LPMS Lecture 14
Case study

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EPower

Introduction

- `EPower` provides electricity for a small country
- Four power generation sources

Gas

Coal

Nuclear

Wind

- Can also supply power from abroad via the **interconnect**
- Must match **demand**
- Objective is to maximize profit

EPower needs **your** advice on how to reduce its environmental impact

EPower: Generation and emissions

Power and energy

- Power output measured in Megawatts (MW)
- Energy is power output for a period of time
  - Equal to “power” $\times$ ”time”
  - Measured in Megawatt hours (MWh)

Power source parameters

Power sources characterized by

- Max power output (MW)
- Running cost (£/MWh)
- Increase cost (£/MW)

Emissions

- Burning **gas** produces CO_2
- Burning **coal** produces CO_2 and sulphur
- Emissions of CO_2 and sulphur are limited

EPower: Demand

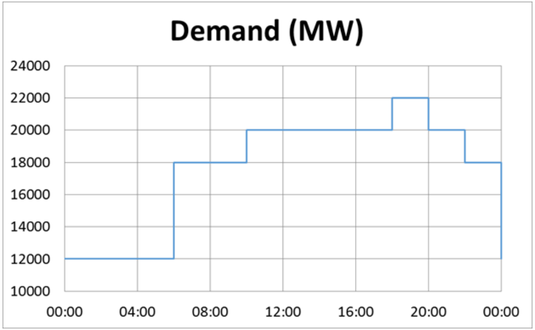
- Average demand varies through the day

  Times: [1 2 3 4 5 6]

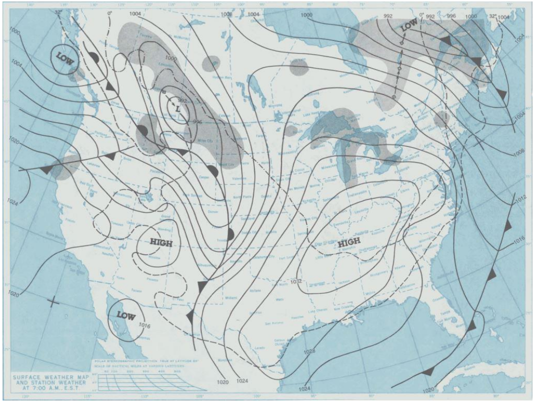
  PeriodLength: [6 2 8 4 2 2]

  Demand: [12000 18000 20000 22000 20000 18000]

- Power output in each period must equal the demand



- Wind power output varies with the weather
- Generation schedule must be adaptable
- Maximum generation capacity 22000 MW



EPower: Interconnect

- Power line linking neighbouring networks
- Used to buy and sell power
- Not linked to any fuel type
- For `EPower` this is modelled as a power source of up to 20000 MW

EPower: Data

Power generation

	Gas	Coal	Nuclear	Wind	Interconnect
Max output (MW)	6000	6000	5000	22000	20000
Running cost (£/MWh)	40	30	50	2	100
Increase cost (£/MW)	80	60	10^{10}	1	50

Electricity price: £35/MWh

Emissions

	Units/MWh		(Units)
	Gas	Coal	Daily limit
Sulphur	0.0	0.4	30000
CO_2	0.8	1.2	200000

Decisions

In each time period

- The power output for each source
- Increase in power output for each source

LPMS consulting

1. Develop a "**base case**" model which replicates current decision-making
   Builds confidence with the client
   - Demonstrates understanding of status quo
   - Generates faith in future recommendations

2. Use the model to advise on strategic decisions in a given set of scenarios
   Gives the client what was asked for

3. Identify a few further specific ideas for the client to consider
   Shows we do more than the minimum

4. Suggest what further consulting might consider
   Hope to get a further fee!

EPower: Case study

Base case

Use `EPower0.dat` to find the operation schedule for a constant maximum wind power output of

