Electricity Markets: Summer Semester 2016, Lecture 12

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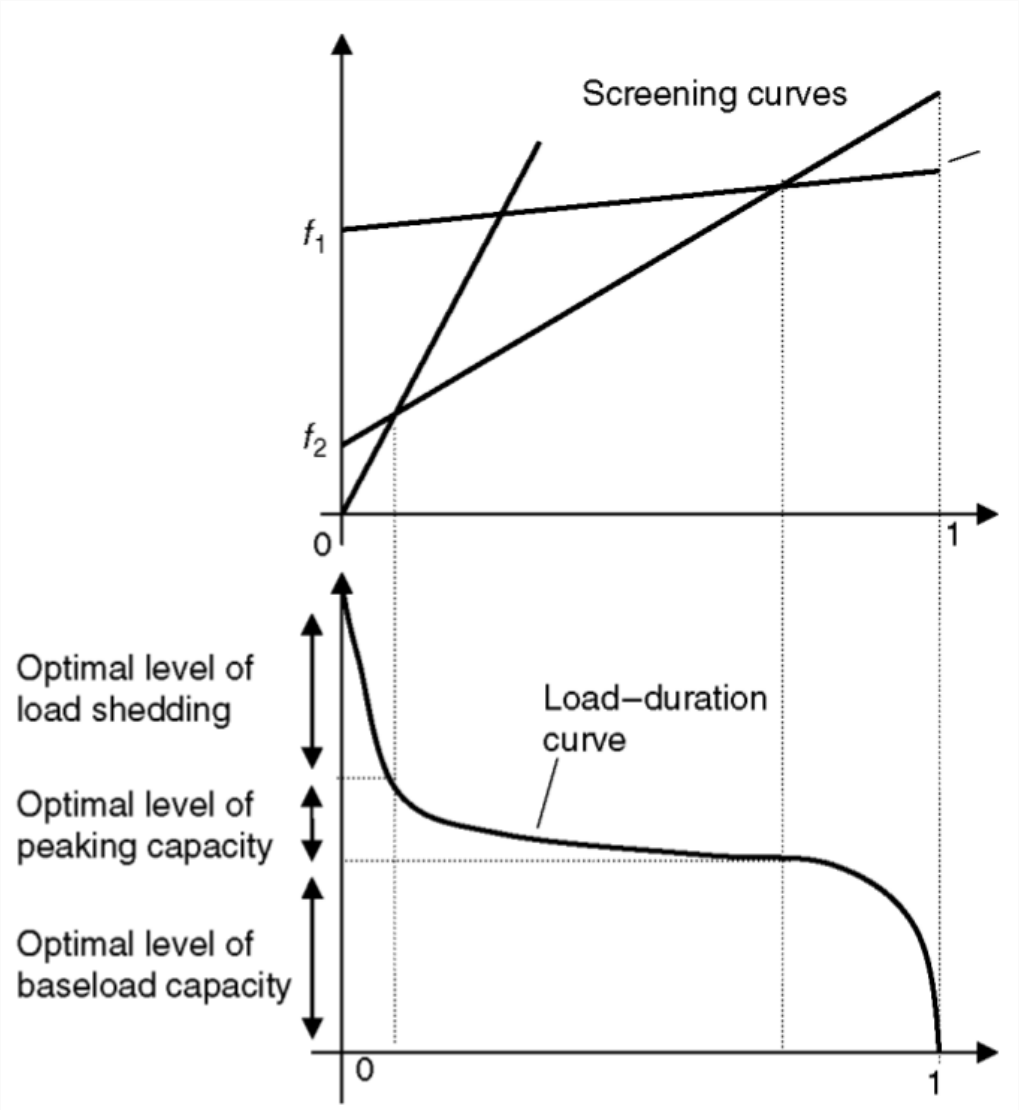
Screening curve versus Load duration



The optimal generation investment is determined by the interaction of the load-duration curve with the screening curve of the generation technologies available.

In the perfect market, there will be times with load shedding and prices above the marginal cost of the most expensive generator, so that every generator can recover its fixed costs.

