

# **Storage Reservoirs – the answer to intermittent Renewables?**

*Tim Foster – Smartest Energy*

*Kieron Hanson - Hydroplan*



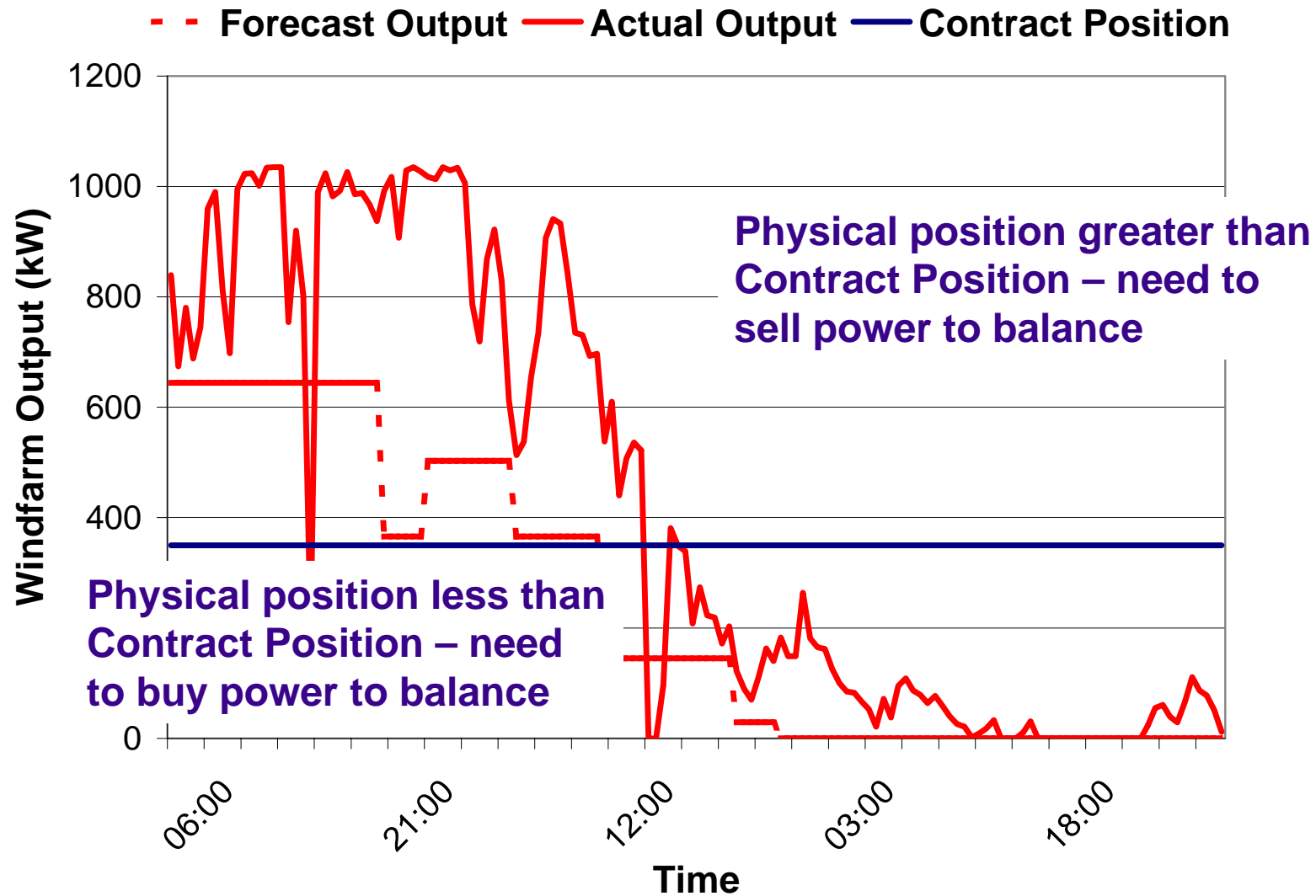
# Overview

- The British Electricity Market
- What do we mean by Variability?
- Opportunities for Hydropower Storage
- Pumped Storage
- Conclusions

# The British Electricity Market

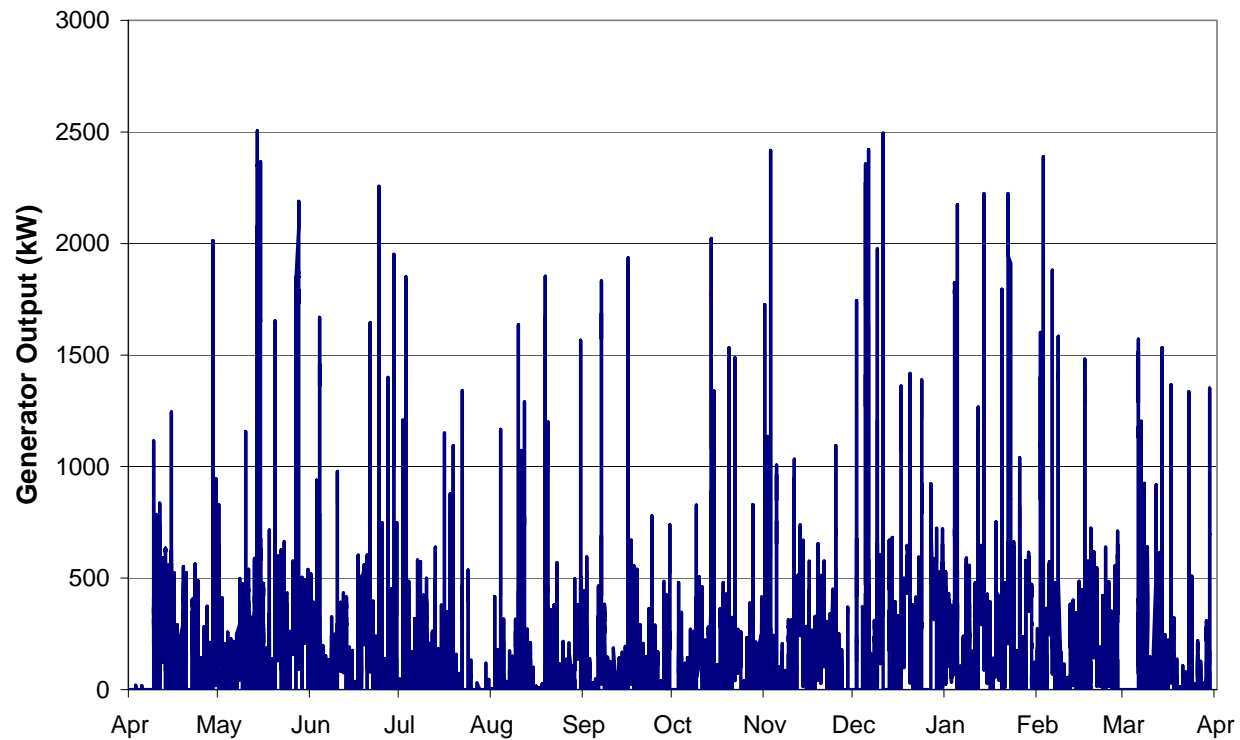
- The British Electricity Trading and Transmission Arrangements (BETTA)
  - Single wholesale electricity market covering England, Wales and Scotland
  - Over the Counter (OTC)/bilateral traded market
- Electricity cannot be stored so supply must exactly meet demand
- In order to meet a Contract Position adjusting trades must be undertaken via the APX or Balancing System
  - Automated Power Exchange (APX – UKPX)
    - Anonymous 24 x 7 marketplace for integrated trading, clearing and notification for spot and prompt power contracts up to gate closure (1½ hours before delivery)
  - Balancing System
    - Post gate closure balancing process administered by Elexon
    - System Sell Price – the price paid by the System Operator if out-turn is greater than Contract Position
    - System Buy Price – the price charges by the System Operator if out-turn is less than contract position