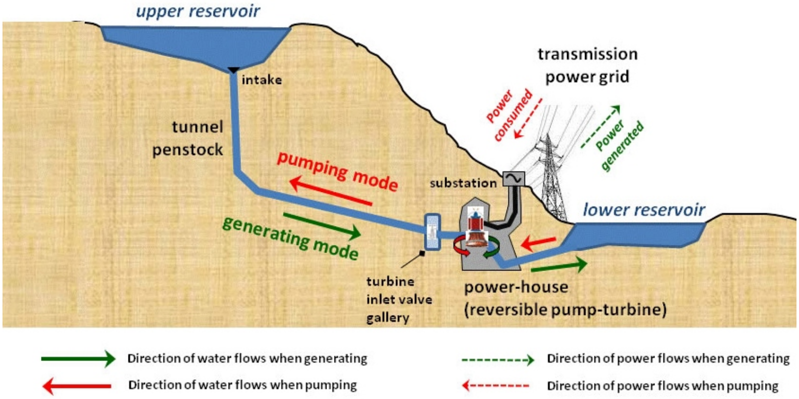
- 0 MW (calm day)
- 22000 MW (very windy day)

Investigation

Use `EPower.dat` to find the operation schedule for an average maximum wind power output and assess

- Effect of building a pump storage hydro-power scheme
- Effect of not using nuclear power

EPower: Pumped-storage hydro



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- For EPower, natural flow into reservoir yields power output of 400 MW
- Collect natural flow to release at higher power output during peak demand
- Increase scope for hydro power by pumping water up at times of low demand

EPower: Pumped-storage hydro

Data

- Running cost: £5/MWh
- Increase cost: £5/MWh
- Maximum reserve: 25000 MWh
- Natural inflow: 400 MW
- Pumping efficiency: 80%

Decisions

- In each time period:
  - The pumping power demand
  - The hydro power output
- The energy stored in the reservoir at the end of each time period

Modelling

- Treat energy stored in the reservoir as an inventory problem
  - Energy input comes from natural inflow and (efficient) pump power over time
  - Energy output comes from hydro power output over time
  - Energy stored must not exceed reserve
- Add pumping power demand to customer demand so pumping power is generated

EPower: Investigation data

- Data file `EPower.dat` has values for pump storage hydro-power scheme
  - When necessary, "switch off" the pump storage hydro-power scheme by setting

    ```
    MaxOutput("Hydro") := 0
    NaturalHydroInflow := 0
    ```

    and redefining the hydro-power model
  - Cost of building pump storage hydro-power scheme is accounted for by a daily charge of £1 million
- For your wind power output, see `EPowerScenarios.pdf` on Learn
  - Add your value to `EPower.dat` and submit this file

Consultancy: My experience

I have done consultancy work for companies writing software for

- Animal feed formulation
- Chemical engineering
- Petroleum engineering
- Power and water engineering

Some of these relationships have lasted over 20 years

Consultancy: Golden rules

As a consultant, tell the customer them something that

- **They know**
  - Establish your credibility
- **They wanted to know**
  - Answer the question that was asked
- **They didn't ask to know**
  - Shows that you do more than the minimum
- **They might want to know**
  - Tempts them to re-employ you

Case study deliverables

- Report: Cover page plus max 4 pages
- Model:
  - **One** MOSEL file
  - **One** data file including your wind scenario

Marks	For
25	Results
25	Mosel skills
25	Report content
15	Report-writing skills
10	Bonus

Bonus is for observations/conclusions/recommendations and unprompted investigations

Case study deliverables: Report contents

- Introduce the aspect of the company to be investigated
  - Place the investigation in context
  - Don't include large tables of data: refer to an appendix if necessary
  - Don't include equations
- State the "base case" results clearly
  - Use tables and charts sparingly
  - Shows that you start from a point well-understood
- Consider the points to be investigated systematically
  - Use tables and charts sparingly
  - Don't just give results, but also interpretation and analysis
- Think what else you could investigate with your model
- Offer general observations, conclusions and recommendations

Case study deliverables: Report presentation

- Aim to produce a neat and tidy document
  - Right-left justified text
  - Quote values to a sensible number of significant figures
  - Make tables and charts a sensible size
- Don't spend **hours** beautifying your document
  - Can raise suspicions
  - There are no marks for fancy graphics
- Something of **you** should come across

Case study deliverables: Model

- Write the model to be readable by a **Mosel user**
- Ensure that the base case can be solved using `EPower.dat`
- Not necessary for the model to generate all the results in your report without modification

  But, give some indication how to use it to investigate different aspects of the case study
- Submit one data file including your wind scenario
- Use good Mosel style

Summary: http://www.maths.ed.ac.uk/hall/Xpress/Consultancy.html