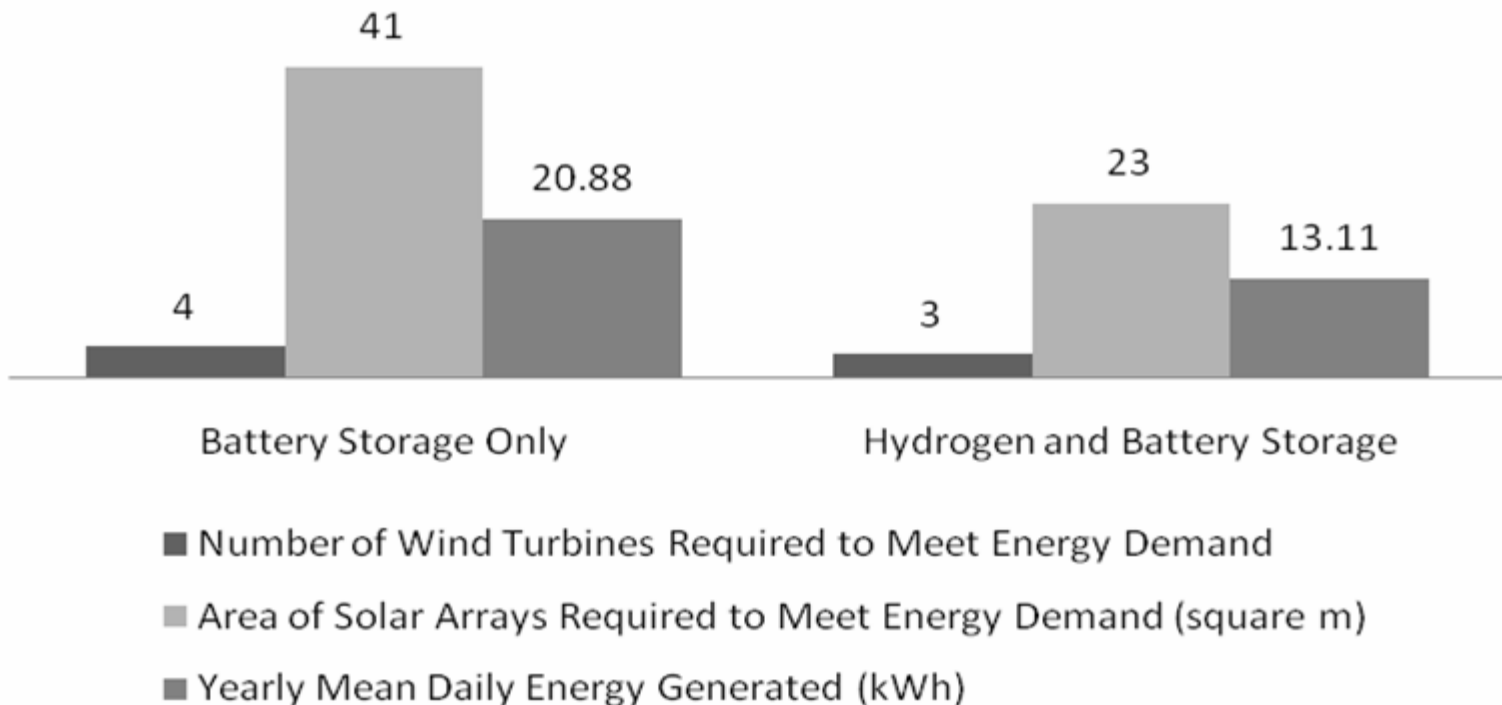
- Less cost, smaller footprint





Less Renewable Energy Generators Required To Meet Demand

Comparison for a 10 kWh/day System





Energy Storage Estimates

- 20 kWh per day system, 20 m³ solar arrays, 9 kW Wind Turbine
- 120 kWh short term capacity (3 days, 50% DOD)
- For Hydrogen System, 600 kWh long-term capacity required.
- For Battery Only, 650 kWh long-term capacity required (50% DOD)
- Solar Batteries: VOLUME = 12 m³ , WEIGHT = 23 Mt
- LiFePO₄ Batteries: VOLUME = 6 m³ , WEIGHT = 7 Mt
- Hydrogen Long-term + LiFePO₄ Battery: **VOLUME = 2 m³ , WEIGHT = 3 Mt**
- *Smaller Mass and Footprint = Less cost*





Future Plans

- Fuel Cell to Battery and Electrolyser to Battery Interface
- Plug-and-Play System
- Maximise performance of FC and Electrolyser systems





Conclusions

- Potential Application For FCs And Electrolysers
- Systems Could Have Better Performance, More Elegant With A Smaller Footprint