# Managing a Contract Position



# Variability and Intermittency

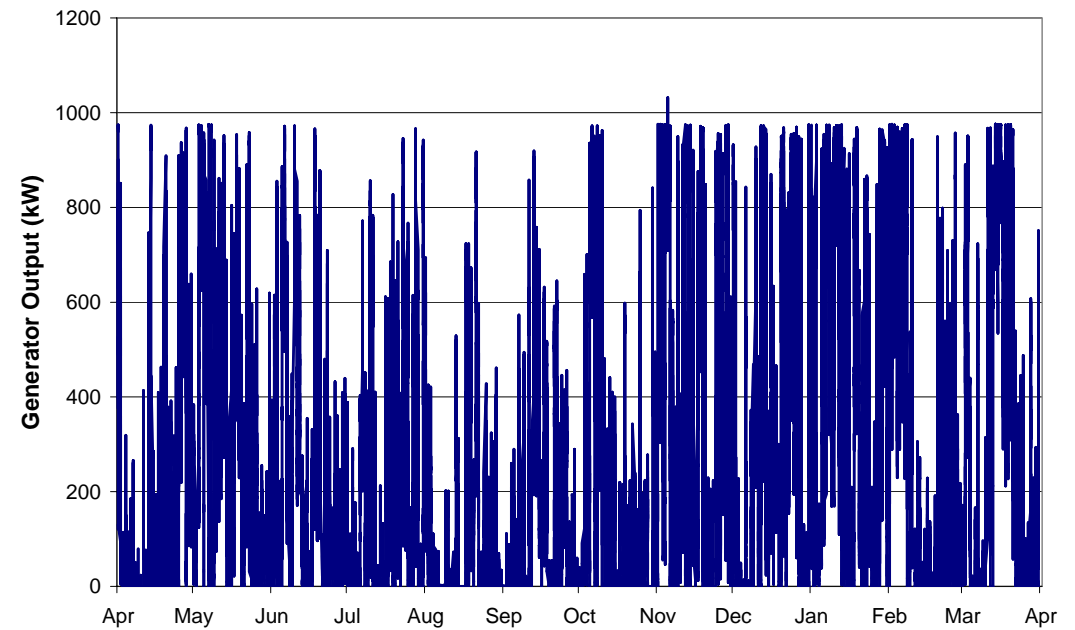
## 5 MW CHP



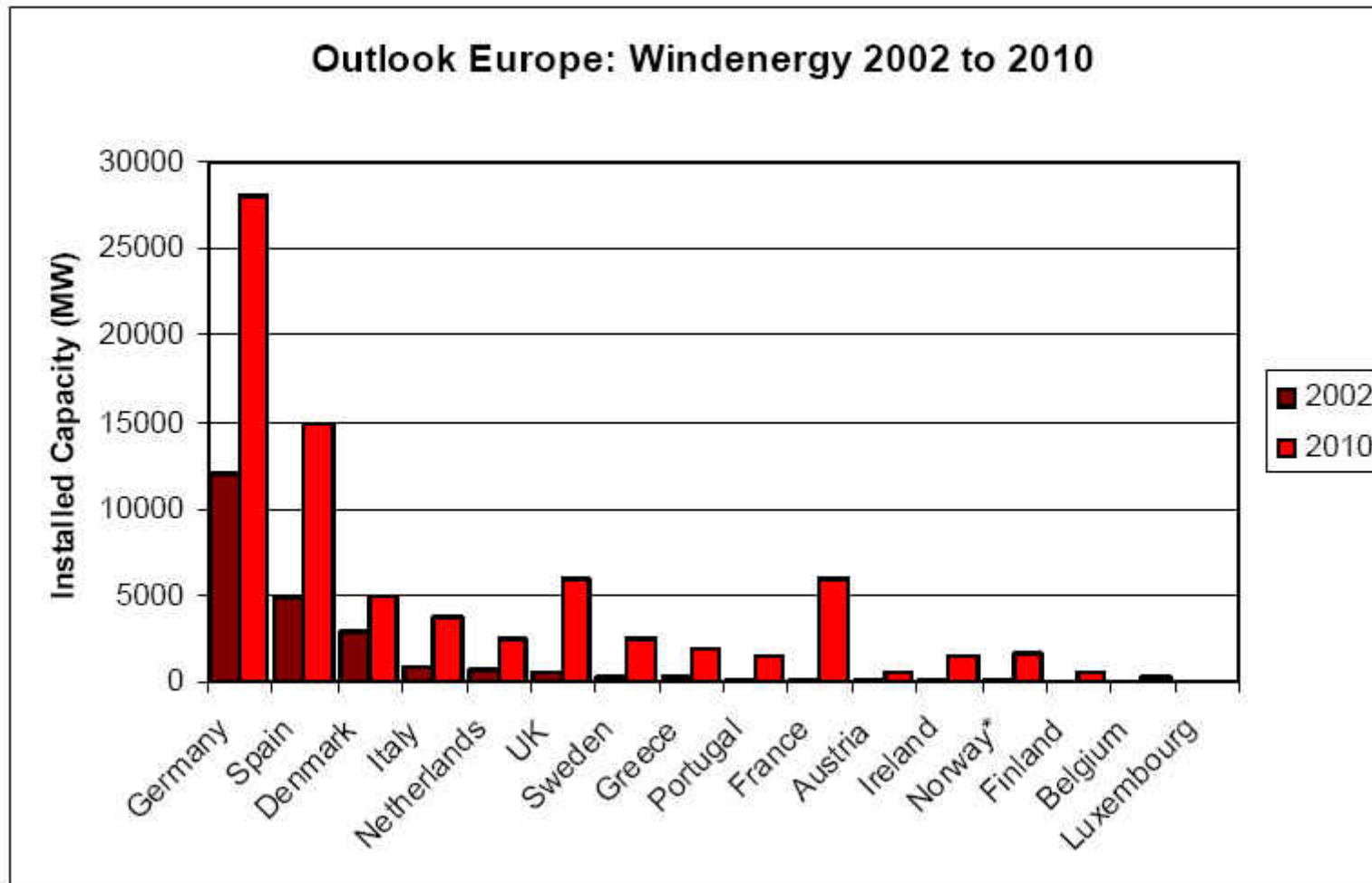
# Variability and Intermittency



2 MW Wind turbine



# Variability and Intermittency – Will it get worse?

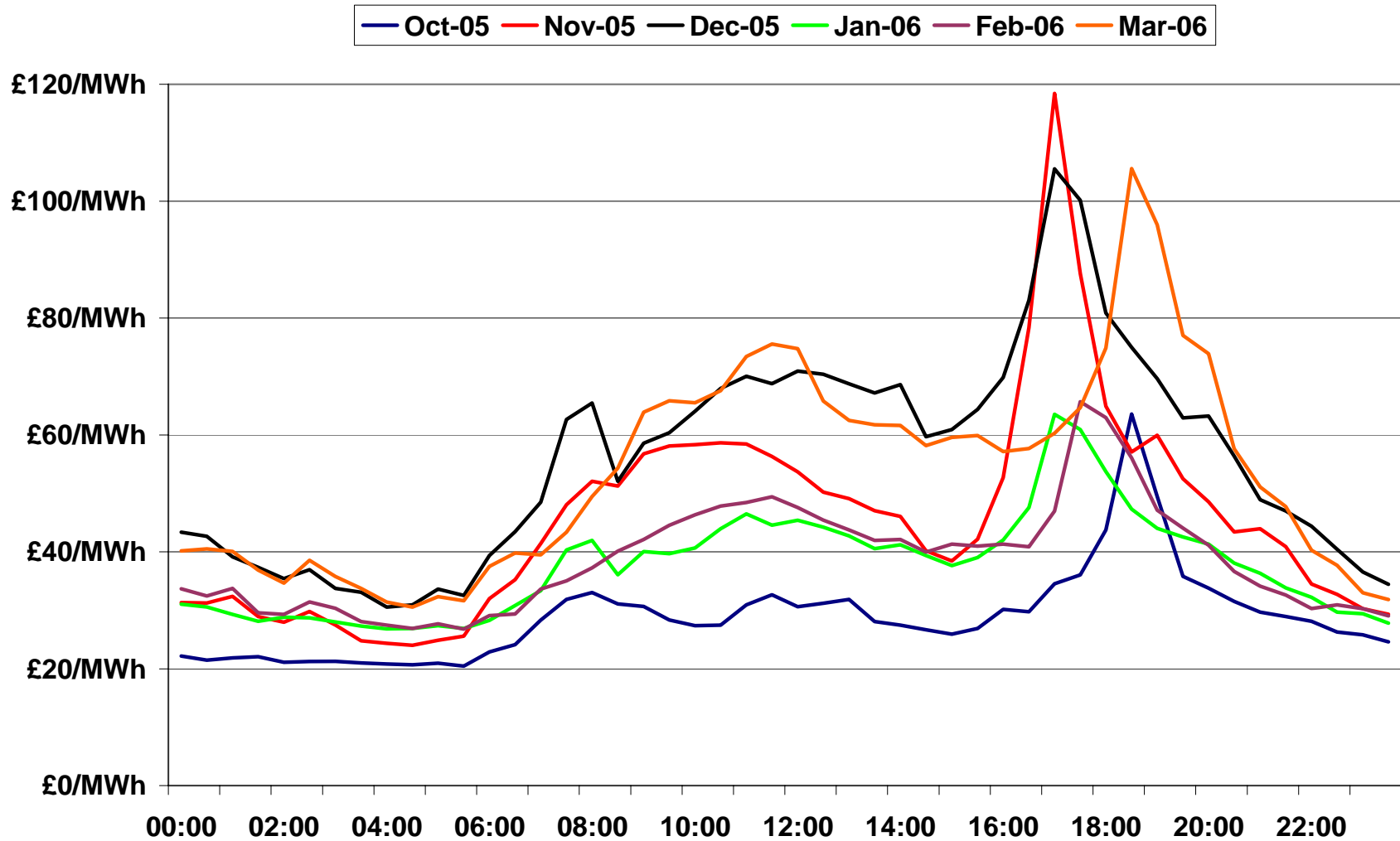


Source: EWEA 2004

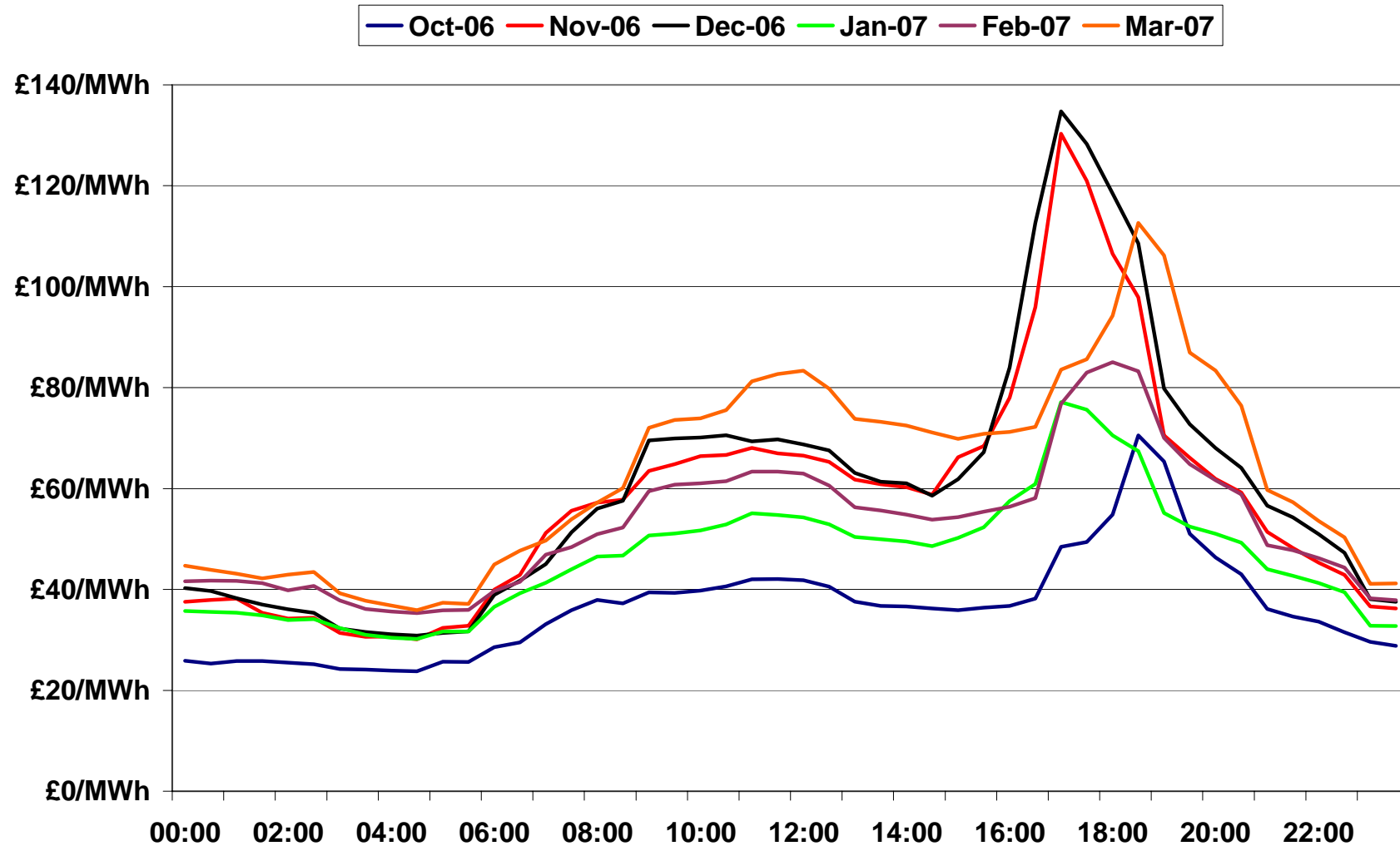
# The Role of Storage in Managing Variability

- Most Independent Hydropower stations operate under standard Power Purchase Arrangements (PPA)
  - Long-term PPA – usually required to raise debt finance with a “floor” price and discount from index pricing mechanism
  - Short-term PPA – 1-3 years of forward price
- Dedicated storage does allow a generator to offer Flexible Services to assist the management of imbalance

# Average System Sell Prices for Winter 2006



# Average APX Prices for Winter 2006



# Utilising Flexible Generation

- Generators are more likely to be utilised during the weekday/weekend trading blocks 3-5 (7:00am to 7:00pm)
- Simple dispatch and certainty of delivery is key
- Ideally with little or no fuel price risk
  - i.e. Volatility in the natural gas market this winter
- “Fuel” constraints (i.e. storage) is not an issue if known in advance
- Clearly hydropower meets all these requirements
  - Capability to store energy and vary the size of this storage
  - Water resource can be utilised to match peak requirements
  - Water can be reused – pumped storage

# Indicative Revenues

- Assuming a 500kW hydropower facility running between 15:00 and 19:00hrs daily (i.e.730MWh/year or 90kW baseload)

|     | Oct    | Nov    | Dec    | Jan    | Feb    | Mar    |
|-----|--------|--------|--------|--------|--------|--------|
| APX | £2,870 | £5,733 | £6,322 | £3,966 | £3,866 | £5,116 |
| SSP | £2,252 | £4,048 | £4,958 | £3,036 | £2,773 | £4,183 |