Source: Biggar and Hesamzadeh, 2014

Grit in the machine 1/2

Several factors make this theoretical picture quite different in reality:

- Generation investment is lumpy i.e. you can often only build power stations in e.g. 500 MW blocks, not in continuous chunks.
- Some older generators have sunk costs, i.e. costs which have been incurred once and cannot be recovered, which alters their behaviour (i.e. the f term is not evenly distributed across all hours)
- Returns on scale in building plant are not taken into account (we did everything linear)
- Site-specific concerns ignored (e.g. lignite might need to be near a mine and have limited capacity)
- Variability of production for wind/solar ignored
- There is considerable uncertainty given load/weather conditions during a year, which makes investment risky; economic downturns reduce electricity demand

Grit in the machine 2/2

Several factors make this theoretical picture quite different in reality:

- Fuel cost fluctuations, building delays which cost money
- Risks from third-parties: Changing costs of other generators, political risks (CO_2 taxes, Atomausstieg, subsidies for renewables, price caps)
- Political or administrative constraints on wholesale energy prices may prevent prices from rising high enough for long enough to justify generation investment ("Missing Money Problem")
- Lead-in time for planning and building, behaviour of others, boom-and-bust investment cycles resulting from periods of under- and over-investment in capacity
- Exercise of market power

Episodes of High Prices are an Essential Part of an Energy-Only Market

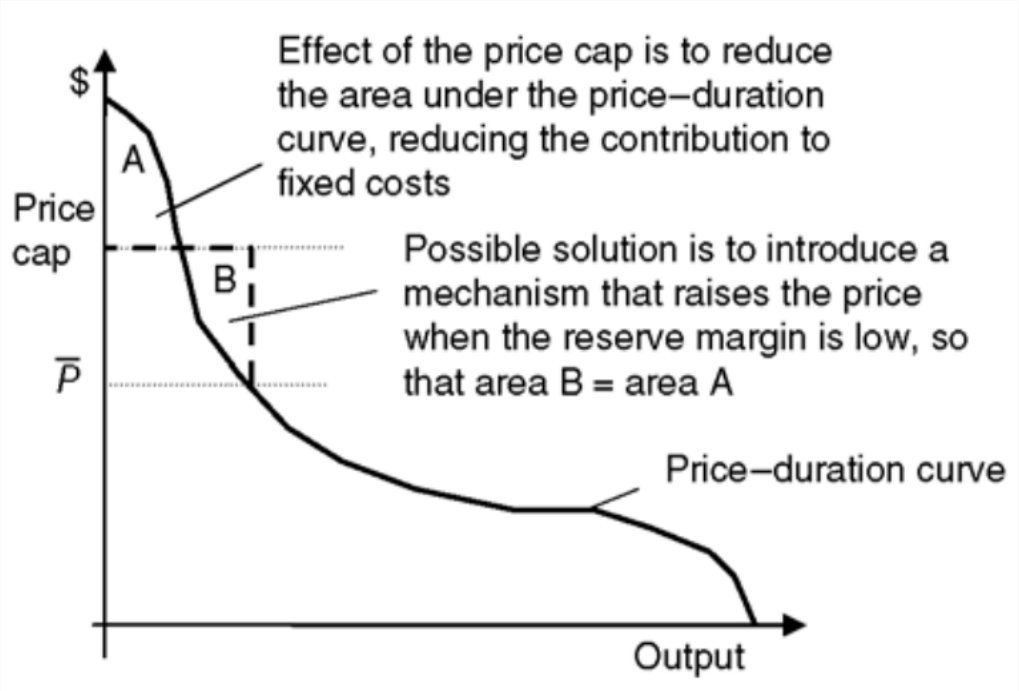
In an energy-only market (in which generators are only compensated for the energy they produce), the wholesale spot price must at times be higher than the variable cost of the highest-variable-cost generating unit in the market. Episodes of high prices and/ or price spikes are not in themselves evidence of market power or evidence of market failure.

However, there may be political or administrative restrictions on prices going to very high levels (i.e. consumer protection, concerns about market abuse).

Price cap

Some markets implement a maximum market price cap (MPC), which may be below the Value of Lost Load (VoLL) (V for the inelastic case).

