Economics of Wind

Wind Generation as a Commercial Entity

Doireann Barry, Power System Operation
EirGrid

Tuesday 30th January 2007

Overview of Presentation

- Overview of Irish System, including plant mix
- Wind & the Electricity Market
- Curtailment V Constraints
- 2020 Grid Study

Overview of the Irish Systems, including plant mix

Description of Irish Systems (1)

Ireland

- Generation
  - 5,788 MW installed excluding wind
  - 745 MW wind (increasing)
  - 642 MW max wind output
  - 6,533 MW total installed
- Demand
  - Peak 5,042 MW, and increasing

Northern Ireland (UK)

- Generation
  - 1,807 MW installed excluding wind
  - 120 MW wind (approx)
  - 1,927 MW total installed
- Demand
  - Peak 1,719 MW, and increasing

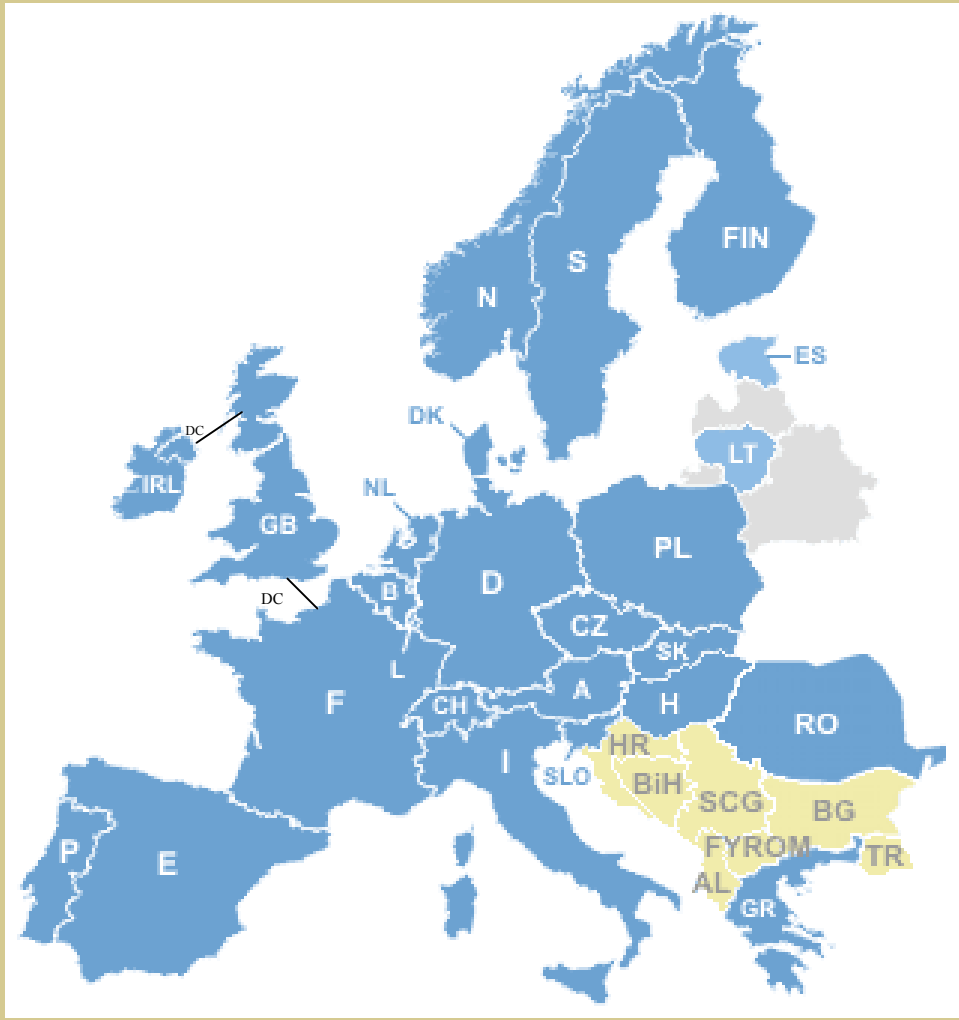
Description of Irish Systems (2)

Interconnection

- Ireland – Northern Ireland
  - 2*600 MVA (275kV AC)
  - 2*120 MVA (110kV AC)
  - Further interconnection proposed

- Northern Ireland – Britain
  - 500MW HVDC undersea double pole cable

- Ireland – Britain
  - 500MW HVDC to be owned by EirGrid due 2012, following Government decision.



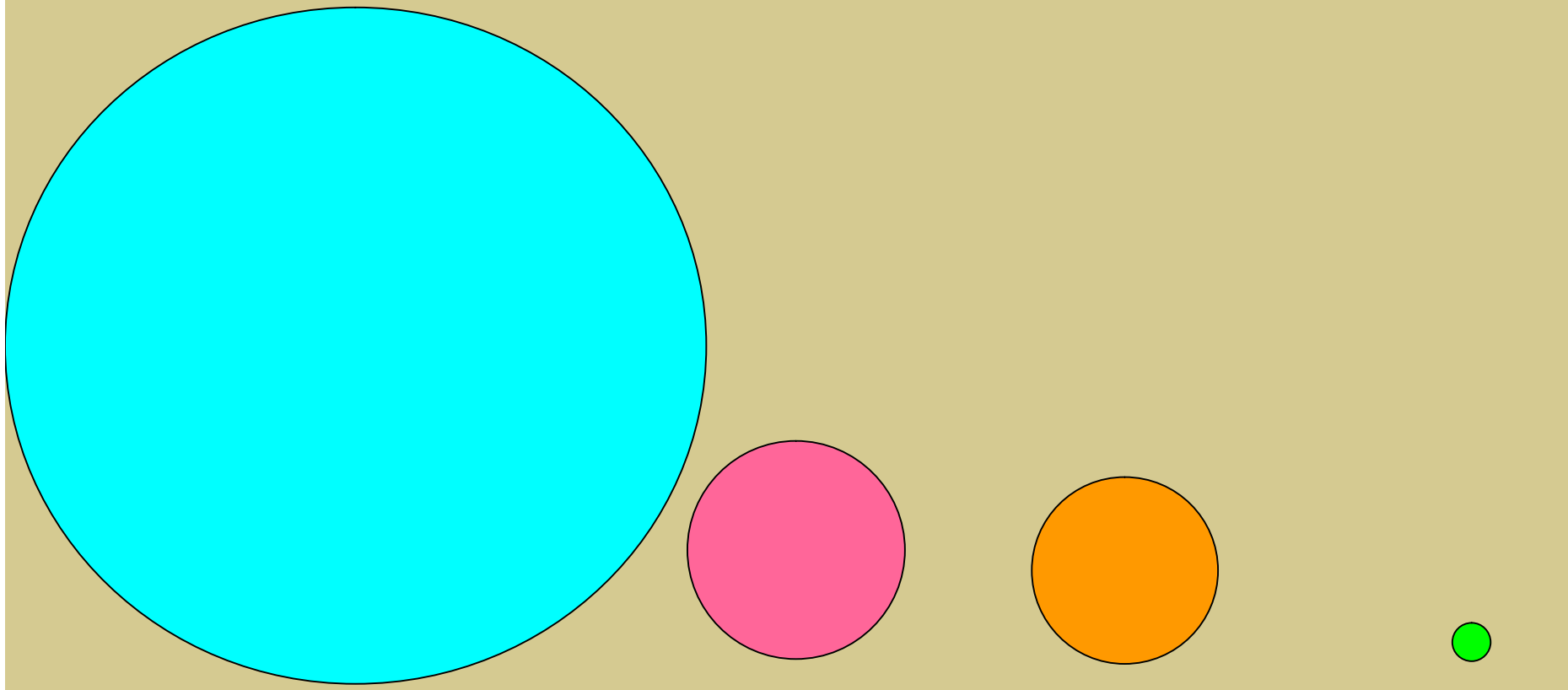
Irish Transmission System

- 439 km of 400kV
- 1,826 km of 220kV
- 4,447 km of 110kV
- 165 substations

Northern Irish Transmission System

- 400 km of 275kV
- 867 km of 110kV
- 38 substations

European Synchronous Power System
Total Generation Capacities



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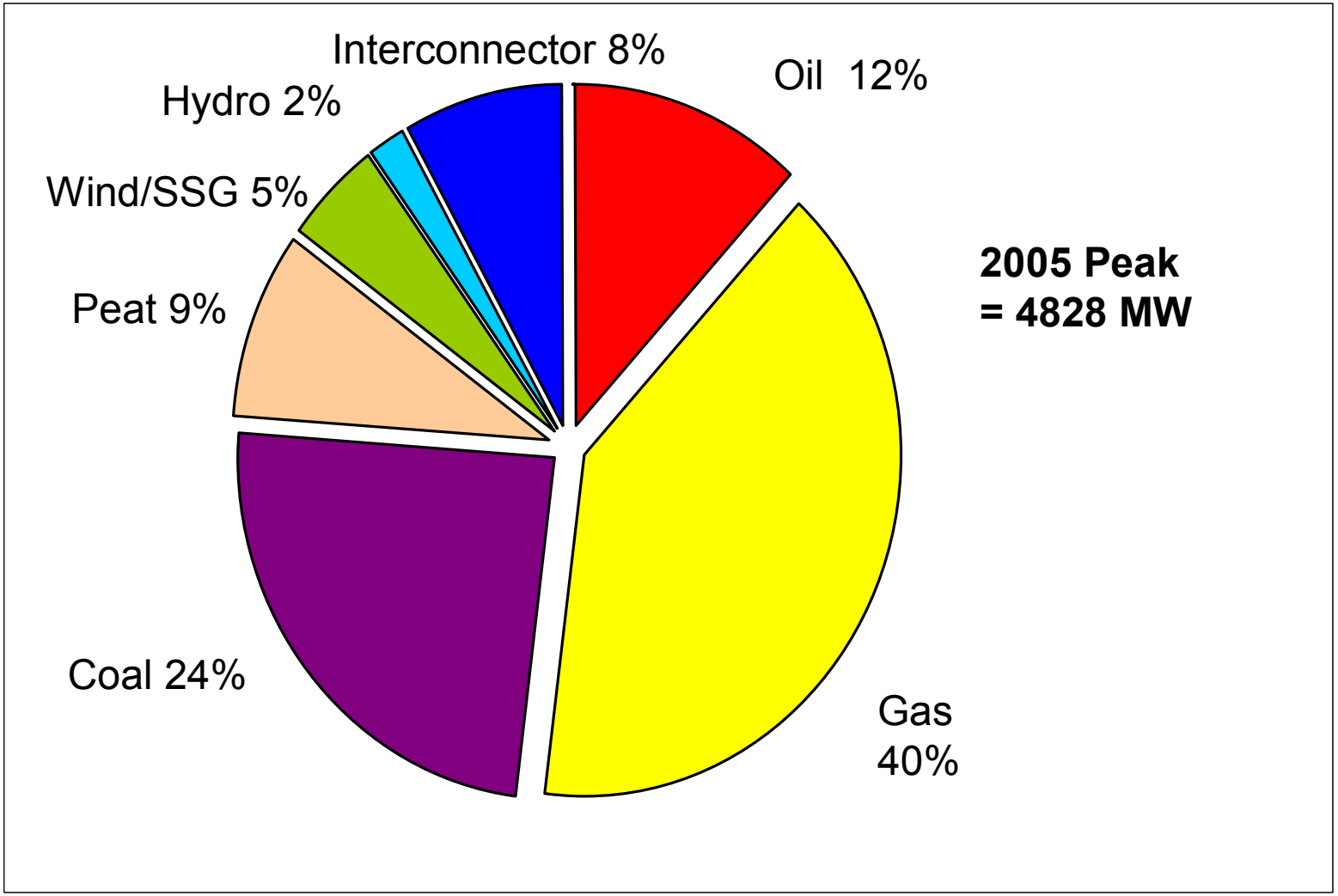
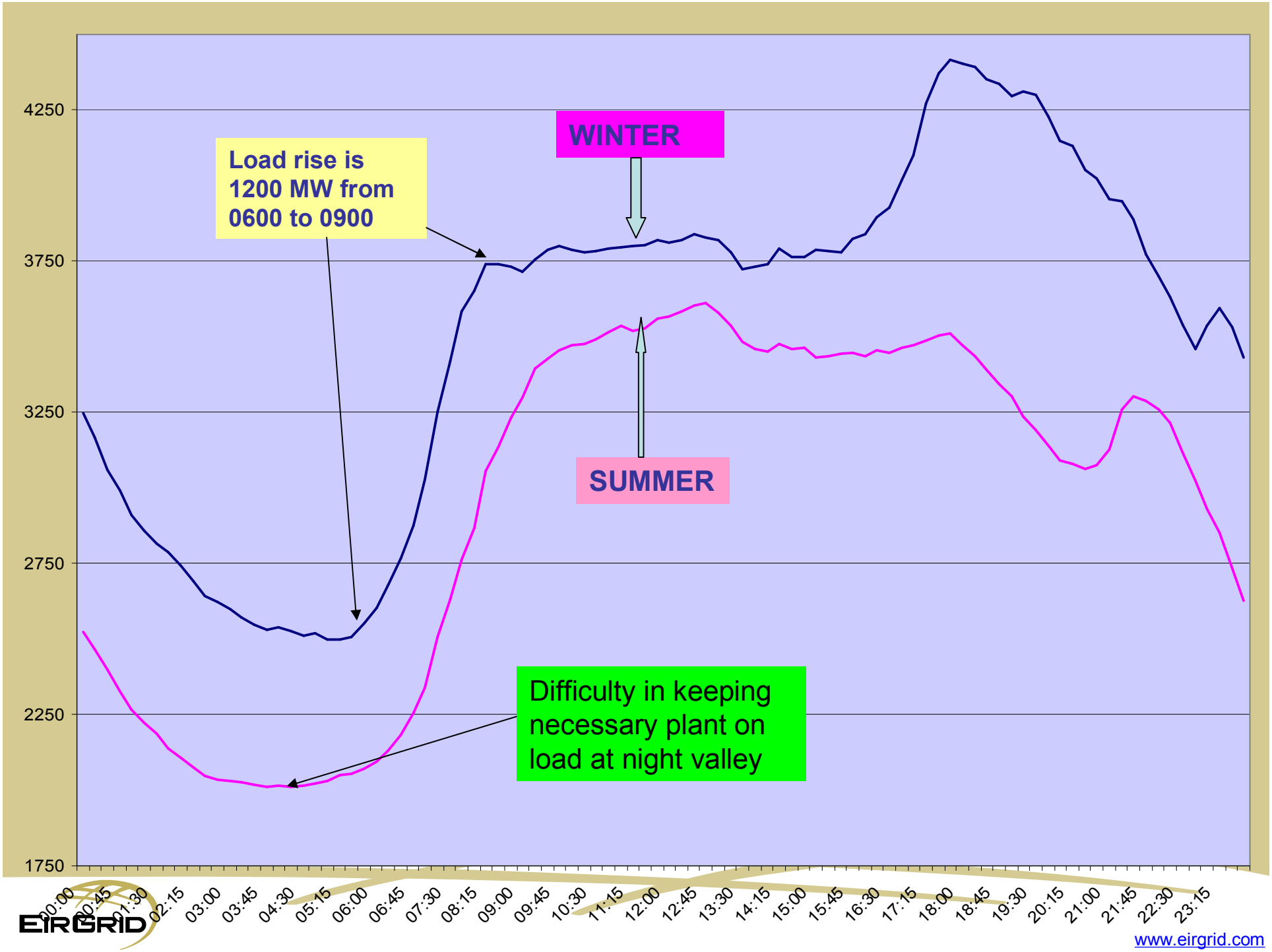
Special Characteristics of combined Irish Systems