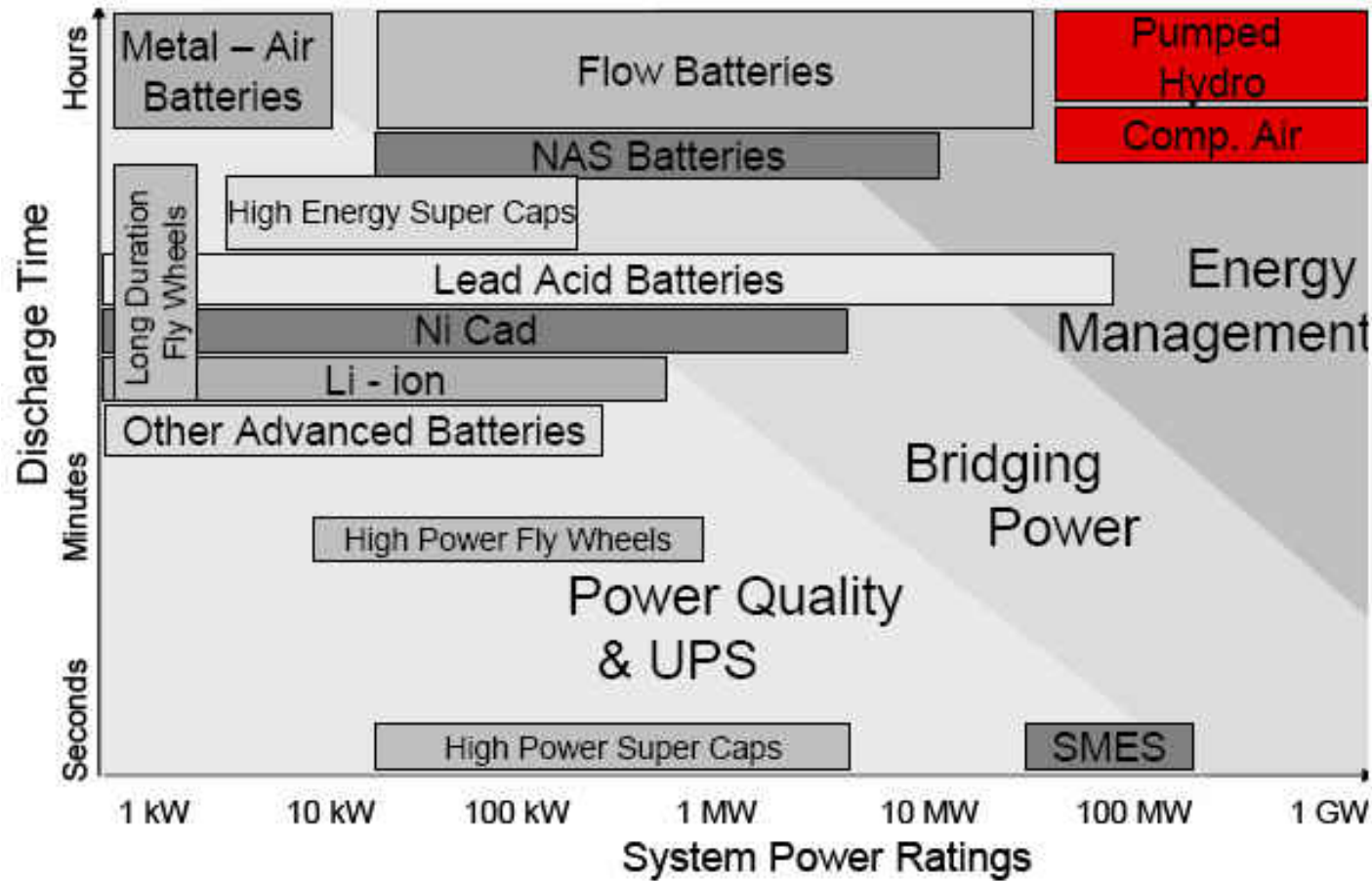
- Total Revenue for Winter 2006
  - APX £27,800
  - SSP £21,200
  - Plus ROC revenue
  - Plus LEC Revenue

## Indicative Economic Return

- A typical RoR 500kW hydropower facility would typically produce 1750MWH/year which might produce an average income of £131k at 7.5p/kWh.
- Running between 15:00 and 19:00hrs daily during the winter provides a further £27k per year
- Adding 4 hour storage to a high head scheme might add £100k to the capital cost (CAPEX) which could then be £850k
- **However**, the benefit is 20% increase in revenue for a 13% increase in CAPEX

.....Good Investment Decision!!

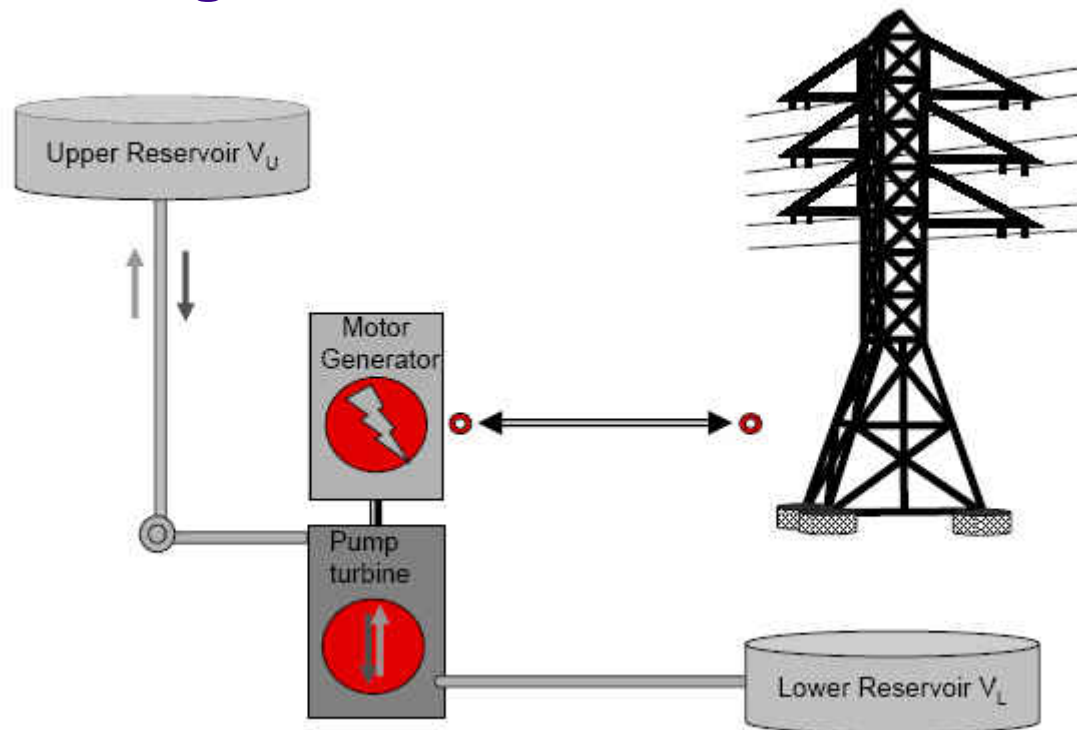
# What is the alternative to Storage?



