As the Lights Go Down…

Under-investment in generating capacity in a deregulated electricity market.

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Structure of Presentation

Key issue: what determines the level of capacity chosen by profit-maximising electricity generators?

- The Context
- The Model
- Results of a Simulation for Ireland
- Observations and Implications

The Context (1)

Liberalisation of national electricity industries across world: New Zealand (1987-), UK, USA.

Atomisation of holdings of generation assets, decentralisation of investment decisions.

CapGemini's global survey of utilities (2004): a "worrying lack of clarity on responsibility for generation adequacy" in NZ

… although the failure to identify a single "responsible" party is not surprising.

The Context (2)

Investment decisions will be driven by the maximisation of profits of individual generators – rather than fulfillment of social or political goals.

Does this fact have any long-term implications for system capacity?

The Context (3) - Ireland

Like NZ, an island nation with population of approximately 4m.

Small electricity market (approximately 5,100 MW installed capacity) relative to “lumpy” generation plant – eg. Moneypoint (912 MW) and Poolbeg (1020 MW) stations.

Limited hydro capacity and potential – 220 MW installed.

Ireland’s electricity generation still dominated by government-owned Electricity Services Board (ESB) (87% of system generating capacity)

The Context (4) - Ireland

Prices charged by ESB's generation division must be approved by the regulator, the Commission for Energy Regulation (CER).

40% increase in retail electricity prices between 2001 and 2004.

ESB staffing levels reduced, but remaining workers earn more than double the average industrial wage.

Impression that CER allows pass-through of eg. fuel cost increases → no incentive for ESB to pursue efficiency.

Irish Competition Authority (2003): introduce competition in generation by splitting up ESB's generating assets

The Model

Perhaps motivated by deregulation in Spanish electricity industry, three Spanish economists have proposed a model that explores the motivation of generators:

Castro-Rodriguez, F., Marin, P. and Siotis, G., 2001.

***Capacity Choices in Liberalized Electricity Markets*.**

London: Centre for Economic Policy and Research (CEPR Discussion Paper No 2998).

Available from: www.cepr.org/pubs/dps/DP2998.asp

The Model: Two-Stage Game

Stage One – Long-Term Investment Decision:

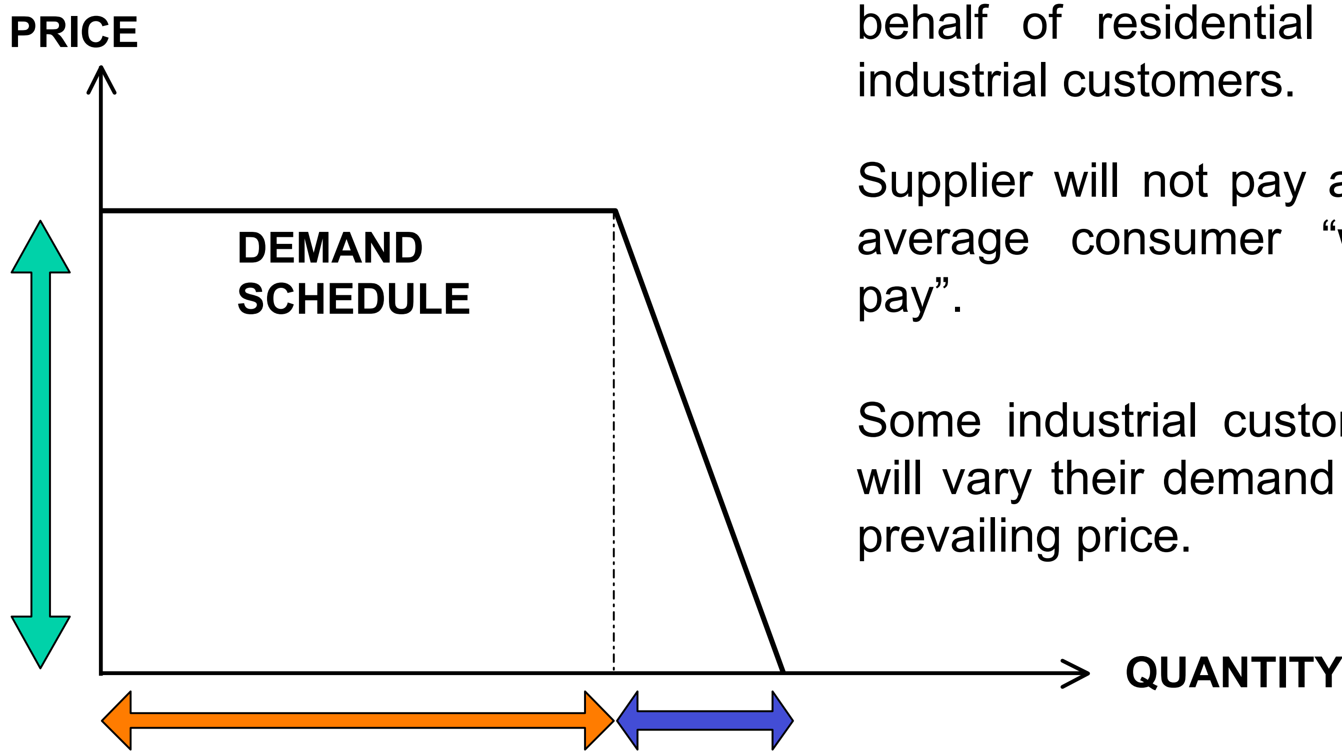
Industry players choose how much capacity to install, based on their estimates as to the demand profile across each hour in the coming period(s).