Large generating unit size	420 MW with a peak of 6,761MW and a minimum of 2,500 MW (single unit can be up to 15% of demand)
Only HVDC interconnection to the island	500MW HVDC bipolar link from Northern Ireland to Scotland and thence to a single overhead 275kV circuit to main UK grid
System separation impact	Must limit interconnector flows between two systems
Frequency response	>0.5 Hz fall for loss of a large generator
Operating reserve must be fast acting	5 second response essential
Dependence on imported gas	Only 3 pipelines from same source
Underfrequency can initiate defence measures	Pumped storage response, gas-turbine peaking, contracted customer disconnection, load shedding

Fuel Mix 2005





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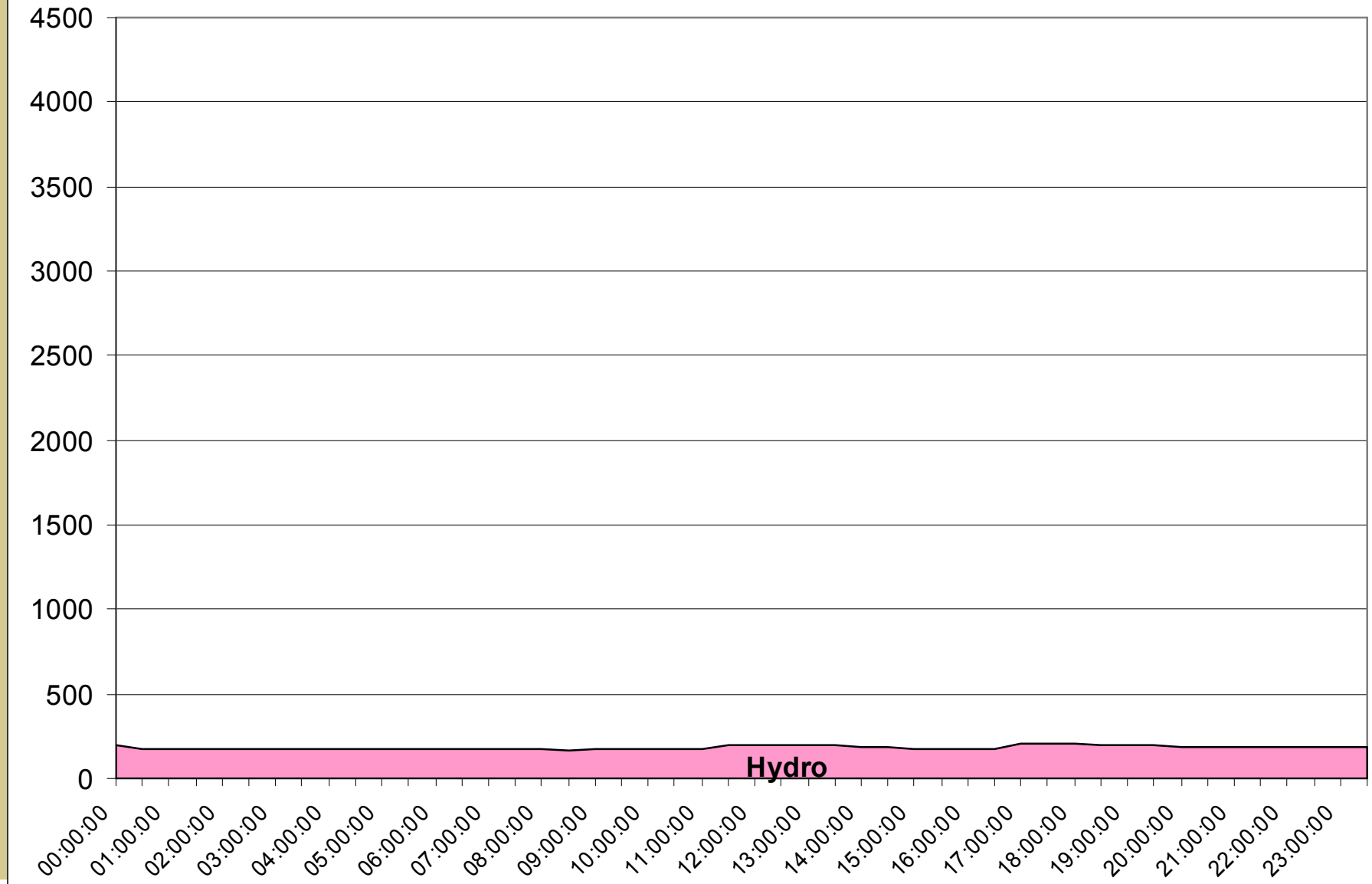
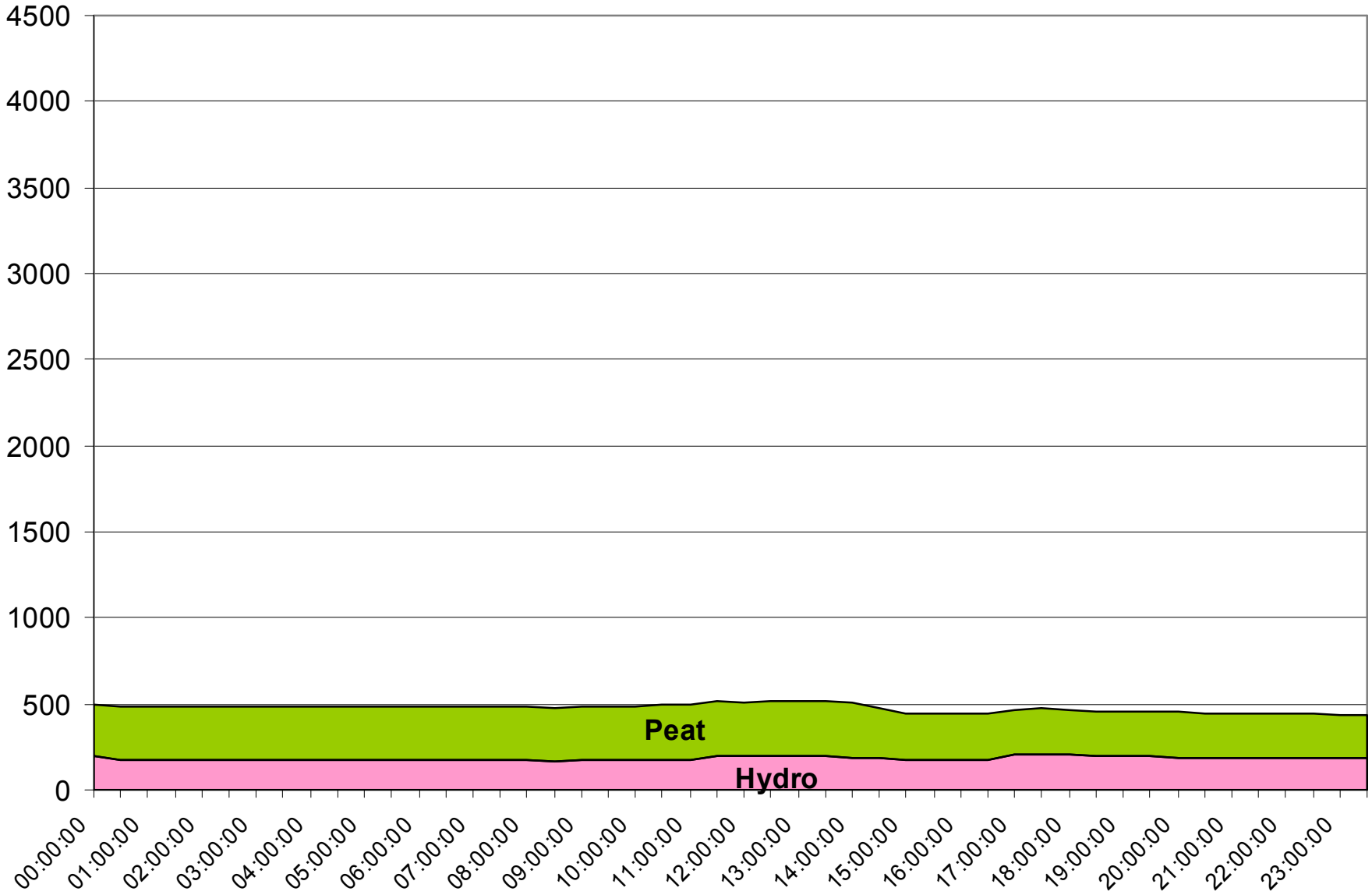
Fuel Mix on Typical Winter Day



Fuel Mix on Typical Winter Day



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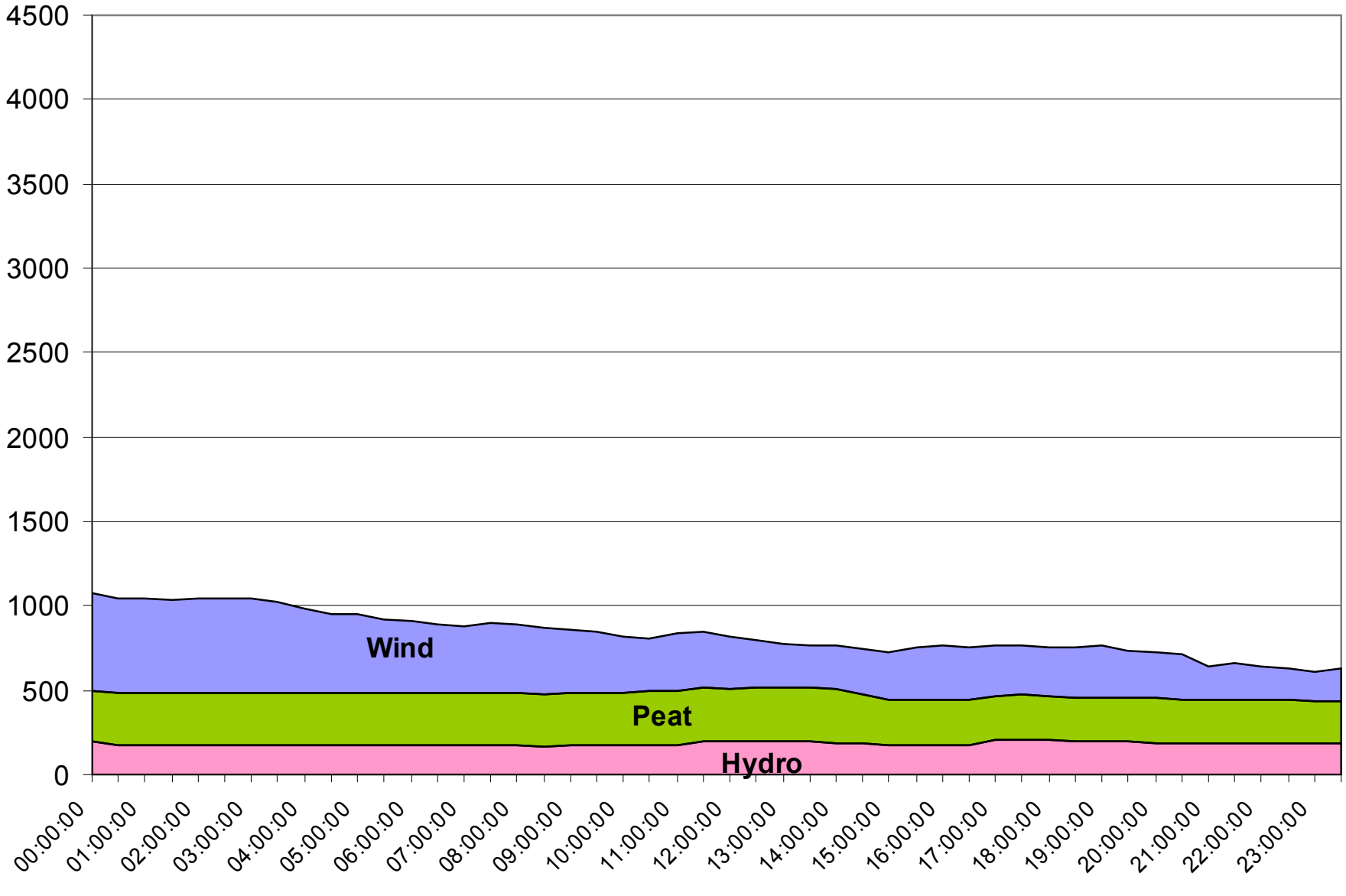
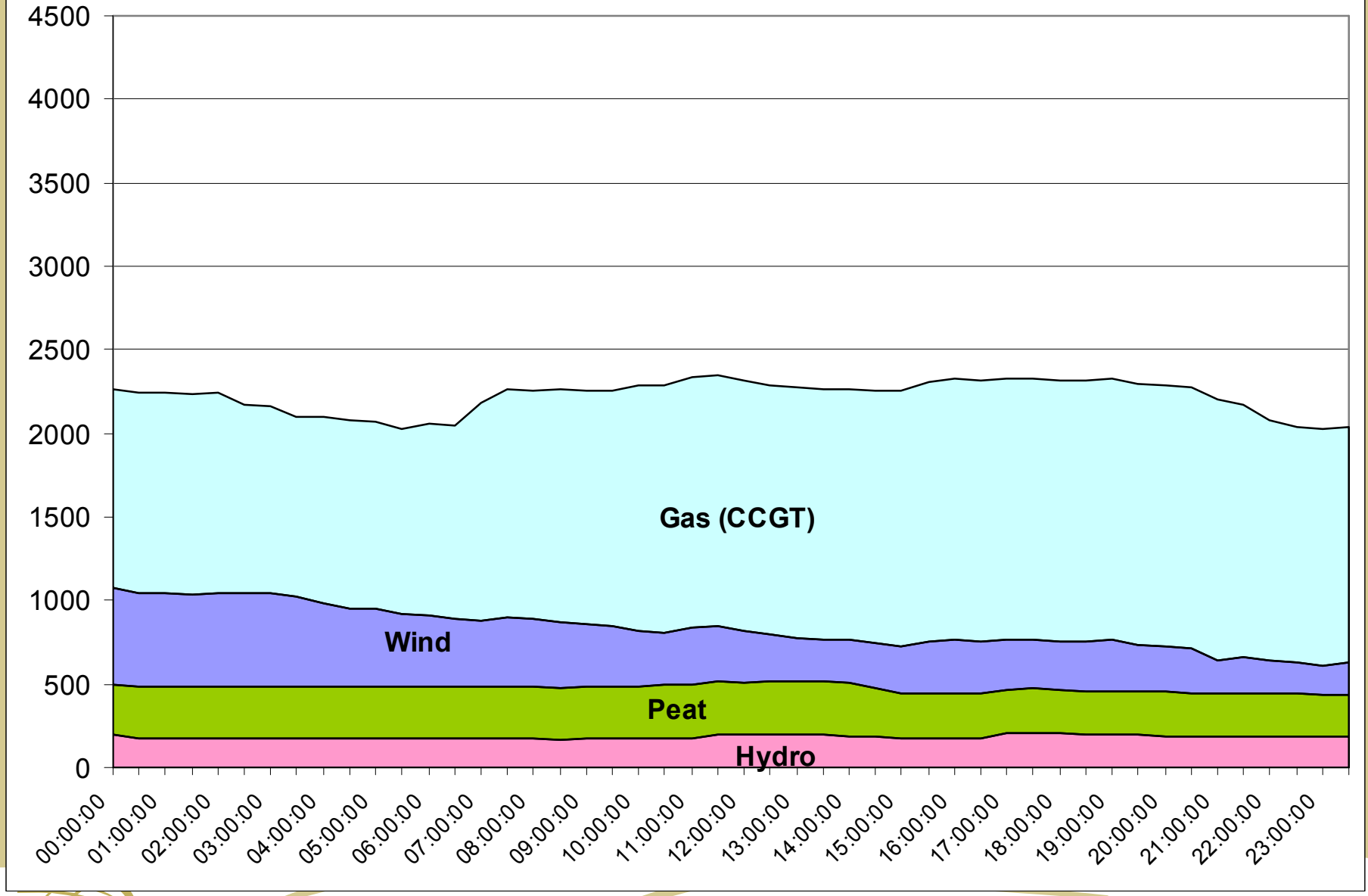
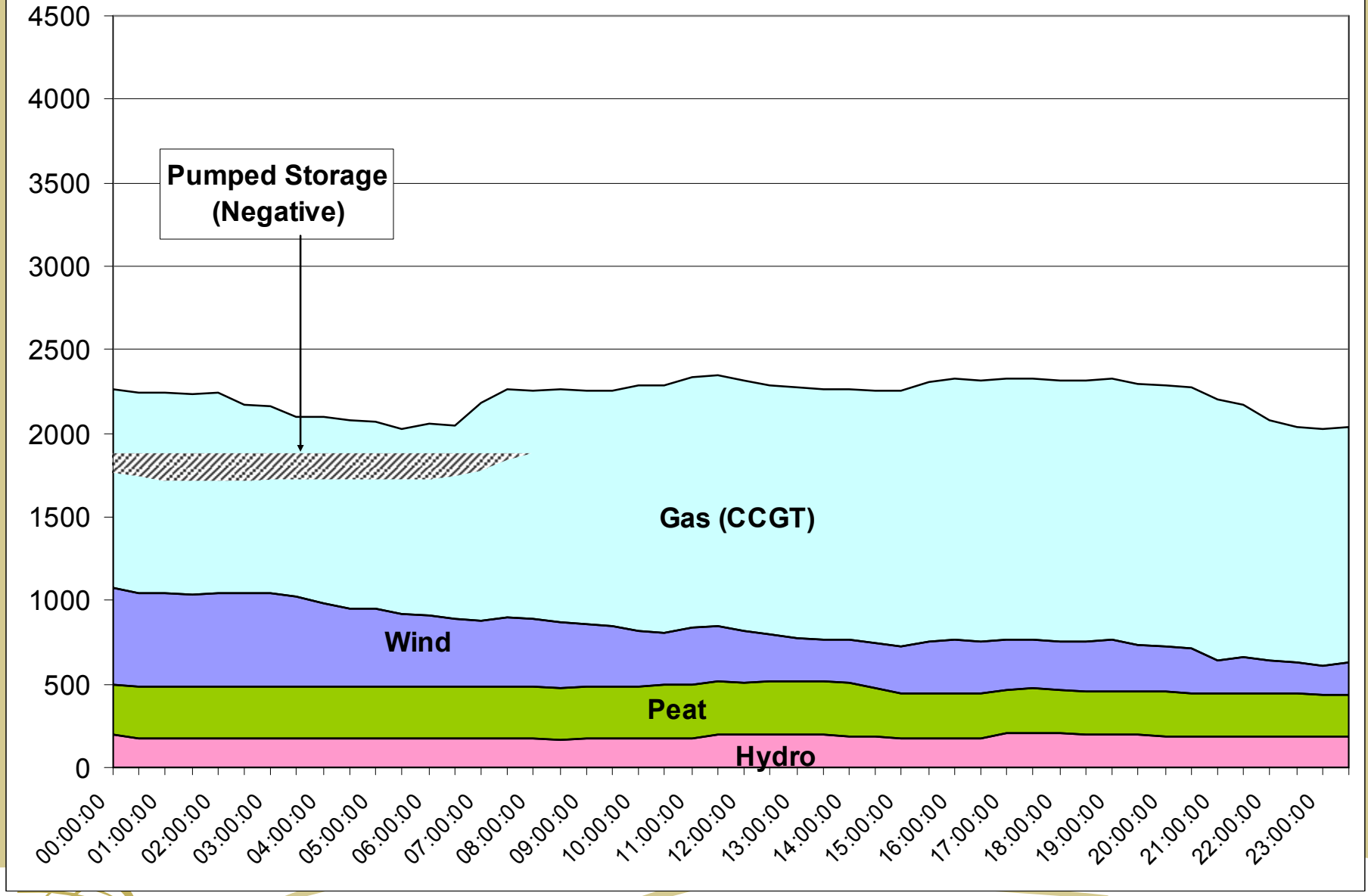