Source: Mirjam Sick VATEch

# Is Small Scale Pumped Storage Viable ?

## Traditional Large PS



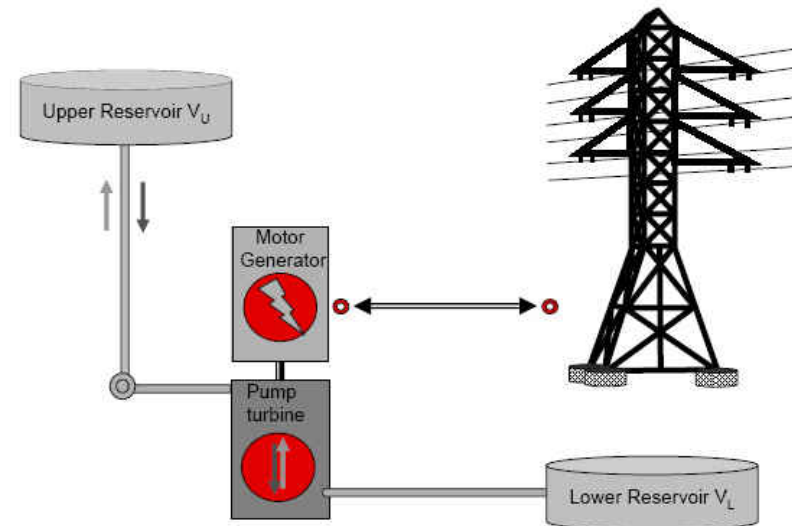
Typically > 300MW and > 300m Head

Source: Mirjam Sick VATEch

# Is Small Scale Pumped Storage Viable ?

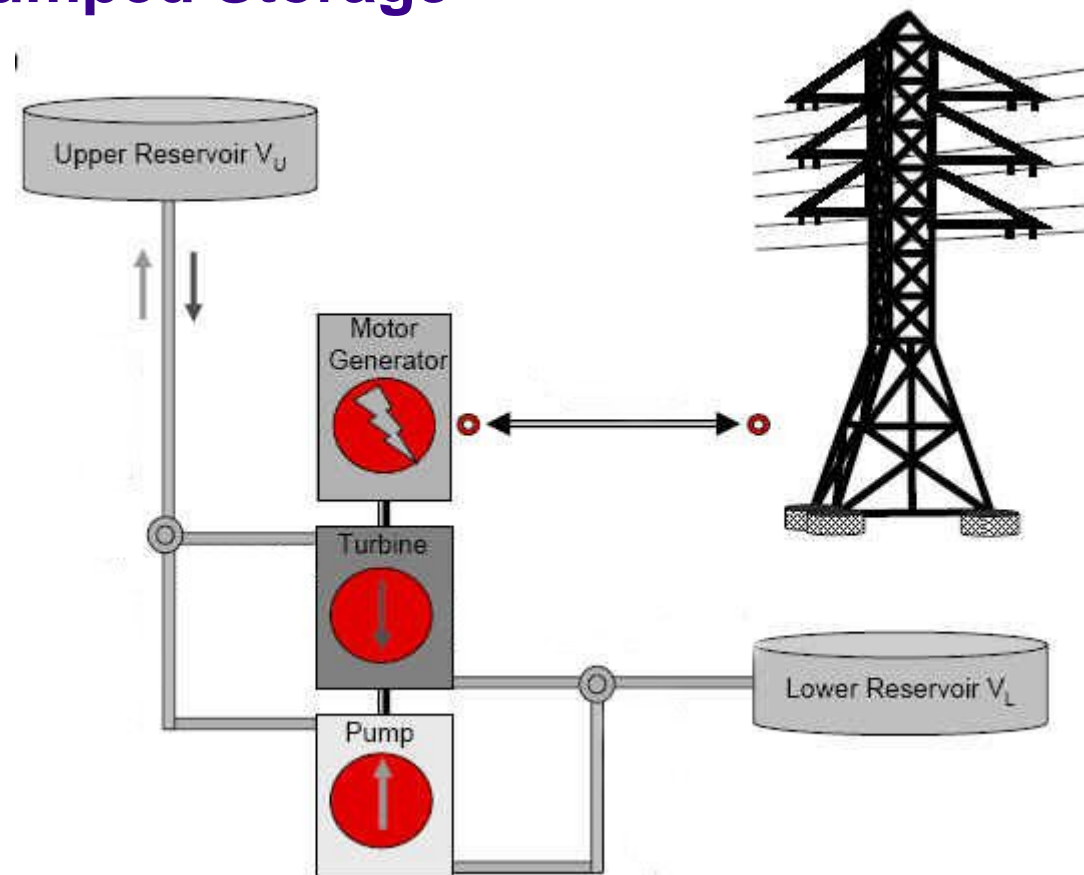
## Benefits

- Fast Response – grid regulation
- Balancing Power
- Peak Shaving
- Seasonal Variation