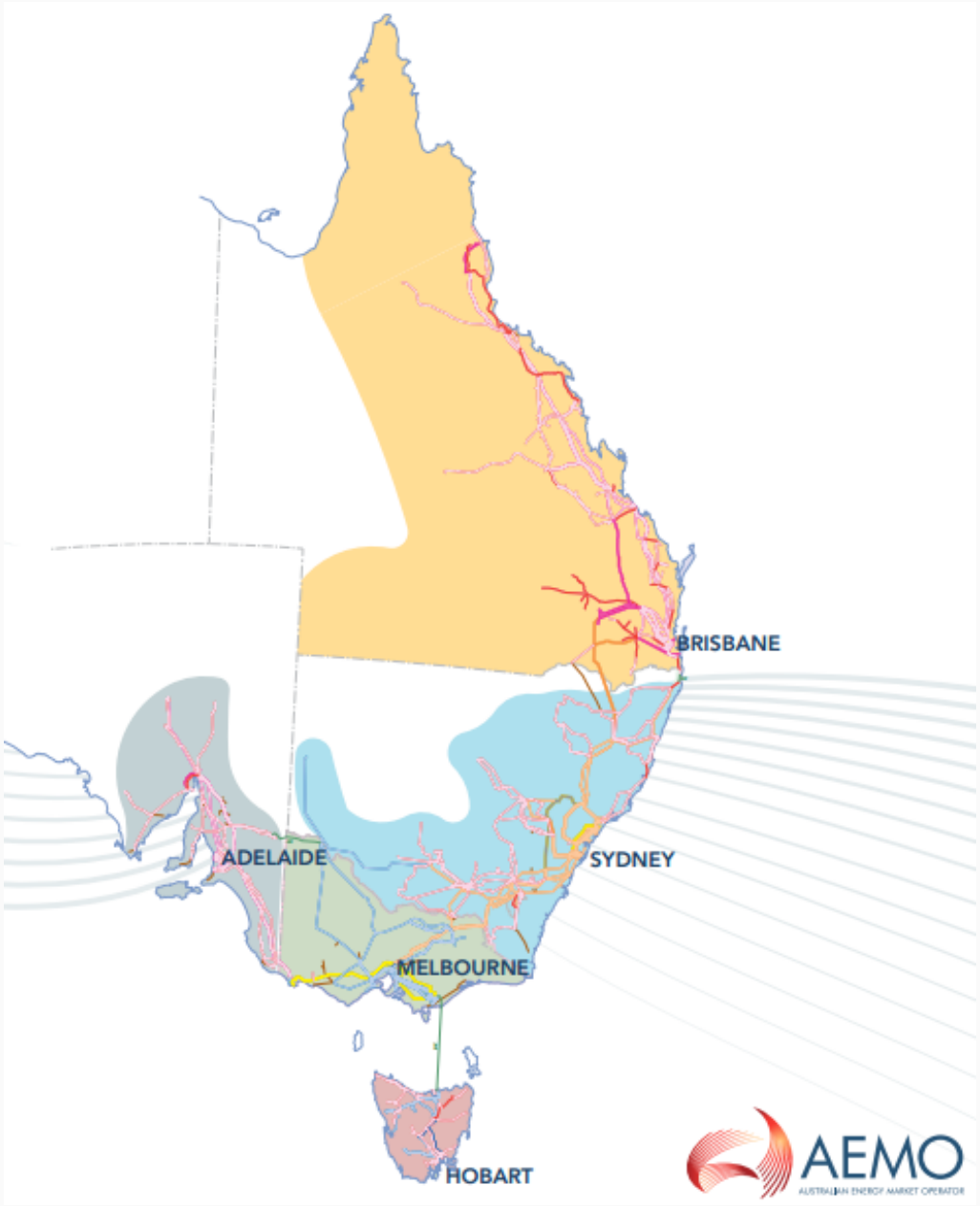
In the Eastern Australian National Electricity Market (NEM), a MPC of A$13,800/MWh (€ 9,300/MWh) for the 2015-2016 financial year is set, corresponding to the price automatically triggered when AEMO directs network service providers to interrupt customer supply in order to keep supply and demand in the system in balance.



This can introduce distortions which make it difficult for some generators to recover costs.

Source: Biggar and Hesamzadeh, 2014

Australian National Electricity Market (NEM)



NEM split into five states, New South Wales, Queensland, South Australia, Tasmania and Victoria, each with its own zonal price.