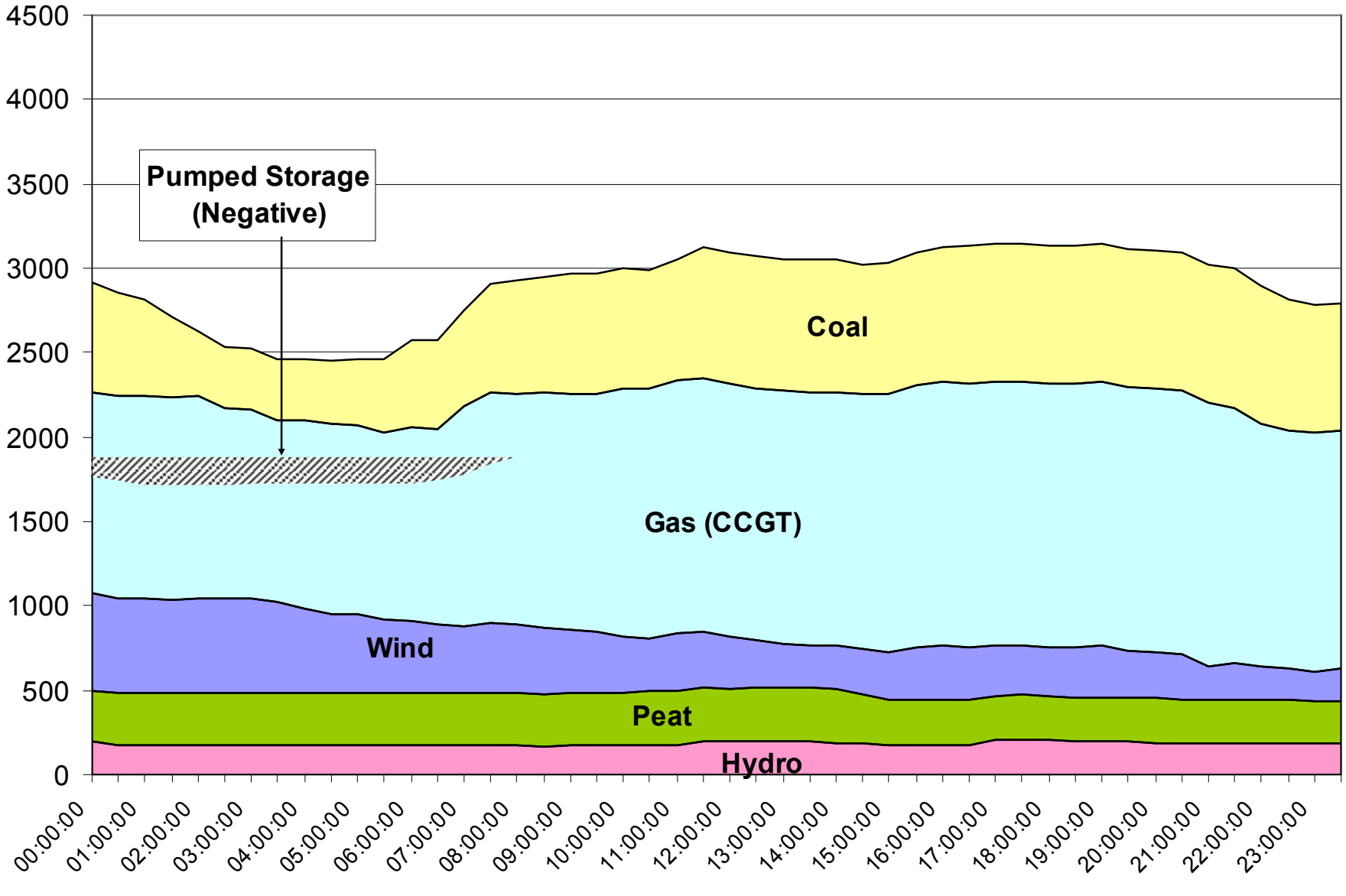
Fuel Mix on Typical Winter Day



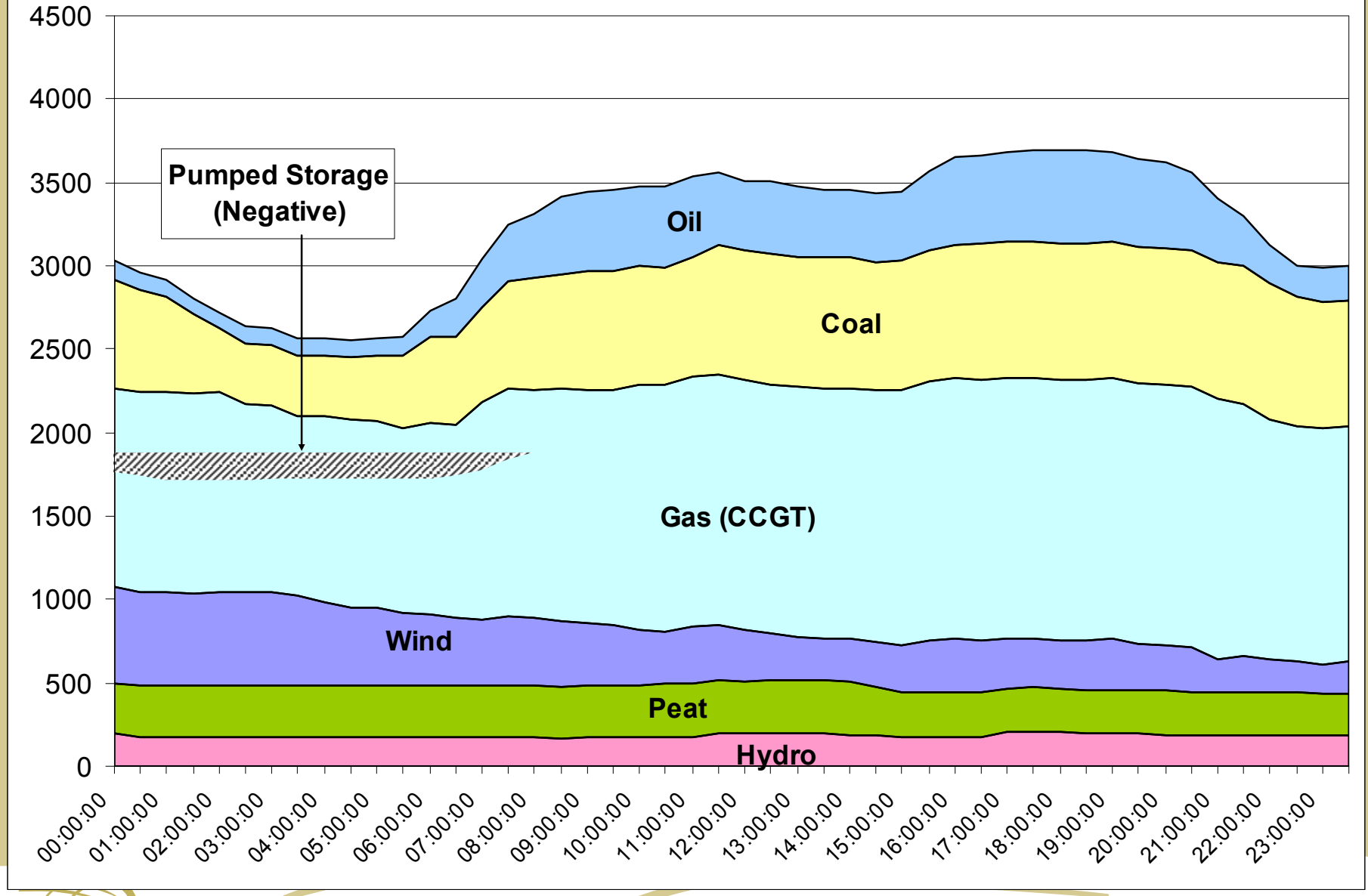
Fuel Mix on Typical Winter Day

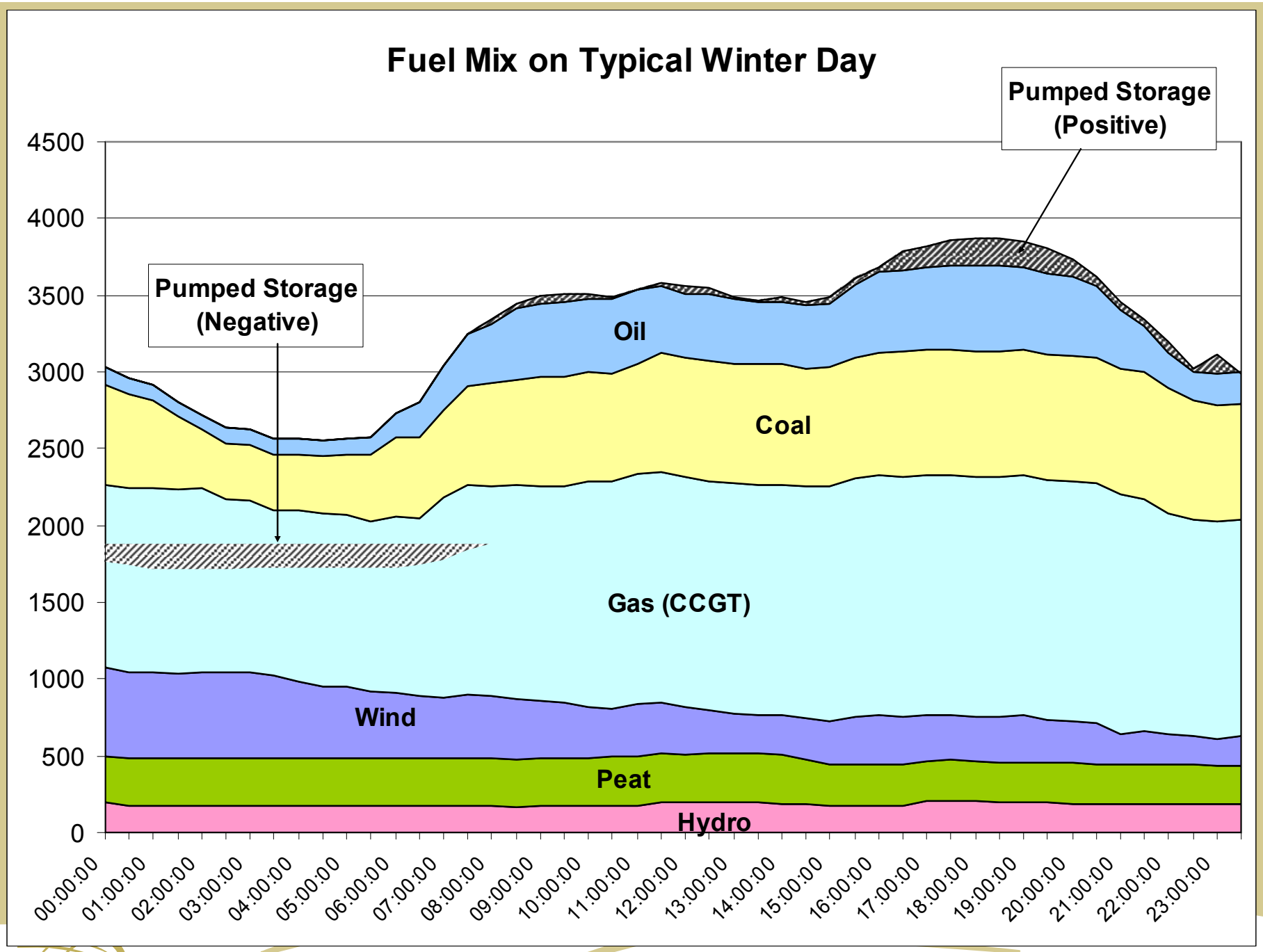


Fuel Mix on Typical Winter Day



Fuel Mix on Typical Winter Day




Fuel Mix on Typical Winter Day
Pumped Storage (Positive)
Pumped Storage (Negative)
Oil
Coal
Gas (CCGT)
Wind
Peat
Hydro
4500
4000
3500
3000
2500
2000
1500
1000
500
0
00:00:00
01:00:00
02:00:00
03:00:00
04:00:00
05:00:00
06:00:00
07:00:00
08:00:00
09:00:00
10:00:00
11:00:00
12:00:00
13:00:00
14:00:00
15:00:00
16:00:00
17:00:00
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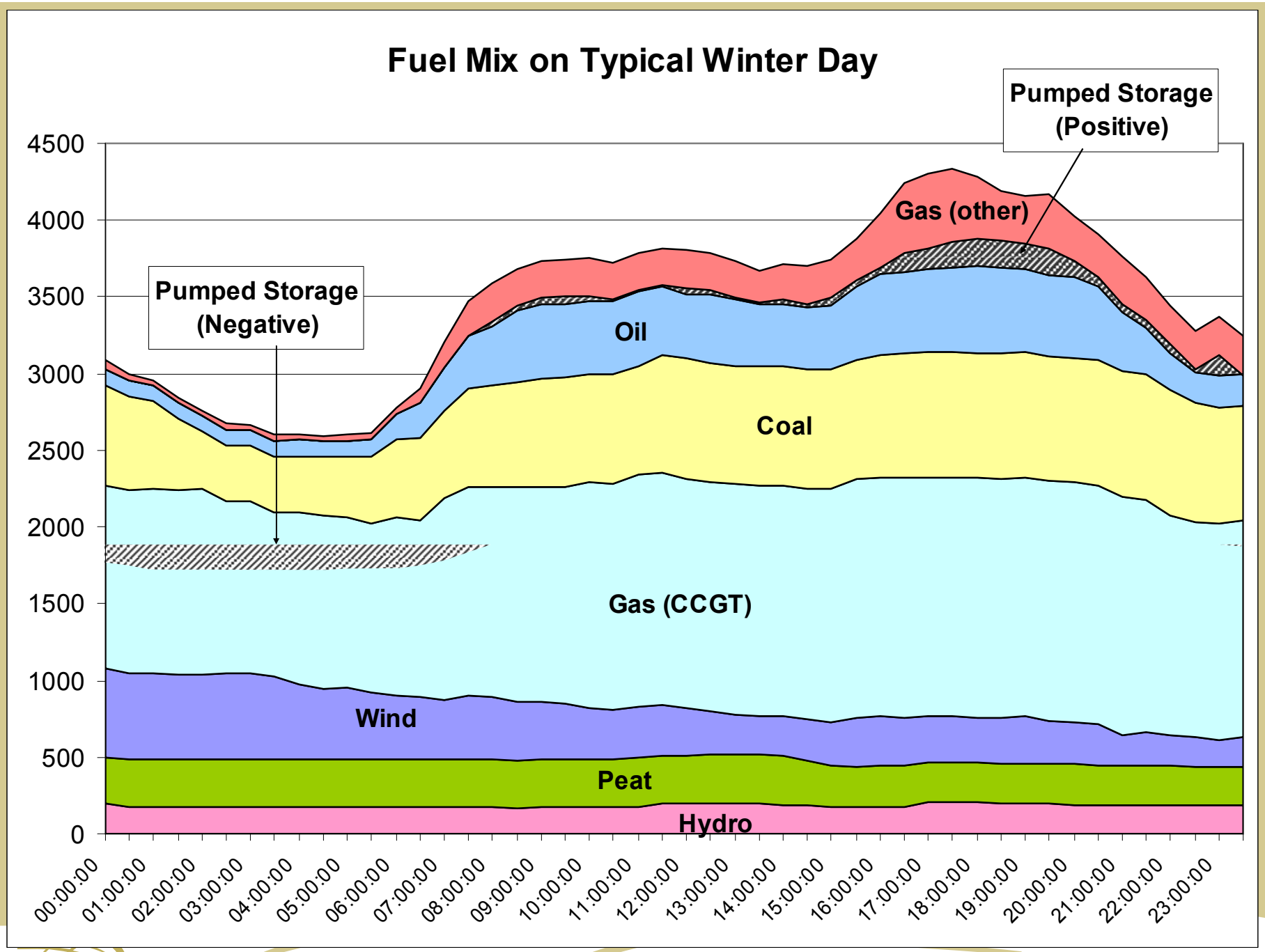
19:00:00
20:00:00
21:00:00
22:00:00
23:00:00


Fuel Mix on Typical Winter Day
Pumped Storage (Positive)
Pumped Storage (Negative)
Gas (other)
Oil
Coal
Gas (CCGT)
Wind
Peat
Hydro
4500
4000
3500
3000
2500
2000
1500
1000
500
0
00:00:00
01:00:00
02:00:00
03:00:00
04:00:00
05:00:00
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09:00:00