# Is Small Scale Pumped Storage Viable ?

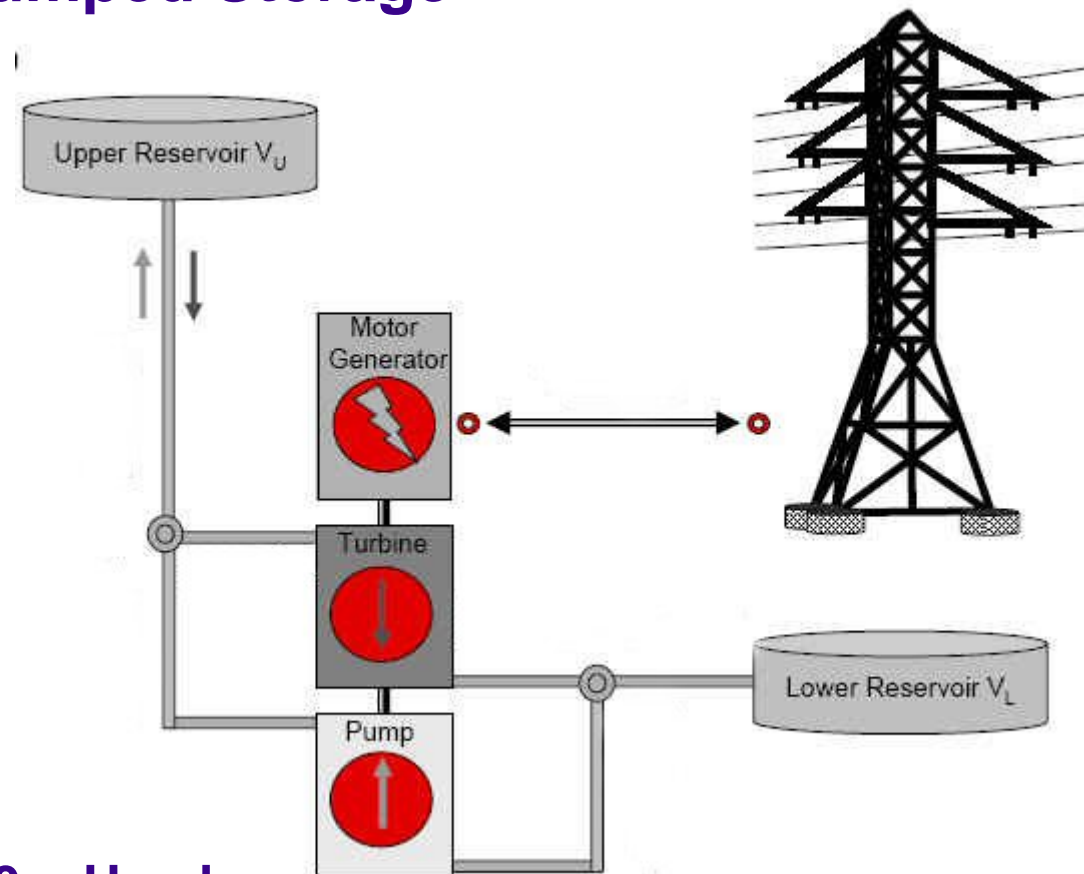
## Small Pumped Storage



Source: Mirjam Sick VATech

# Is Small Scale Pumped Storage Viable ?

## Small Pumped Storage



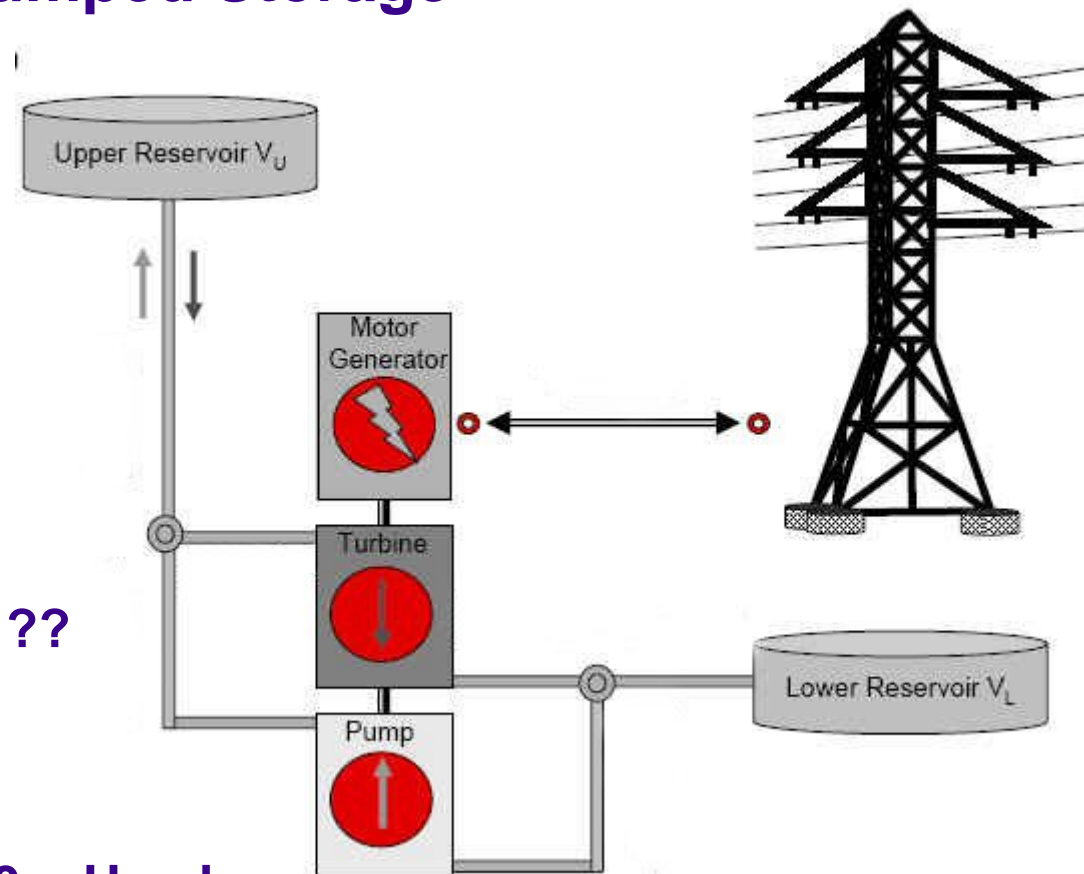
11MW Pump

Say 150m – 250m Head

Source: Mirjam Sick VATEch

# Is Small Scale Pumped Storage Viable ?

## Small Pumped Storage



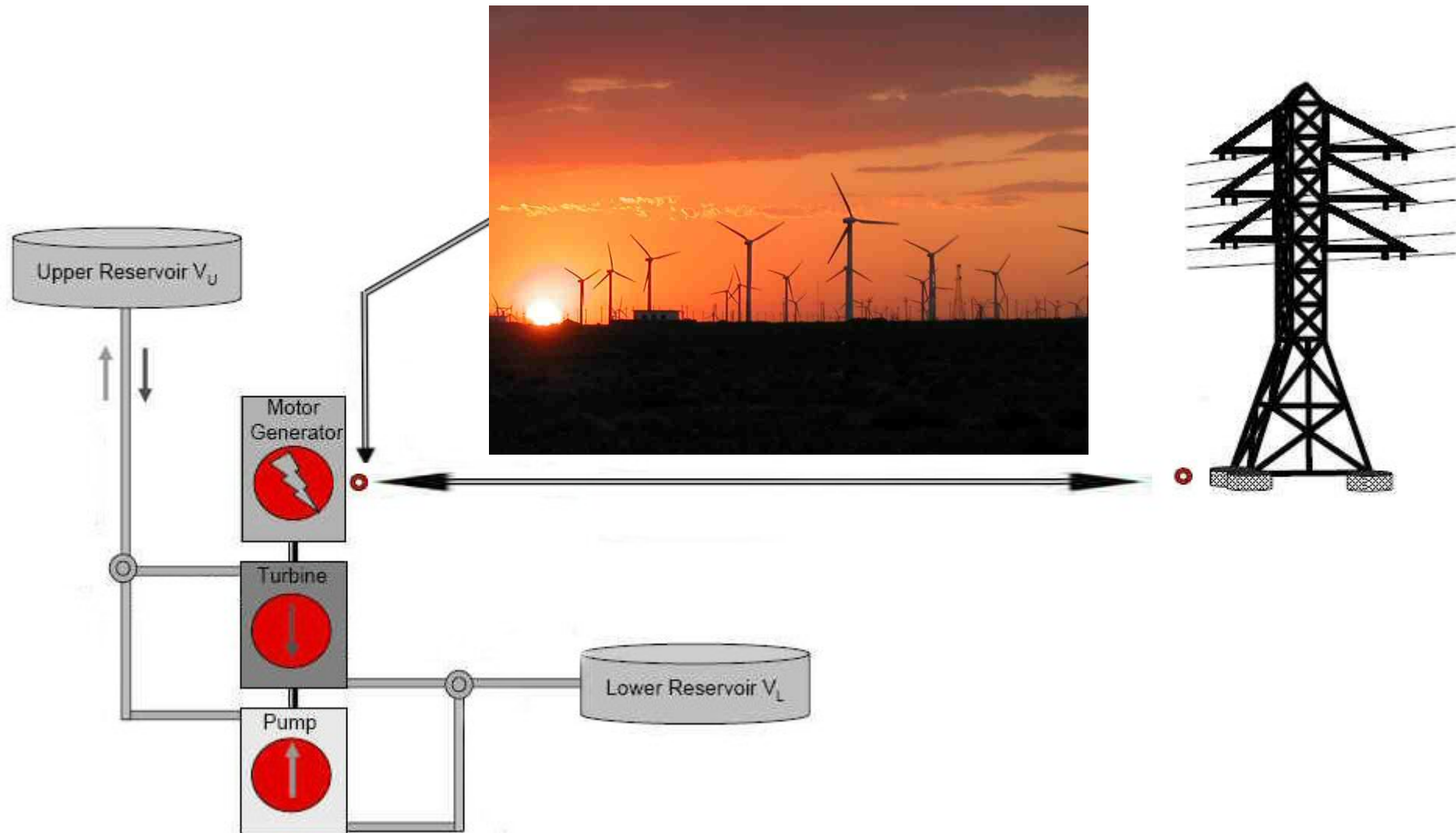
11MW Turbine ??

11MW Pump

Say 150m – 250m Head

Source: Mirjam Sick VATEch

# Is Small Scale Pumped Storage Viable ?



# Is Small Scale Pumped Storage Viable ?

## Economic..... Or not?

Consider:

Wind farm (say 30 – 40 MW) with even wind distribution throughout each day !!

For 8 hours (during the night) it does not export everything to the grid but pumps water up to the top reservoir via an 11MW pump. It uses 32.1GWh to pump each year @ 2.5p/kWh = £0.80m “lost” to the wind farm

11MW Turbine then releases the energy at a high tariff but because of pump & turbine efficiencies only produces 24.1 GWh in the year but at a higher tariff

Assuming an 11MW “small” PS scheme costs £12.1m and the developer wants a 10 year payback. Taking account of operating costs (say 5%) then the nett income needed is £1.27m / year. The total annual cost is £1.27m + 0.80m = £2.07m. Hence, the differential between the low and high tariffs must be 8.6p/kWh for about 8 hours!!!

# Is Small Scale Pumped Storage Viable ?

## Economic..... Or not?

Now Consider:

That the site of the small PS has the potential for a 3MW conventional hydro site. With storage it could produce 13.1 GWh / year