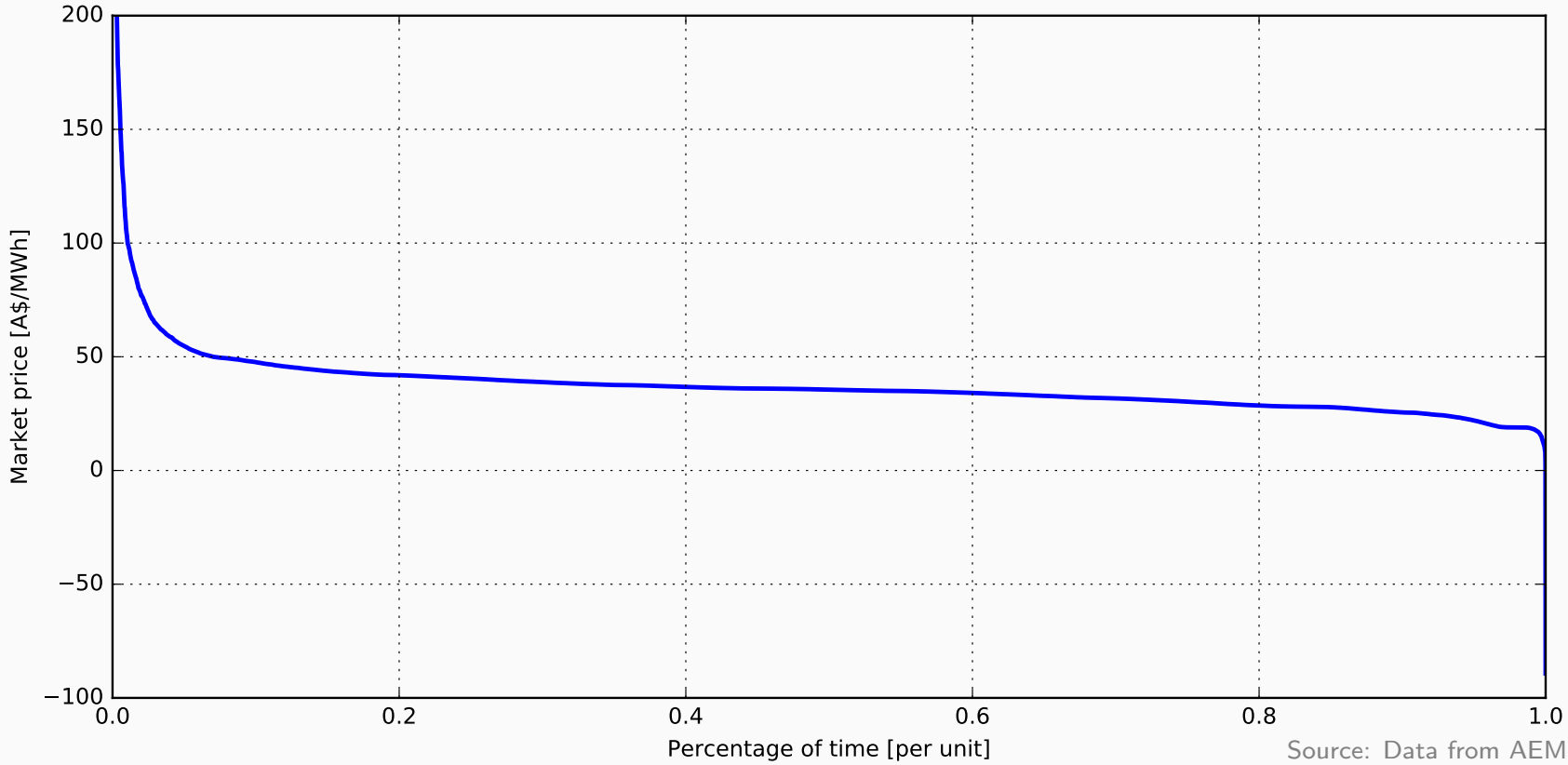
Peak load of 33 GW, generation capacity of 50 GW.

It is the world's longest interconnected system, stretching over 5,000 kilometres.

Source: AEMO

New South Wales price duration curve 2015

On 23rd September 2015 the price in NSW hit a year-maximum of A$13420/MWh, just below the cap, even though the demand was only 9963 MW, compared to the 2015 peak of 12602 MW.