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16:00:00
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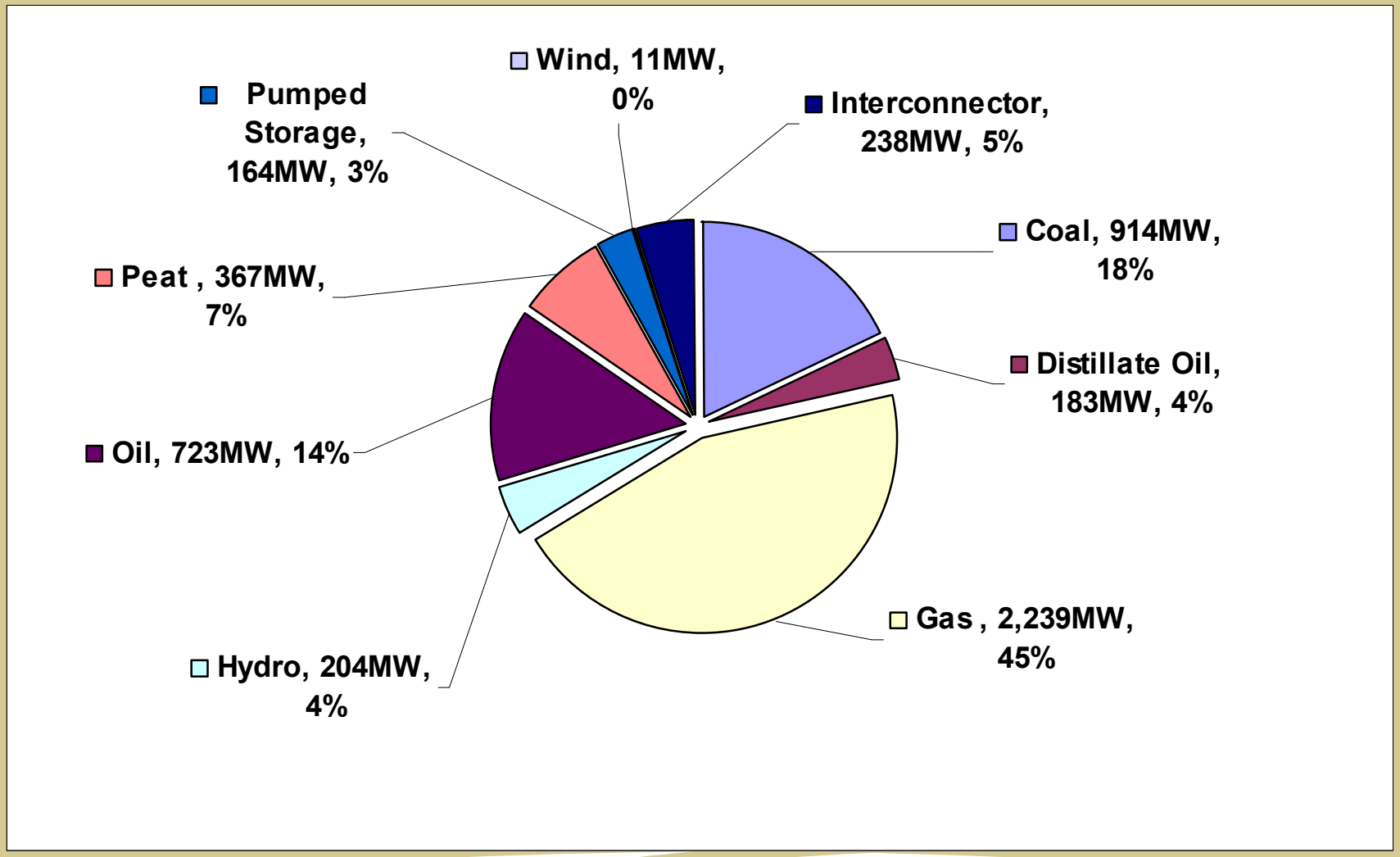
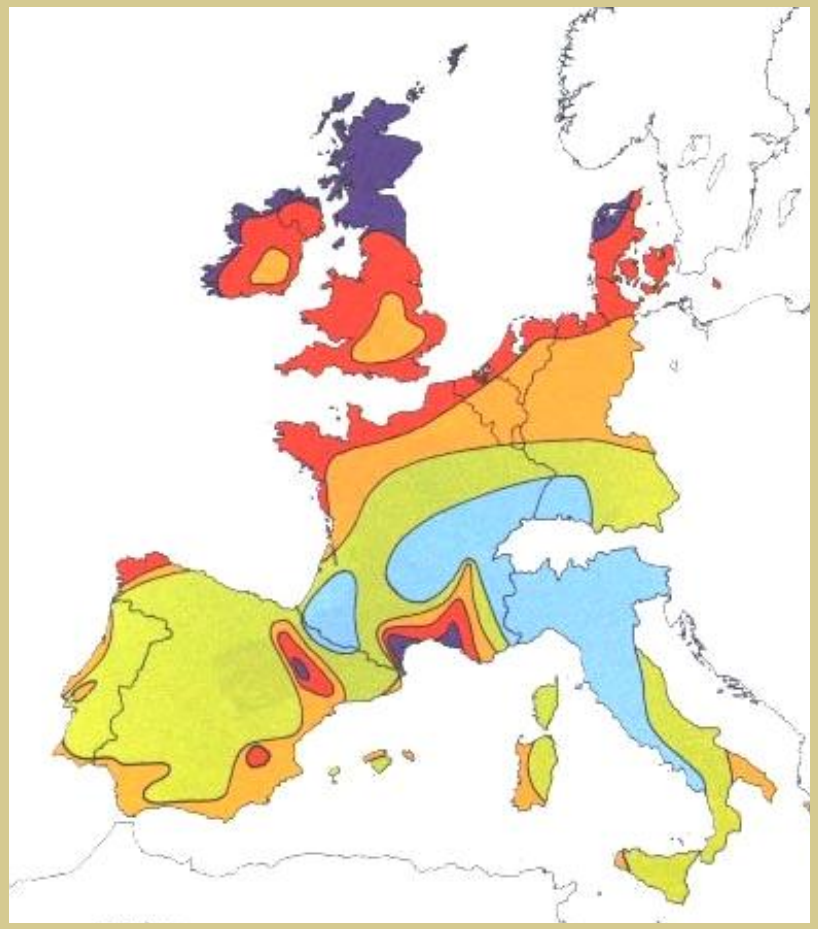
21:00:00
22:00:00
23:00:00

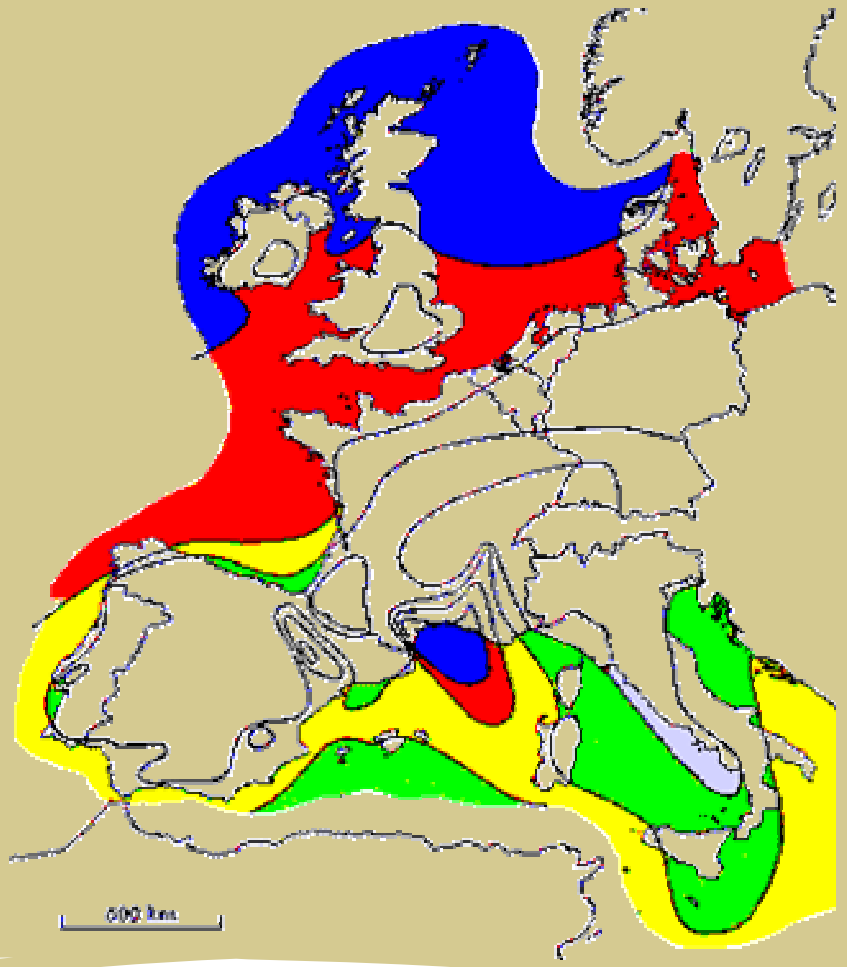
Fuel Mix at Peak Demand Day



Onshore and Offshore Wind Potential



Source: European Wind Atlas – RISØ National Laboratory



Wind Generation on the Irish System

Status	TSO / DSO	Total MEC (MW)	# Wind Farms	Cumulative Total	**Wind as % of Installed Capacity**
Connected	TSO	332.66	8		
Connected	DSO	411.83	61		
	Total	**744.48**	**69**	744.48MW	11%
Contracted	TSO	280.53	8		
Contracted	DSO	265.9	29		
	Total	**546.43**	**37**	1,260.91MW	17%
Gate 2	TSO	467.20	16		
Gate 2	DSO	832.84	101		
	Total	**1,300.03**	**117**	2,590.91MW	~25%
Unsigned Applicant	TSO	891.88	19		
Unsigned Applicant	DSO	1,041.55	80		
	Total	**1,933.43**	99	4,524.37MW!	??
			322		

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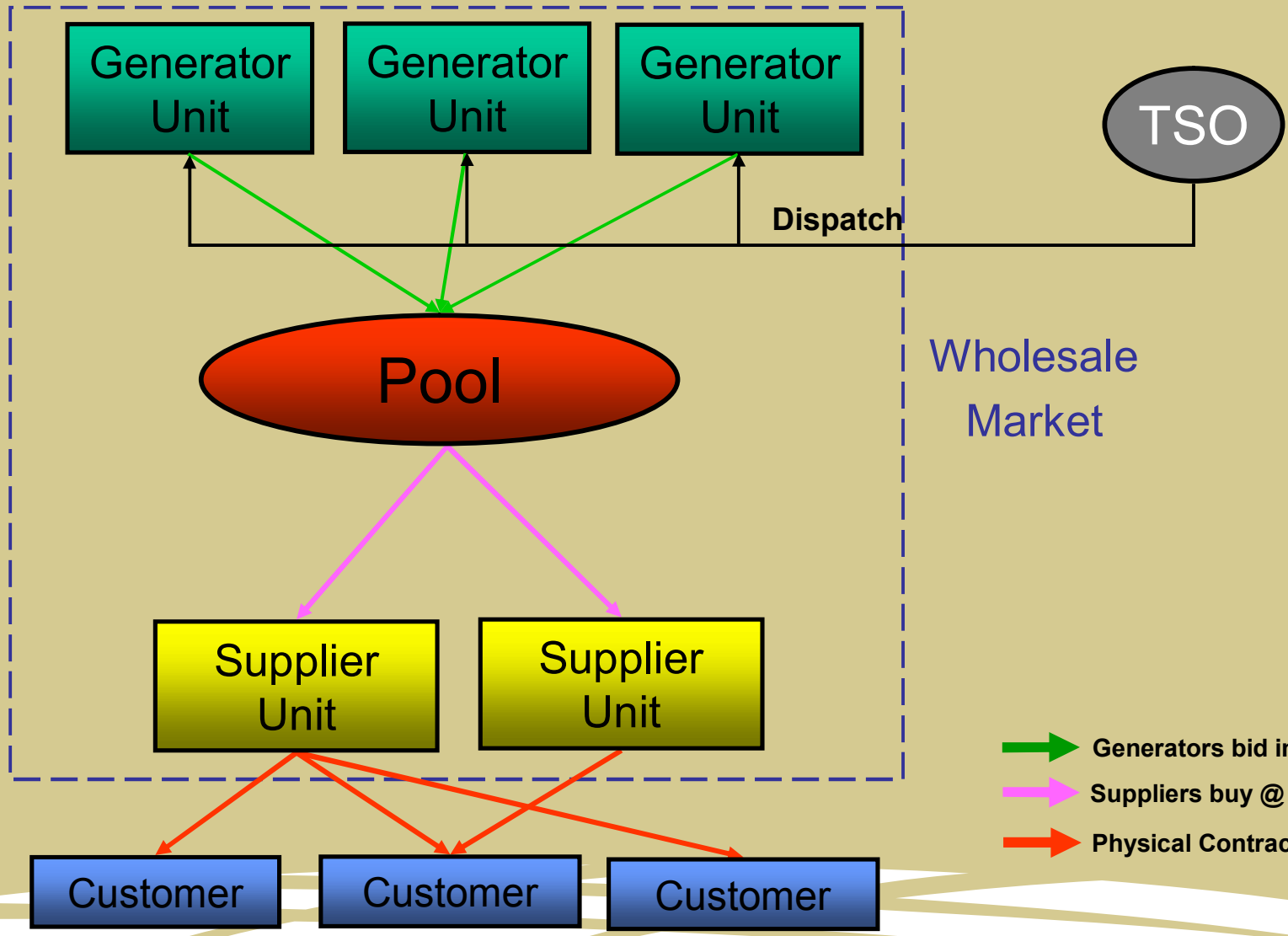
Wind & the Single Electricity Market