As before the Wind Farm delivers water for 8 hours (during the night) and loses £0.80m.

14MW (11MW + 3MW) Turbine then releases 24.1 GWh from the pumped water plus 13.1 GWh from the natural catchment = 37.2 GWh

Assuming a 14 / 11MW “small” PS scheme costs £13.8m and the developer wants a 10 year payback. Taking account of operating costs (say 5%) then the nett income needed is £1.45m / year. The total annual cost is £1.45m + 0.80m = £2.25m. Hence, the differential between the low and high tariffs is reduced to 5.9 p/kWh for about 8 hours.

# Is Small Scale Pumped Storage Viable ?

## Economic..... Or not?

Finally:

Assume that the 13.1 GWh / year attracts Renewable Obligation Certificates (ROCs) at 4p/kWh = £0.52m

Now the total annual cost is  $£1.45m + 0.80m - £0.52m = £1.73m$ .  
Hence, the differential between the low and high tariffs must be 4.5 p/kWh for about 8 hours.

ALMOST THERE???

Not Quite.....but consider the grid transmission benefits!!

# Conclusions

- Storage (even a few hours worth) can add value to a traditional hydro project – typically 5 - 10%
- On an imperfect grid, storage can be useful and hydro reservoirs are the most efficient storage mechanism
- Small Pumped Storage coupled with wind farm(s) is not quite economically viable but:-
  - It could provide Balancing at grid nodes
  - It does reduce the need for some increased grid capacity
- **Intuitively, Pumped Storage must add benefits to the grid and with a little incentive a valuable resource could be added**



**Watch This Space...!!**