Source: Data from AEMO

Australian Market in Future

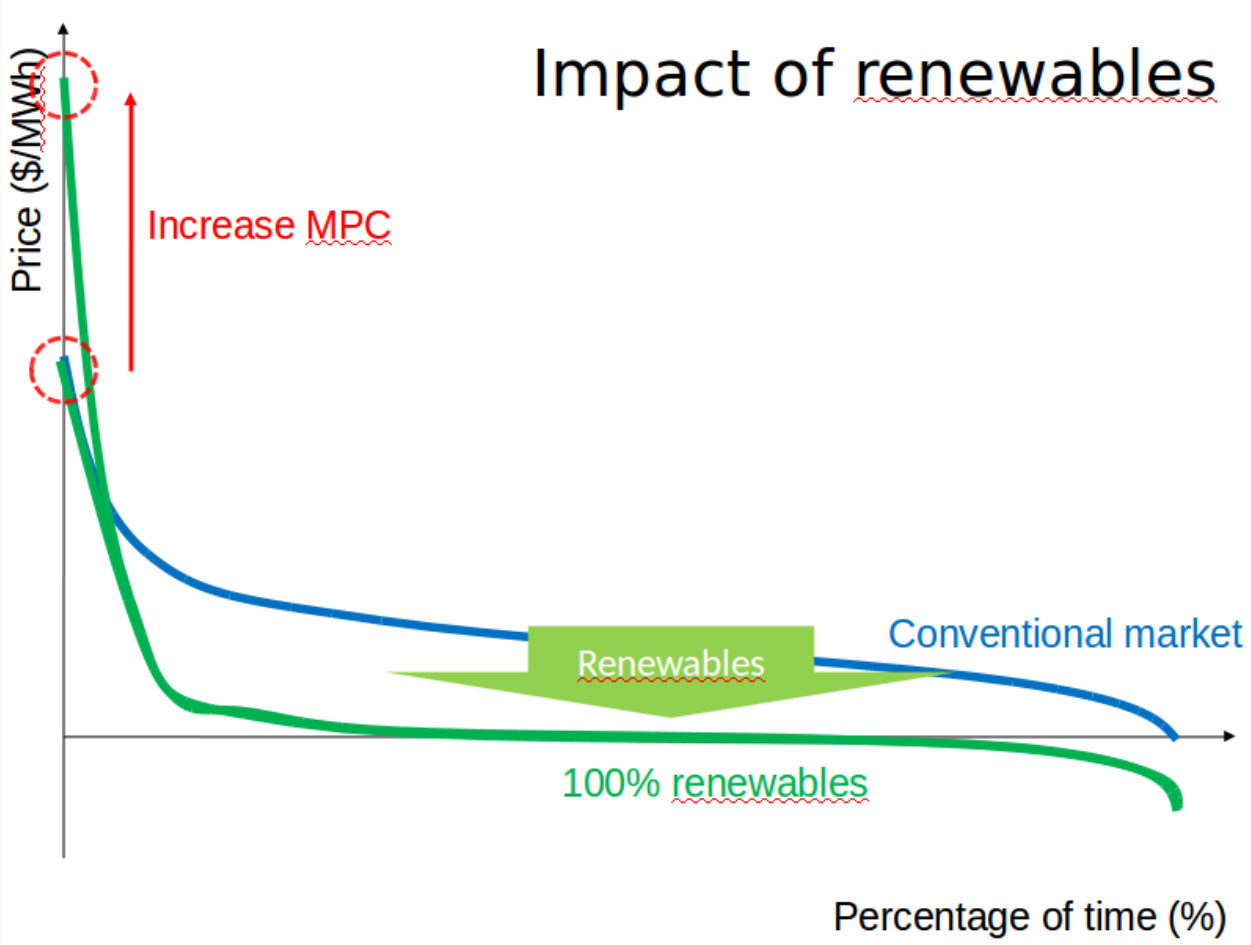
A recent paper on the Australian market: "100% Renewables in Australia: Will a Capacity Market be Required?" by Jenny Riesz, Iain MacGill, 2013, link, analysed the effect high shares of renewables would have on the market and the MPC.

"However, most renewables have very low SRMCs, which in a competitive market is likely to lead to an increasing proportion of low priced periods. This has led to suggestions that a capacity market may be required in the Australian National Electricity Market (NEM). This analysis suggests that existing energy- only market mechanisms in the NEM have the potential to operate effectively in a 100% renewables scenario, but success will rely upon two critical factors: (1) further increase to the already high Market Price Cap (MPC) of A$12,900/MWh. Initial analysis suggests this may need to increase by a factor of six to eight."