Single Electricity Market (SEM) Structure

- New All-island Wholesale Electricity Market
- Mandatory pool with single clearing price (SMP)
  - All energy must be sold directly into and bought from the pool
  - Separate physical energy trades are not permitted
- Capacity payments, Uplift Payments, Constraint Payments
- Locational Tariffs and Loss factors
- Specific rules for “special” participants

Mandatory Pool



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How Generators Get Paid for Energy

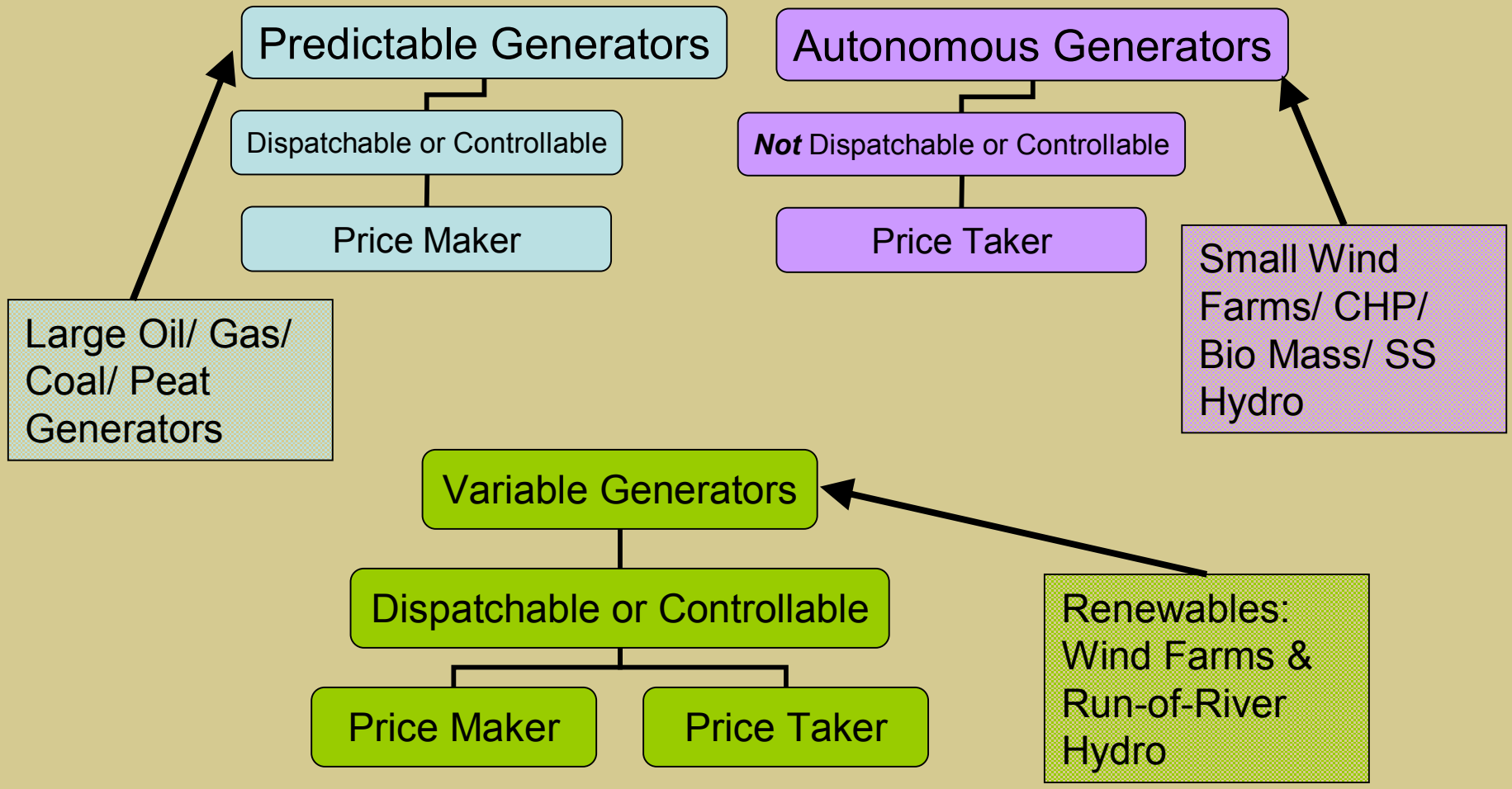
- Energy Payments to all Generator Units based on:
  - Market Schedule Quantity (MSQ)
  - System Marginal Price (SMP)

  - Energy Payment = MSQ x SMP

- SMP is normally understood to equal the incremental cost of supplying next MWh of energy demand

- MSQ is the quantity of generation as determined by the Ex-Post Unconstrained Schedule (EPUS)

Generator Classifications in the SEM



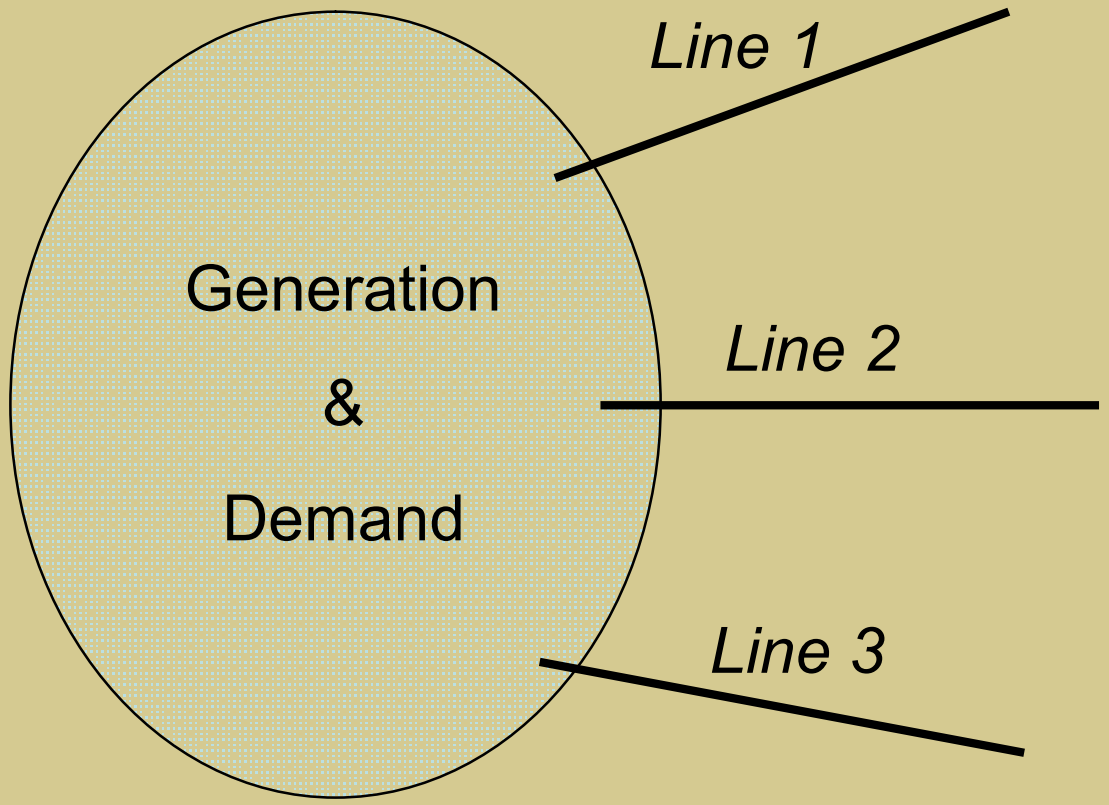
Constraints V Curtailment

Definitions

- Constraints :
  - Applicable to all generators
  - Due to transmission network limitations – typically local or regional
  - Other reasons such as provision of operating reserve

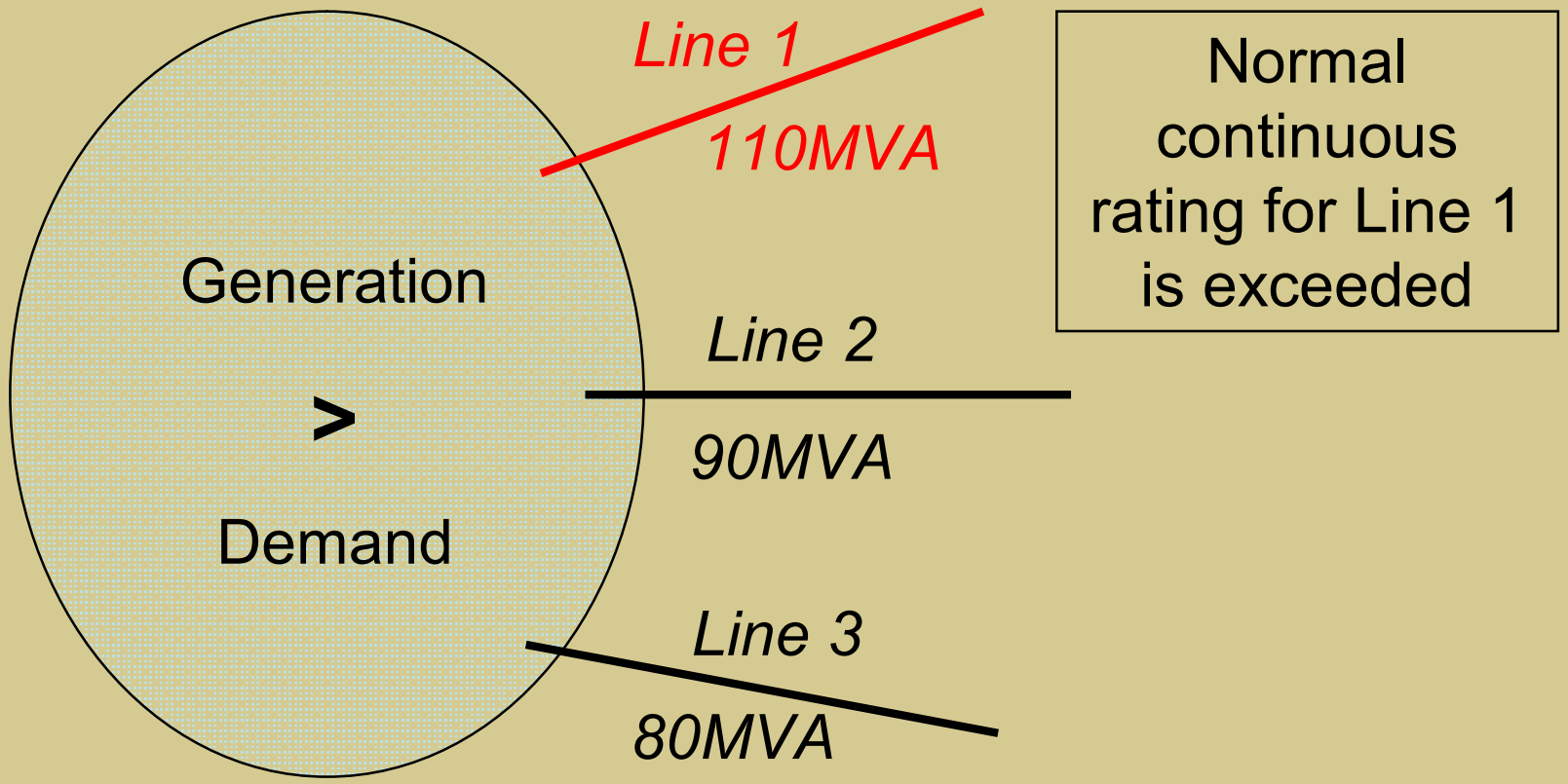
- Curtailment :
  - Requirement to limit total wind output at a point in time
  - A “system-wide” issue

What are Constraints

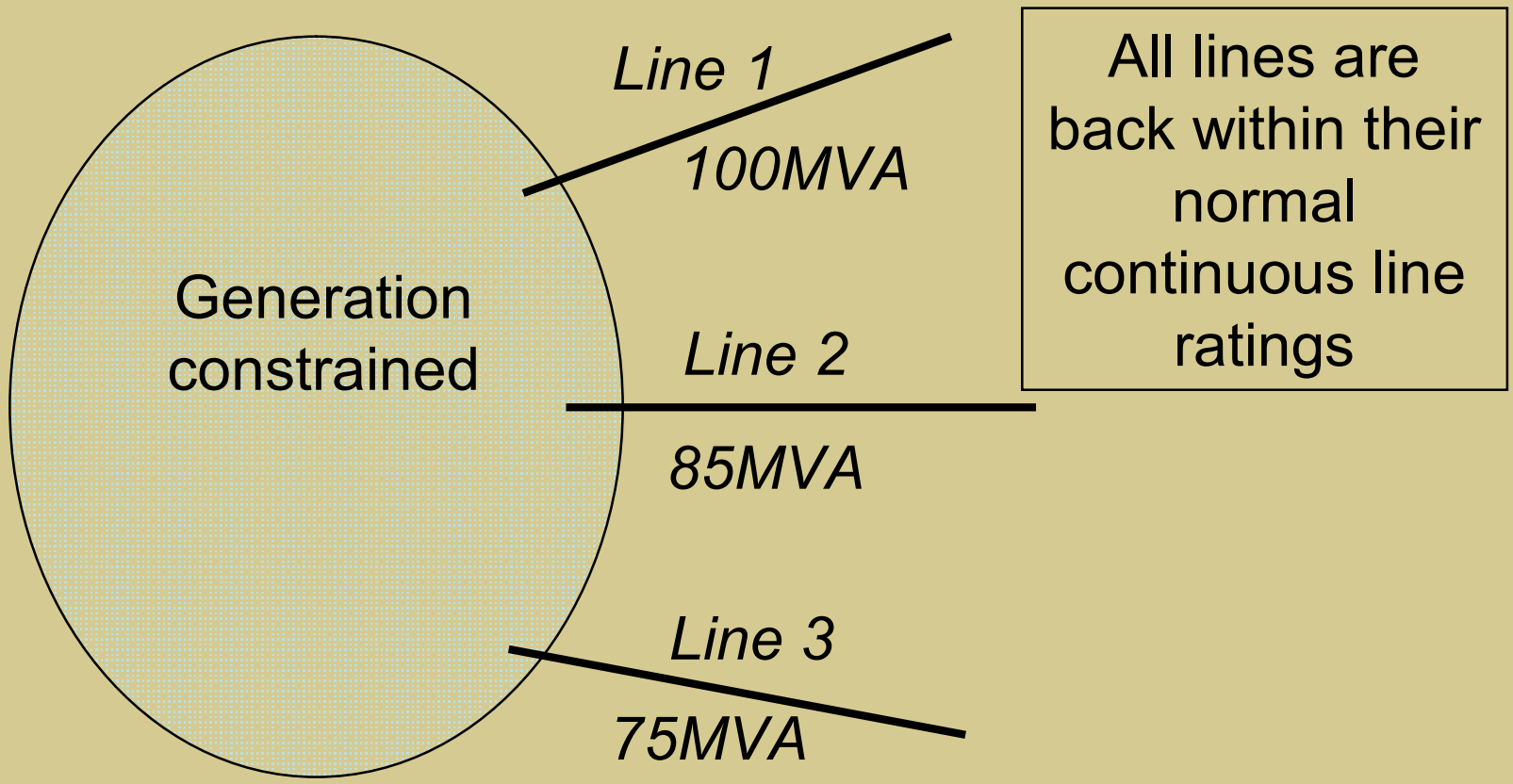


Each line has a normal continuous rating of 100MVA

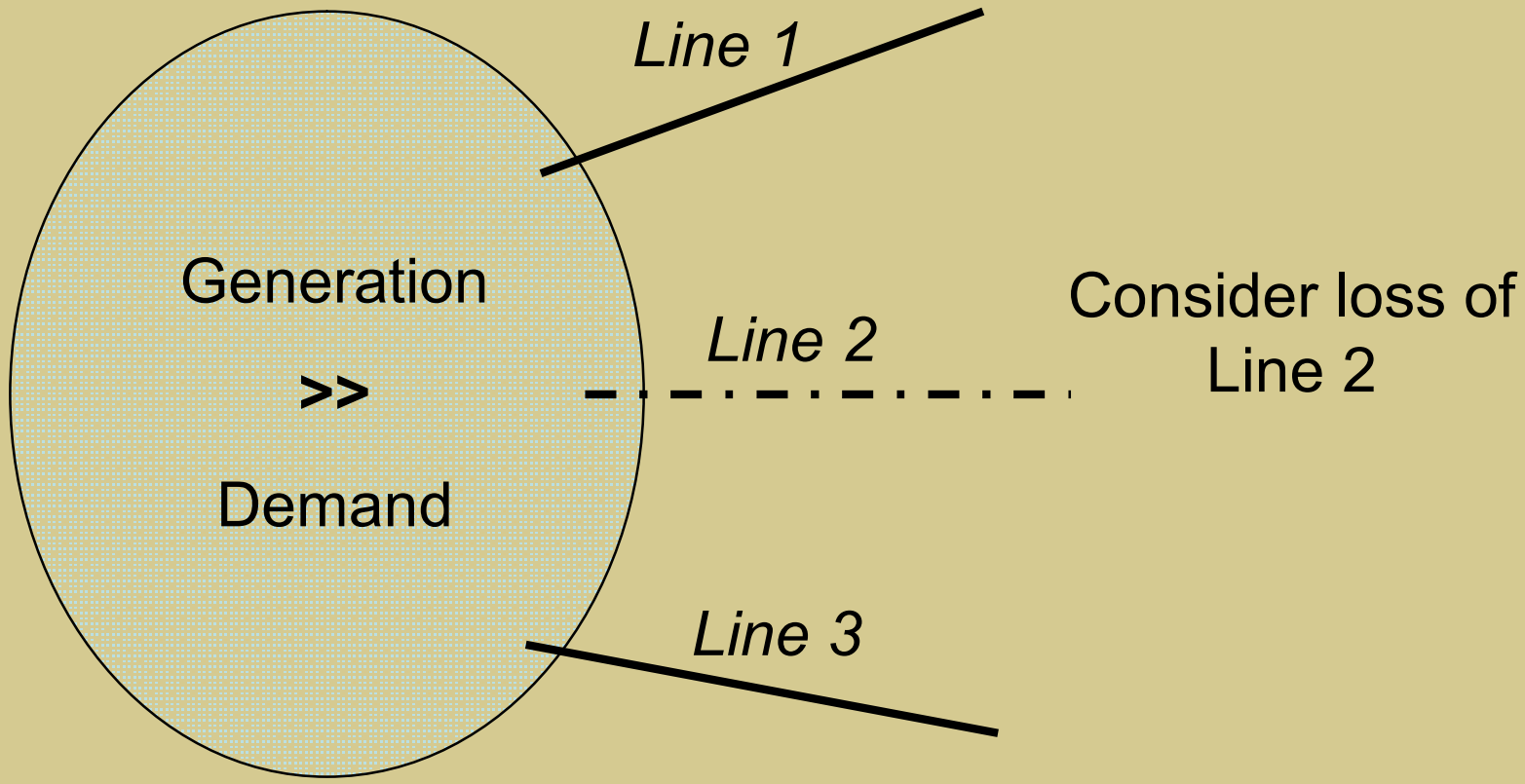
Generation exceeds Demand



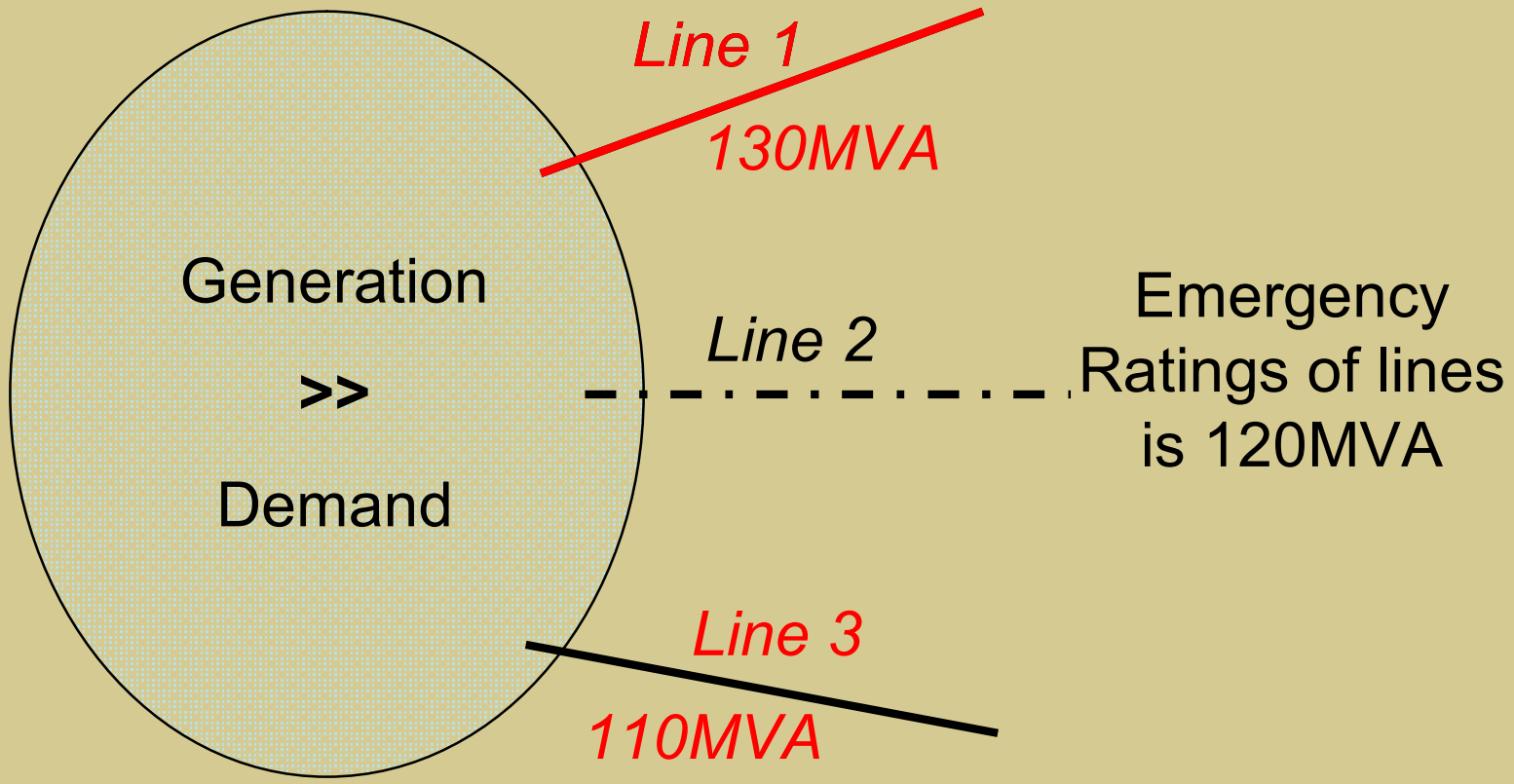
→ Generation must be constrained



Constraints



Constraints



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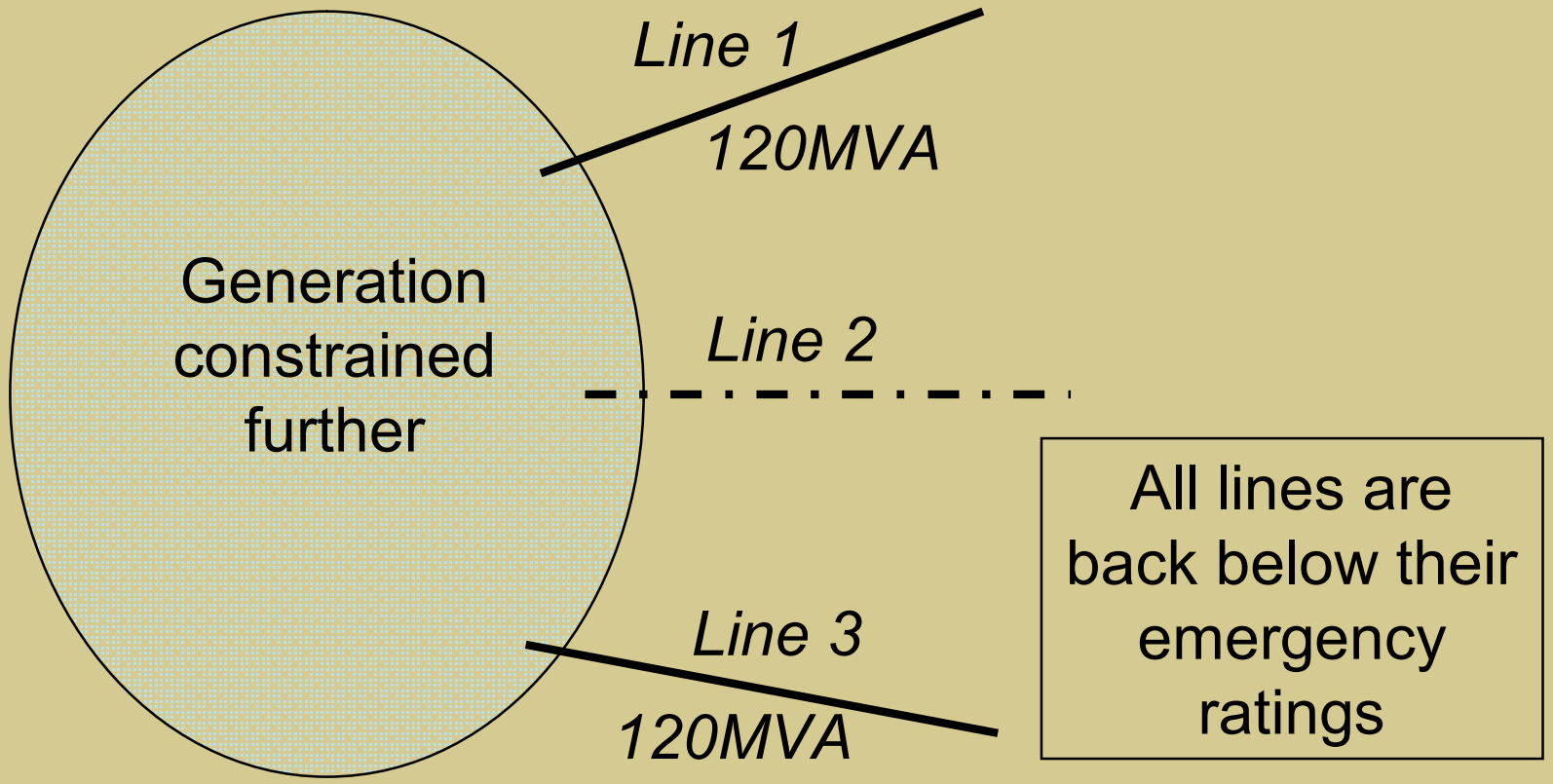
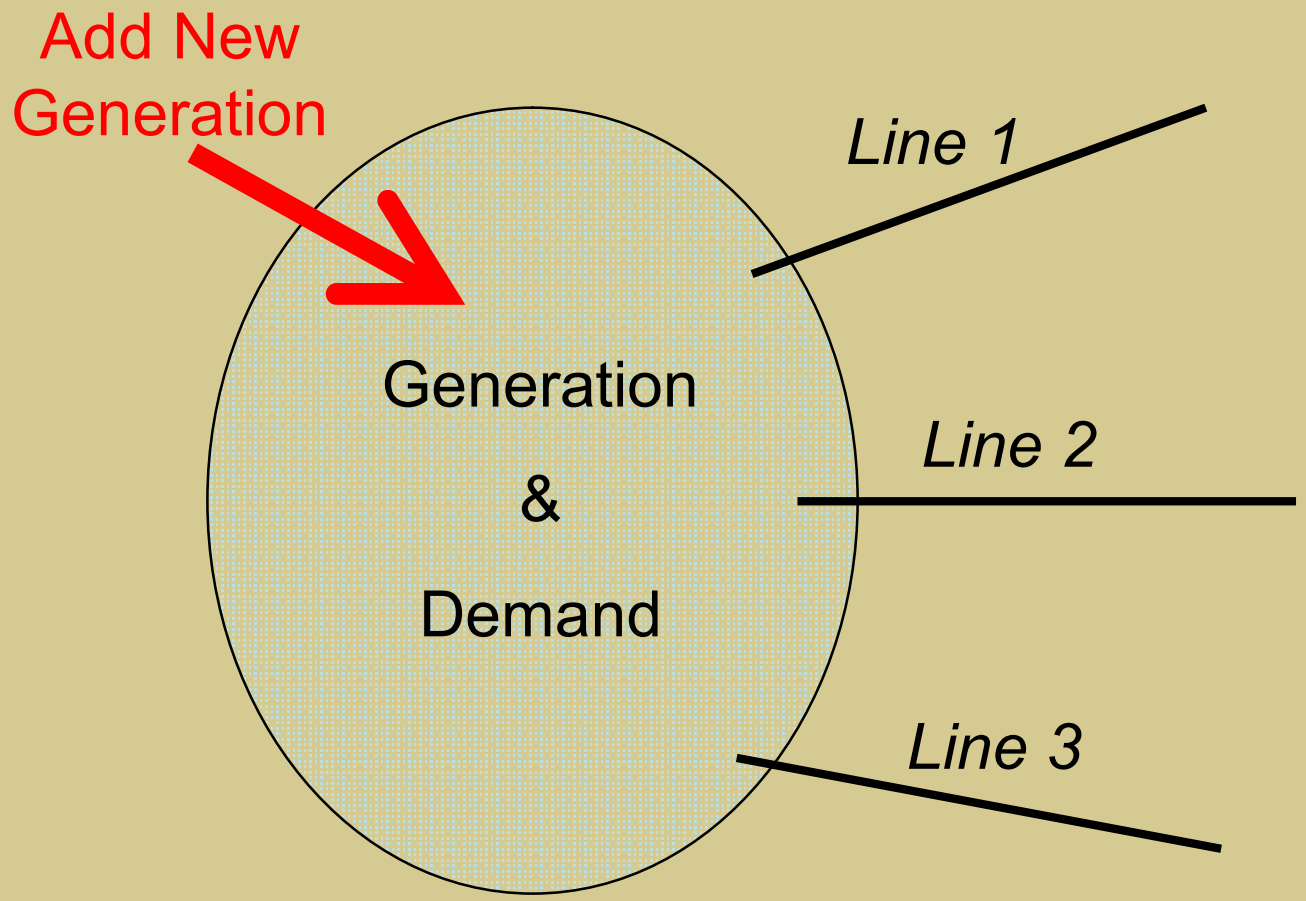