(Australia is also interesting for having a market with 5 min dispatch intervals, compared to hourly for Day Ahead in Germany and quarter-hourly for Intraday Market)

Australian Market in Future

MPC may have to increase 6-8 fold to close to VOLL with high shares of RE so that conventional backup generators can recover their costs:



Source: Jenny Riesz

UK price spikes

Price spikes are also caused by reliability problems with other generators, as has happened recently in the UK:

NATIONAL GRID PLC

5:45 PM Tuesday

UK electricity prices spike after power stations break down

By Kiran Stacey, Energy Correspondent

Electricity prices spiked on Monday night, it has emerged, after several old power stations broke down, forcing National Grid to issue an emergency request for more supplies.

Power prices jumped to £1,250 per megawatt hour at one point as the company that runs the UK's electricity network rushed to make sure there was a big enough gap between demand and supply. The normal price per MWh in the summer is about £50.

National Grid said on Tuesday it had issued a so-called "notification of inadequate system margin [Nism]" at 7pm on Monday — only the third time it has done so since 2009.

The last time the company took such action was after similar plant breakdowns last November, when it also paid heavy users for the first time to turn down their equipment.

Source: Financial Times

Comparison with Uber surge pricing

Note the same, since no long-term investments that need to be covered.

Similar in terms of political concerns.

Capacity Markets

A cap on the price in the wholesale market that is binding at times reduces the revenue that generators can earn from the market thereby reducing their incentives to invest. This is known as the 'missing money' problem and results in an inefficient mix of generation. The incentives for investment can be restored by making additional payments to generators based on their available capacity. These payments are often determined through a market process known as a 'capacity market'. Capacity markets represent a response to an existing market defect (the price cap) and are not necessary where the price cap has been removed.

Flexibilise demand

High price spikes can also be ameliorated by adjust demand, which was here assumed to be fairly inelastic.

Flexibilise demand by making it price-responsive.

The technology required to make a sufficient portion of the demand responsive to short-term price signals is not yet available, although some large loads (cement works, etc.) may already implement demand-side management (DSM).

Widespread load disconnections are extremely unpopular and often have disastrous social consequences (accidents, vandalism). They are also economically very inefficient. Their impact can be estimated using the value of lost load (VOLL), which is several orders of magnitude larger than the cost of the energy not supplied. Consumers are not used to such disruptions and it is unlikely that their political representatives would tolerate them for any length of time.

The Californian electricity crisis: Abuse of market power

California

The deregulated spot market for electrical energy in California went into operation in April 1998.

Prices started to rise and strong peaks started appearing from May 2000 onwards.

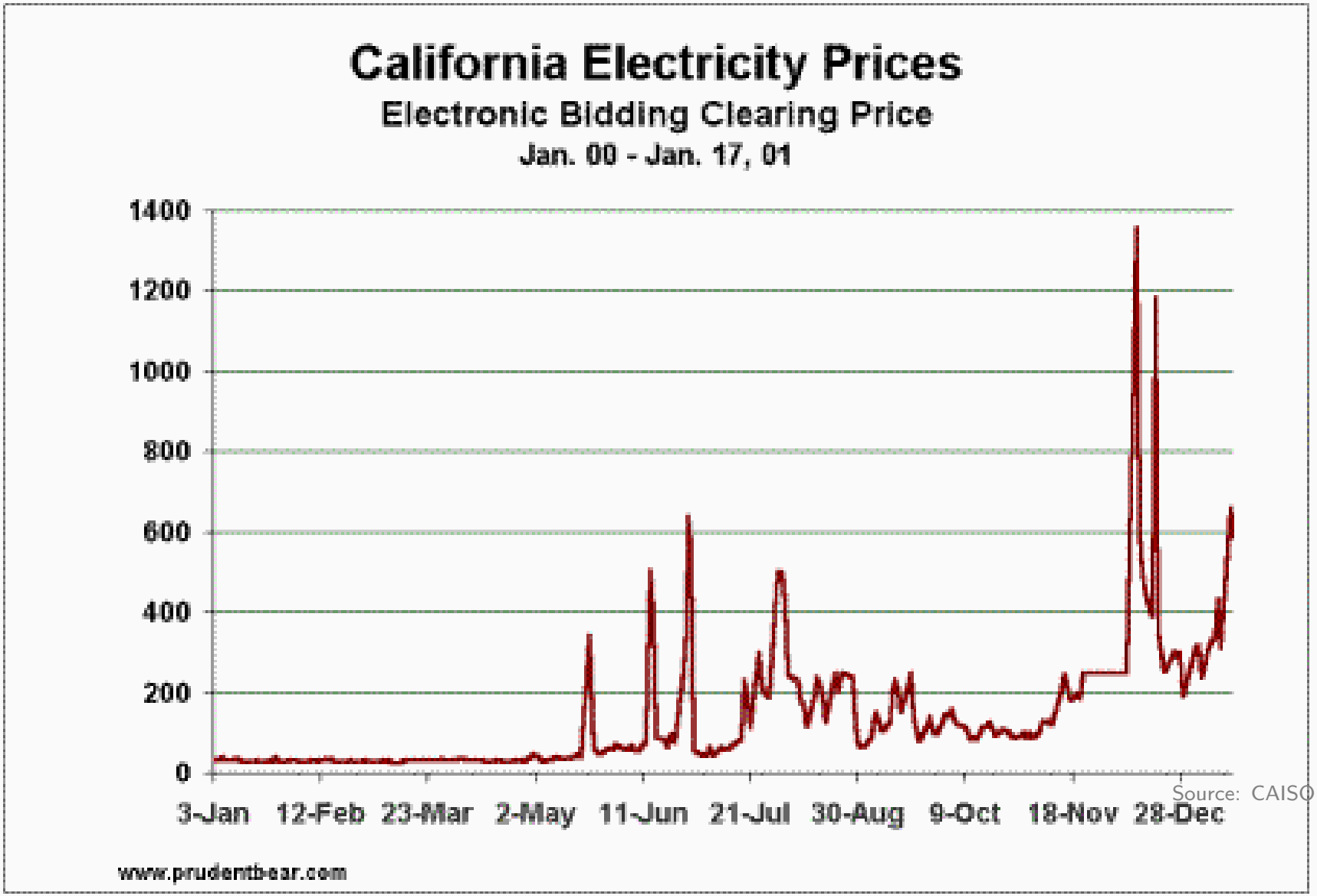
Blackouts followed in 2000-2001, affecting hundreds of thousands of people, culminating in blackouts affecting 1.5 million customers in March 2001.

A shortage of electricity supply had been caused by market manipulations, illegal shutdowns of pipelines by the Texas energy consortium Enron, water shortages and capped retail electricity prices.

Government intervention was required to defuse the crisis.