Application of firm/non-firm direction

- Introduced for Gate 1 offers
- Wind Generators may connect before deep reinforcements are complete
- Applies to generators with the ability/systems for constraint
- Generators not financially compensated for constraints associated with non-firm access
- Non-firm physical access to apply for Gate 2

Constraints – case 3



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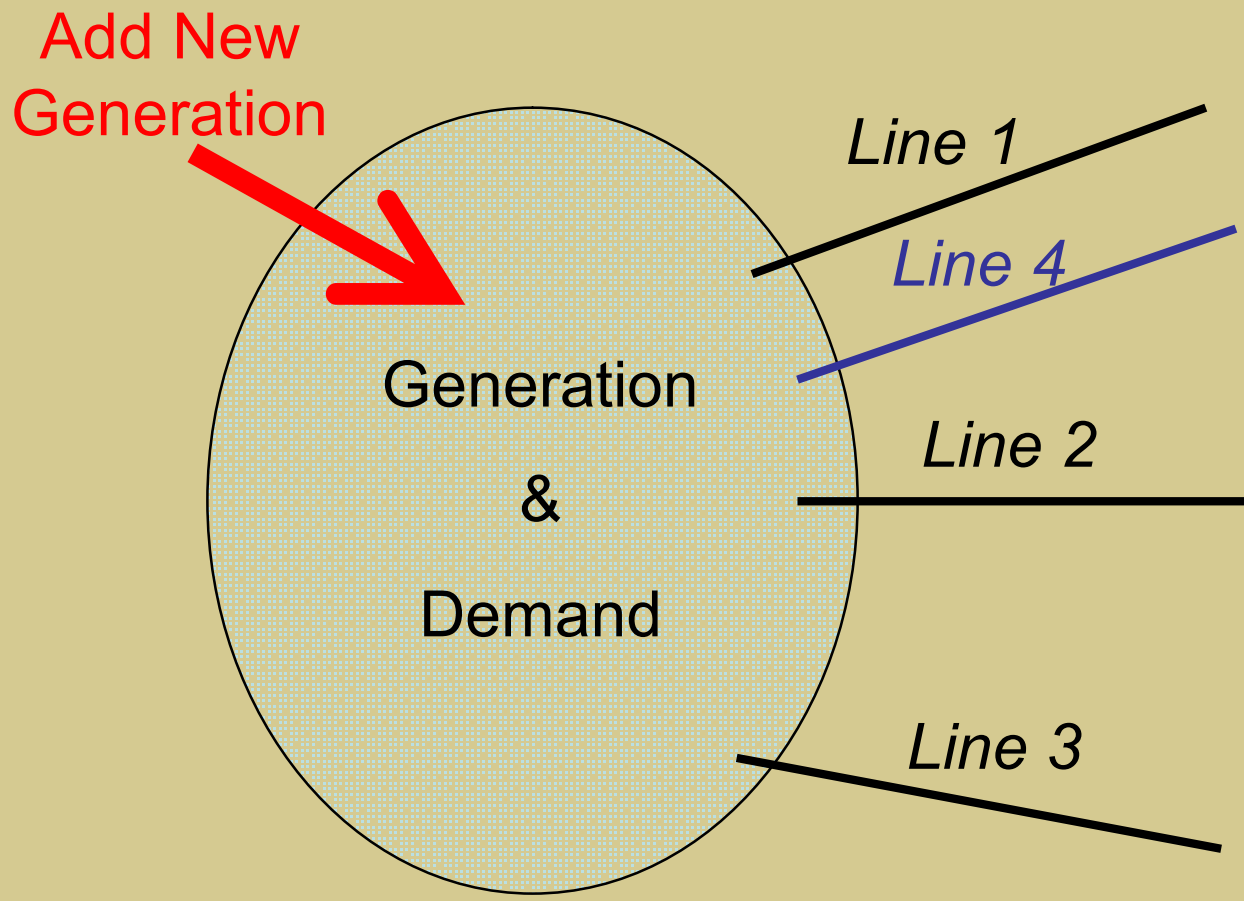
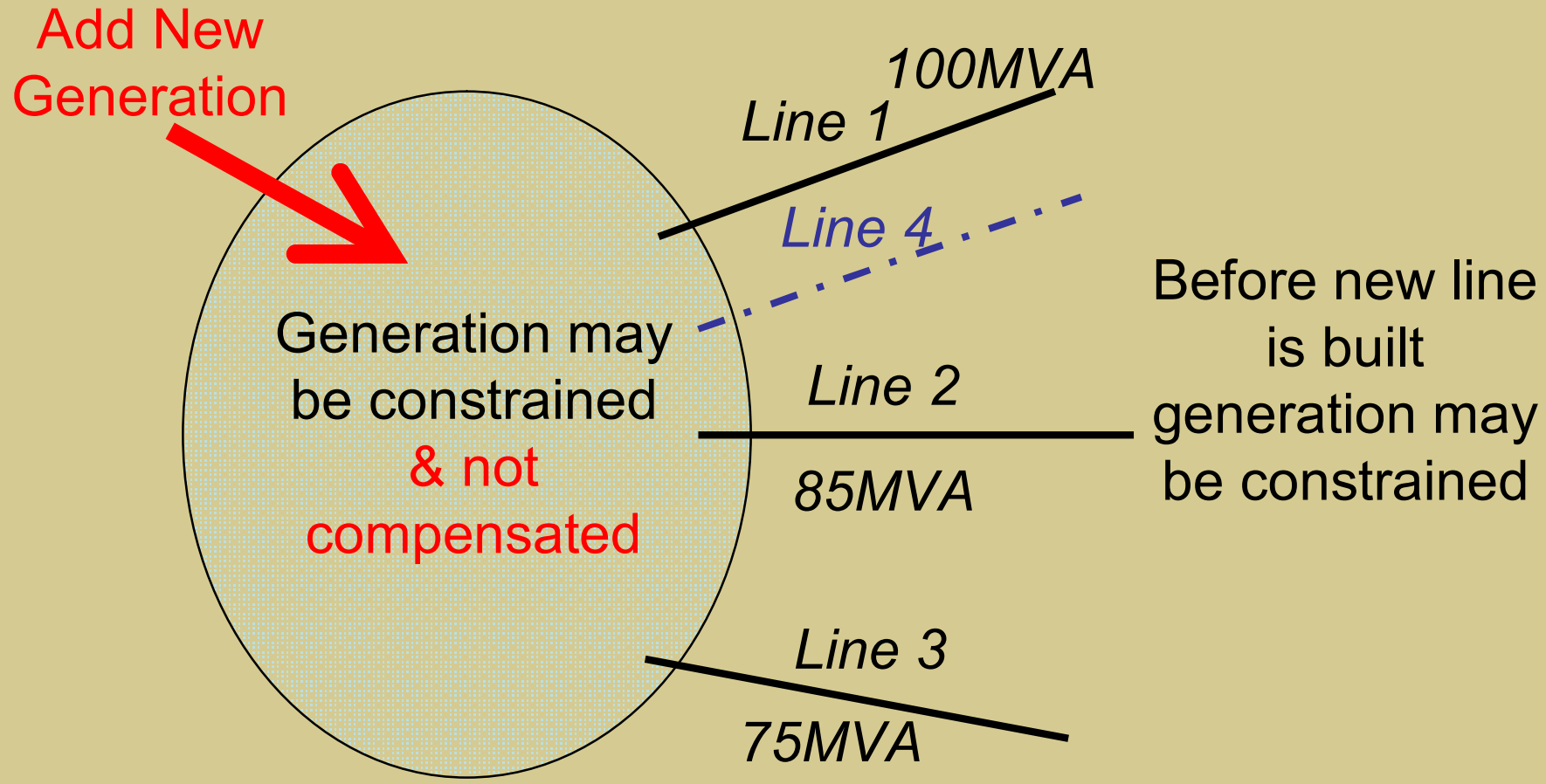
Constraints – case 3



Must build a new line to be able to export generation from the area

Generation *may* be constrained



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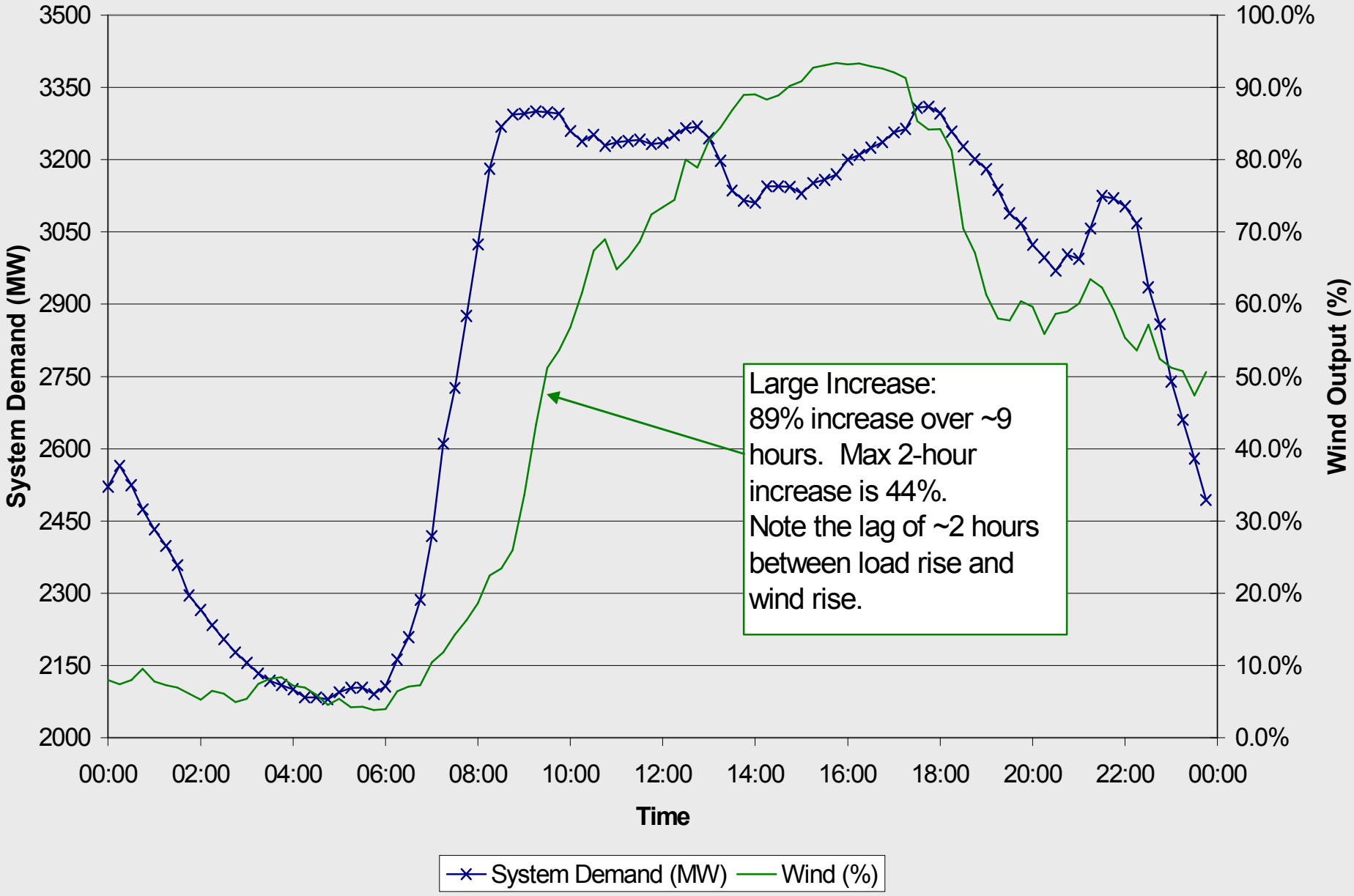
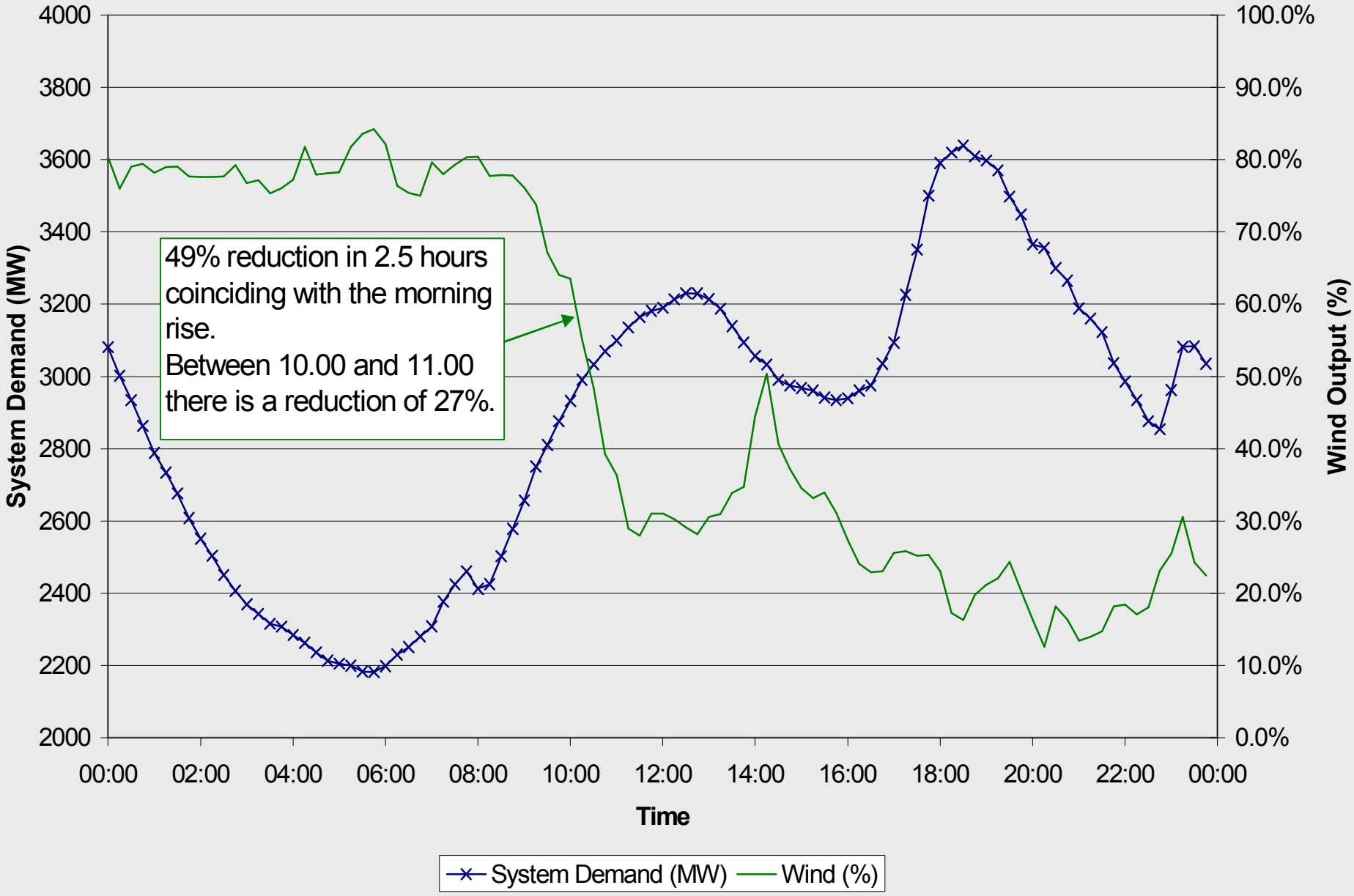
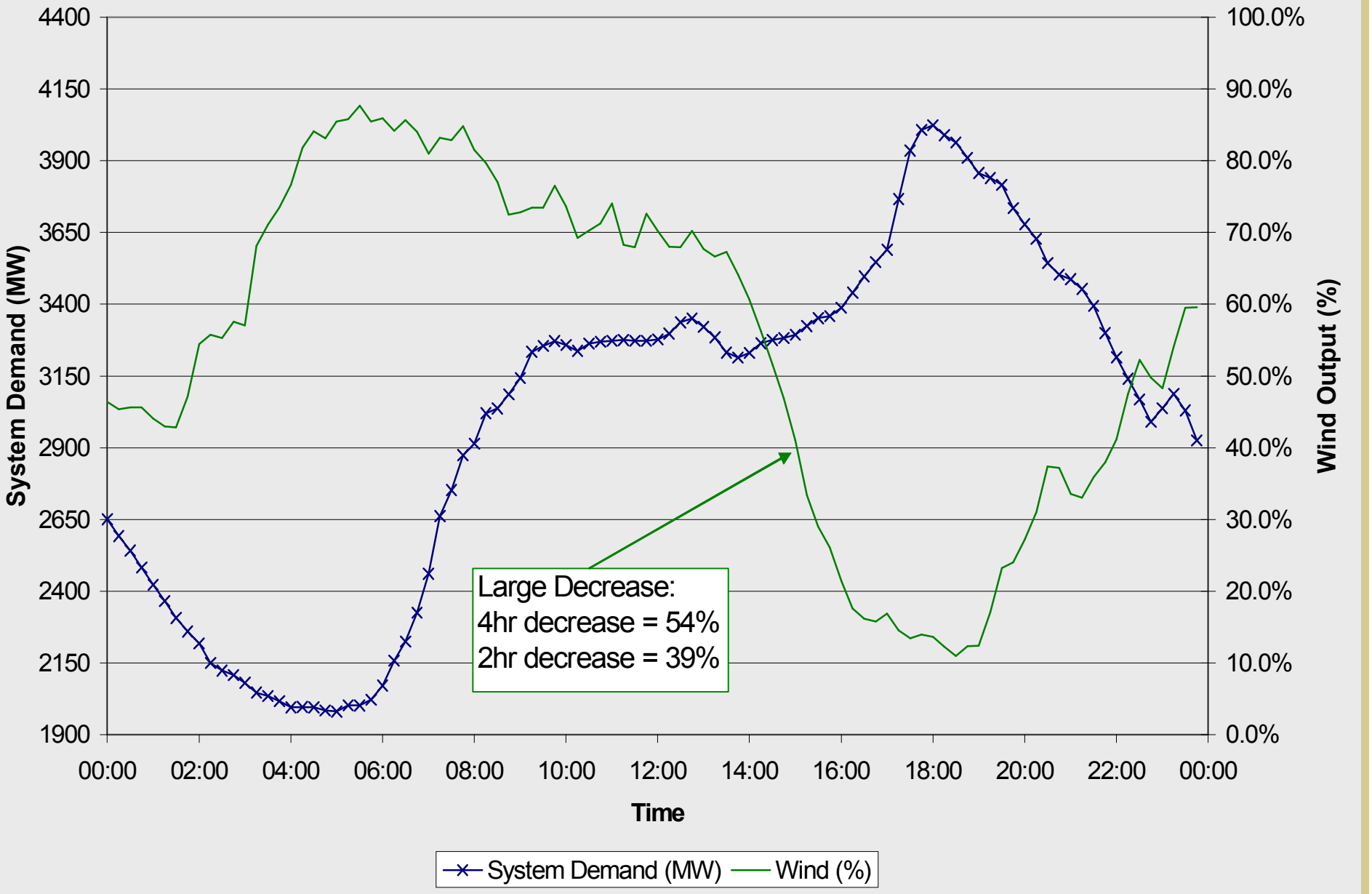
  - A “system-wide” issue