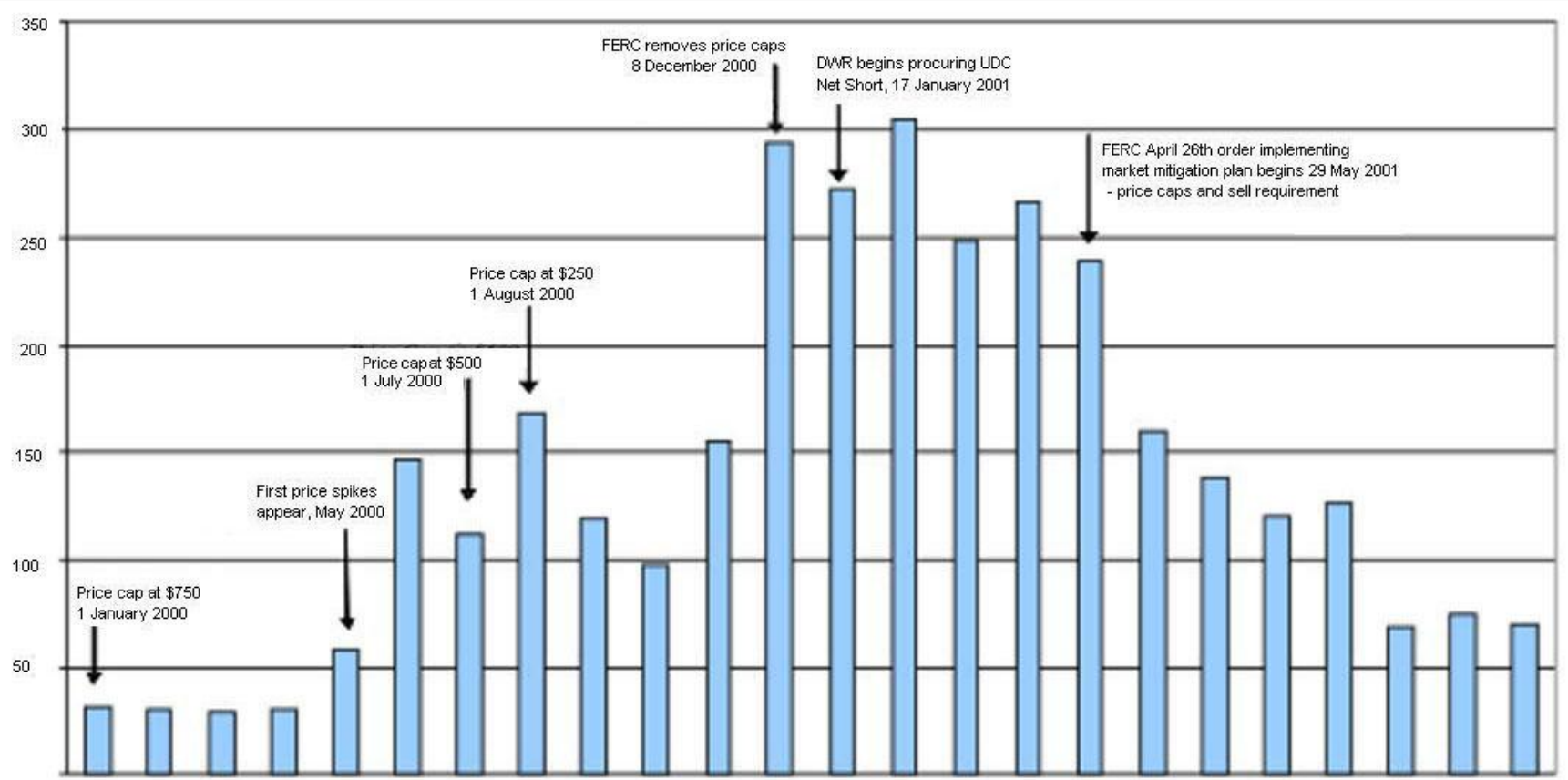
First price spikes

First price spikes started appearing in May 2000



Source: CAISO

Average prices in California in 2000-2001



Date	Jan00	Feb00	Mar00	Apr00	May00	Jun00	Jul00	Aug00	Sep00	Oct00	Nov00	Dec00	Jan01	Feb01	Mar01	Apr01	May01	Jun01	Jul01	Aug01	Sep01	Oct01	Nov01	Dec01
$/MWH	31.63	30.43	29.55	30.78	58.06	146.77	112.06	167.93	118.55	98.02	154.86	294.19	271.98	304.42	248.99	265.89	239.50	159.81	137.83	120.16	126.84	69.37	74.82	69.63

Source: CAISO

Explanations of the crisis

1. Classic case of abuse of market power: artifical shortages were created by taking power plants offline for maintenance at times of peak demand (mainly by Enron)
2. "Overscheduling" of transmission lines - blocking more capacity than was needed, leading to artifical congestion
3. Manipulation of imports and exports from outside the state
4. Delays in approval of new power plants
5. Drought affected hydro and there were fuel price increases
6. Long-term contracts were disallowed by law, forcing all utilities onto the spot market
7. Cap on retail prices squeezed the margins of retailers and dissuaded energy efficiency

Clear-up process

Testimony on crisis in Californian Senate in 2002:

"There is one fundamental lesson we must learn from this experience: electricity is really different from everything else. It cannot be stored, it cannot be seen, and we cannot do without it, which makes opportunities to take advantage of a deregulated market endless. It is a public good that must be protected from private abuse. If Murphy's Law were written for a market approach to electricity, then the law would state 'any system that can be gamed, will be gamed, and at the worst possible time.' And a market approach for electricity is inherently gameable. Never again can we allow private interests to create artificial or even real shortages and to be in control."

The crisis cost tens of billions of dollars.

Source: Wikipedia

Solution to the crisis

Government intervention.

On January 17 2001, Governor Gray Davis declared a state of emergency and bought long-term contracts on the open market at highly unfavorable terms for the utilities, wiping out the state surplus and creating a massive debt. By then, the utilities were in backruptcy and had no buying power. The prices of electricity that the long-term contracts locked in reportedly averaged $69 per megawatt-hour, compared to September 2002 prices of $30 per megawatt-hour.

Retail competition was ended in September 2001.

Energy efficiency was also improved.

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The source LaTeX, self-made graphics and Python code used to generate the self-made graphics are available on the course website:

`http://fias.uni-frankfurt.de/~brown/courses/electricity_markets/`