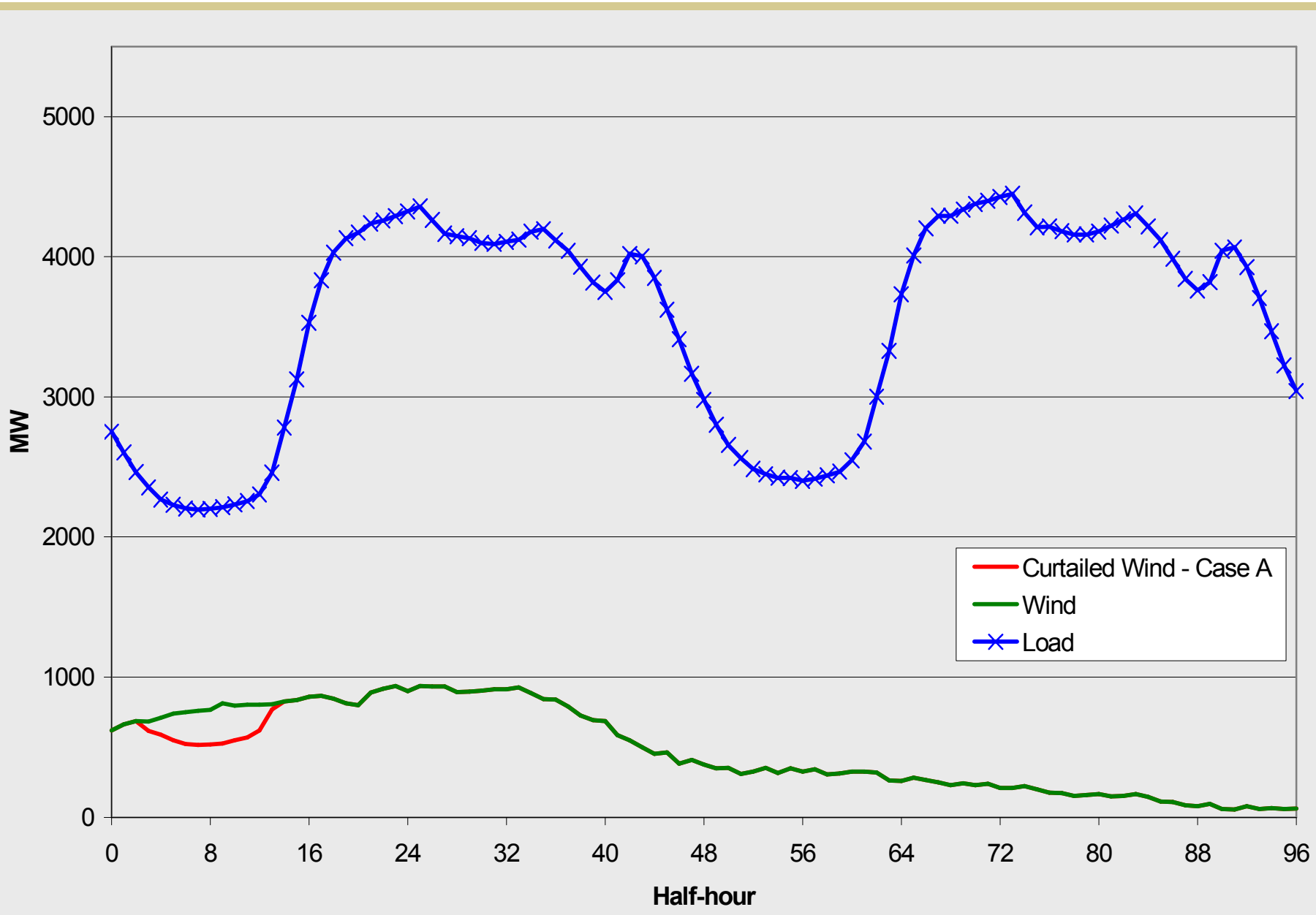
Problematic Wind Profiles

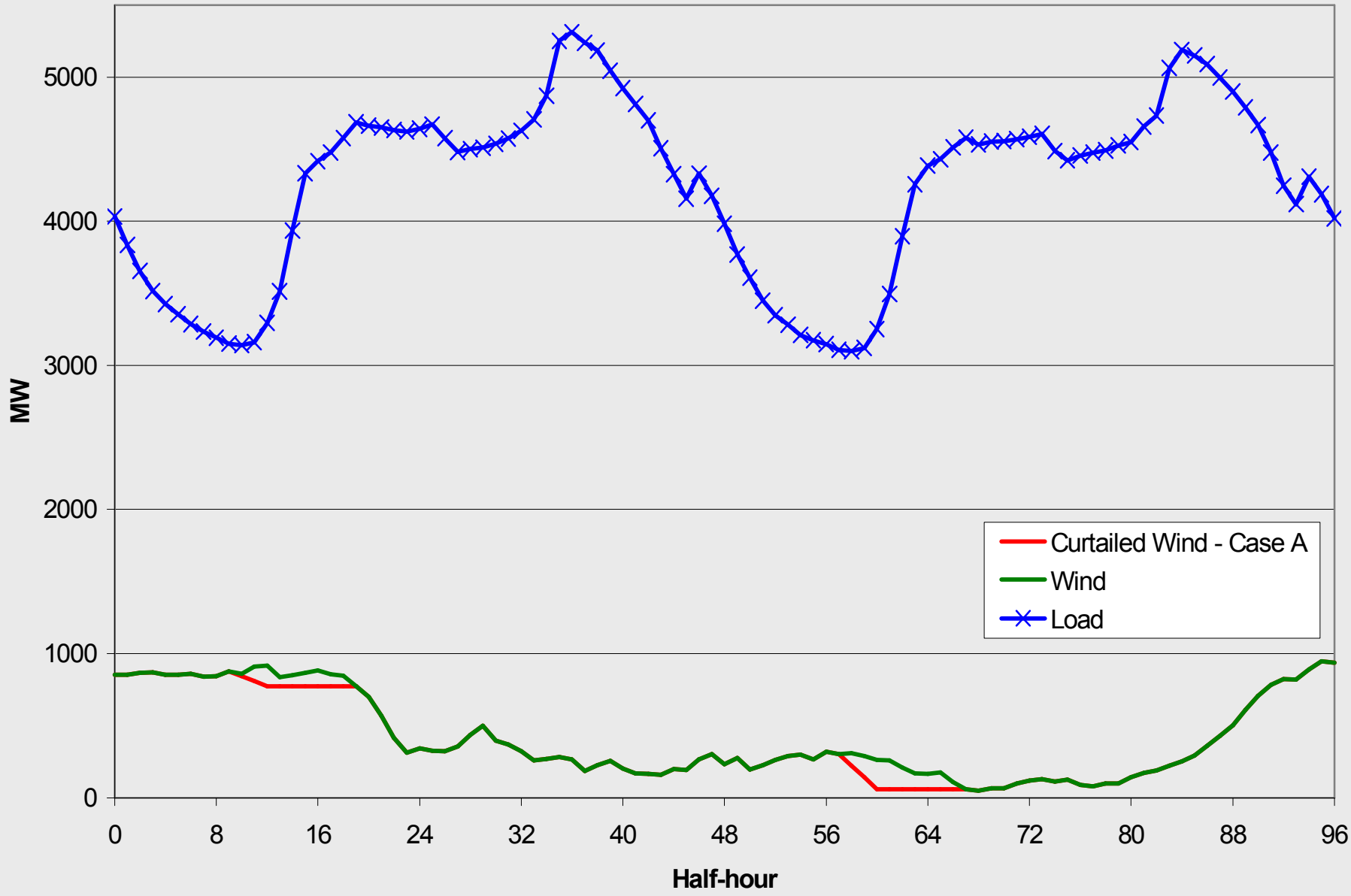
- From analysis of a typical yearly Wind Power Series, a number of problematic profiles emerged
- These wind profiles are problematic because of
  - Timing of the occurrence
  - Reduction in energy over a short period of time
- The ability to forecast these types of profiles is crucial to the safe, secure operation of the system


System Demand (MW)
Wind Output (%)
Time
3500
3350
3200
3050
2900
2750
2600
2450
2300
2150
2000
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Large Increase:
89% increase over ~9 hours. Max 2-hour increase is 44%.
Note the lag of ~2 hours between load rise and wind rise.
System Demand (MW)
Wind (%)


4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
System Demand (MW)
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Wind Output (%)
49% reduction in 2.5 hours coinciding with the morning rise.
Between 10.00 and 11.00 there is a reduction of 27%.
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time
System Demand (MW)
Wind (%)


4400
4150
3900
3650
3400
3150
2900
2650
2400
2150
1900
System Demand (MW)
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Wind Output (%)
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00
Time
Large Decrease:
4hr decrease = 54%
2hr decrease = 39%
System Demand (MW)
Wind (%)


5000
4000
3000
2000
1000
0
MW
0
8
16
24
32
40
48
56
64
72
80
88
96
Half-hour
Curtailed Wind - Case A
Wind
Load


5000
4000
3000
2000
1000
0
MW
0
8
16
24
32
40
48
56
64
72
80
88
96
Half-hour
Curtailed Wind - Case A
Wind
Load

Curtailment management

- Wind Management Techniques
  - EirGrid is developing techniques to minimise curtailment
  - This will be a progressive task
  - Maximise wind to run as high as is feasible while maintaining system security and standards
  - ‘Active’ real-time monitoring and analysis of system conditions is necessary to ensure that curtailment is no greater than required

Analysis of Future Levels of Curtailment

- Analysed 1,100MW of wind generation (installed capacity) in 2010

- Case A - Accurate Wind Forecasting
- Case B – Existing rate of Forecasting Errors

	Case A	*Case B*
Combined Total Curtailment	**1.3%**	**4.2%**
Combined Total Curtailed GWh	**45**	**140**

All Island Grid Studies for Renewables

Workstreams

1. Resource Identification
2. Variability
   - Impact on system operation, fuel costs etc.
   - Management
3. Network Issues
4. Economic and Stakeholder assessment

Workstream 1

- Estimate amount and location of each renewable technology
  - Probably two scenarios – with and without offshore wind
- Estimate cost of deployment
- Workstream 1 is being carried out by ESBI
- Inputs required for later workstreams are virtually complete

Screening Study – Workstream 2A

- After Workstream 1 consultation, it was decided to carry out a screening study of scenarios
- Considered a wide range of input parameters (gas price, carbon price, financing costs etc,)
- Identified a range of generation portfolios to be considered in the more detailed studies

Screening Study
Recommended Portfolios

- The portfolios recommended for further study include:
  - Renewable penetration ranging from 16% to 54%
  - Installed wind ranging from 2,000 MW to 8,000 MW
  - Wind energy ranging from 11% to 36%
- The more detailed phases of the study will assess the feasibility and impacts of these portfolios from a system perspective
- The portfolios have been revised to account for the additional combined cycles that have been or are likely to be approved.

Workstream 2B

- Assess how much variable and unpredictable generation can be accommodated
- Impact on total system costs and emissions
- Will consider impact of
  - Different plant mix
  - Improved forecasting
  - Storage

Workstream 3

- Investigate extent of network development required for renewables
  - Amount of transmission reinforcement that might be required for various scenarios
  - The regional spread of the reinforcements
  - Associated capital costs

Workstream 4

- Based on outputs from workstreams 1, 2 and 3, assess overall economic, stakeholder, market impacts etc.
- Draw the overall results of the study together
- Scope being developed at present
- Consultation meeting probably in early 2007

Present Position

- WS 1 (resources) in progress
- WS 2A (screening study) completed
- WS 2B (variability) under way
- WS 3 (network) commencing
- WS 4 (economic and stakeholder impact) scope being developed
- There are no results yet! - mid-2007

Summary

- EirGrid recognizes the many benefits that wind generation has for the system as a whole and is working to facilitate the integration of wind onto the system
- There are a number of factors that will influence the economics of wind generation on the system in the future
- EirGrid is actively involved in various research projects examining this issue in collaboration with the industry, policy makers and the regulators.

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