Capacity is expensive to install – assign fixed cost per each MW.

Stage Two – Electricity Supply:

Generators make supply bids on spot market. Assume that this occurs "competitively" - ie. price equals marginal cost of generation, except where system capacity constraint binds.

The Model – Demand (1)

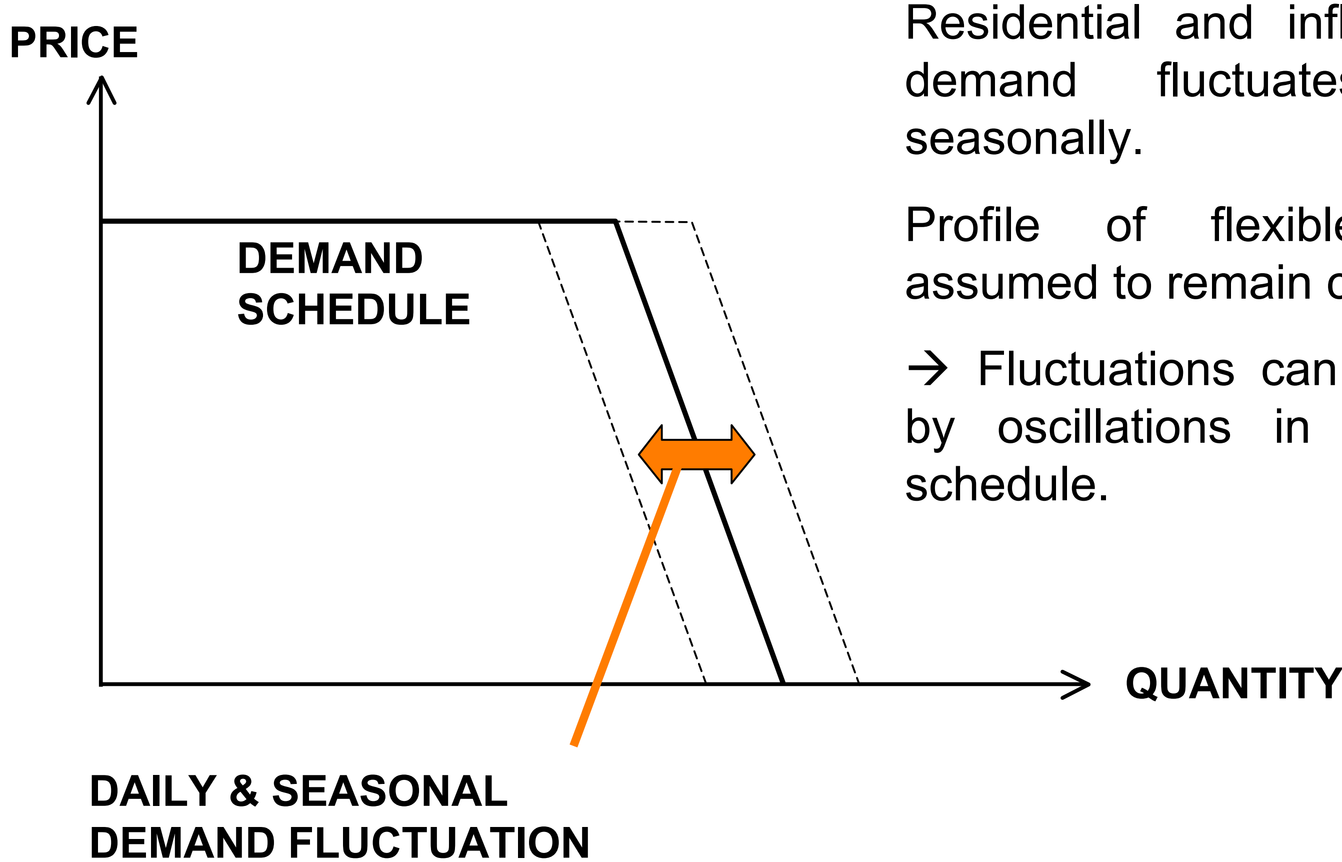


Electricity supplier intermediates on behalf of residential and inflexible industrial customers.

Supplier will not pay any more than average consumer "willingness to pay".

Some industrial customers can and will vary their demand depending on prevailing price.

The Model – Demand (2)

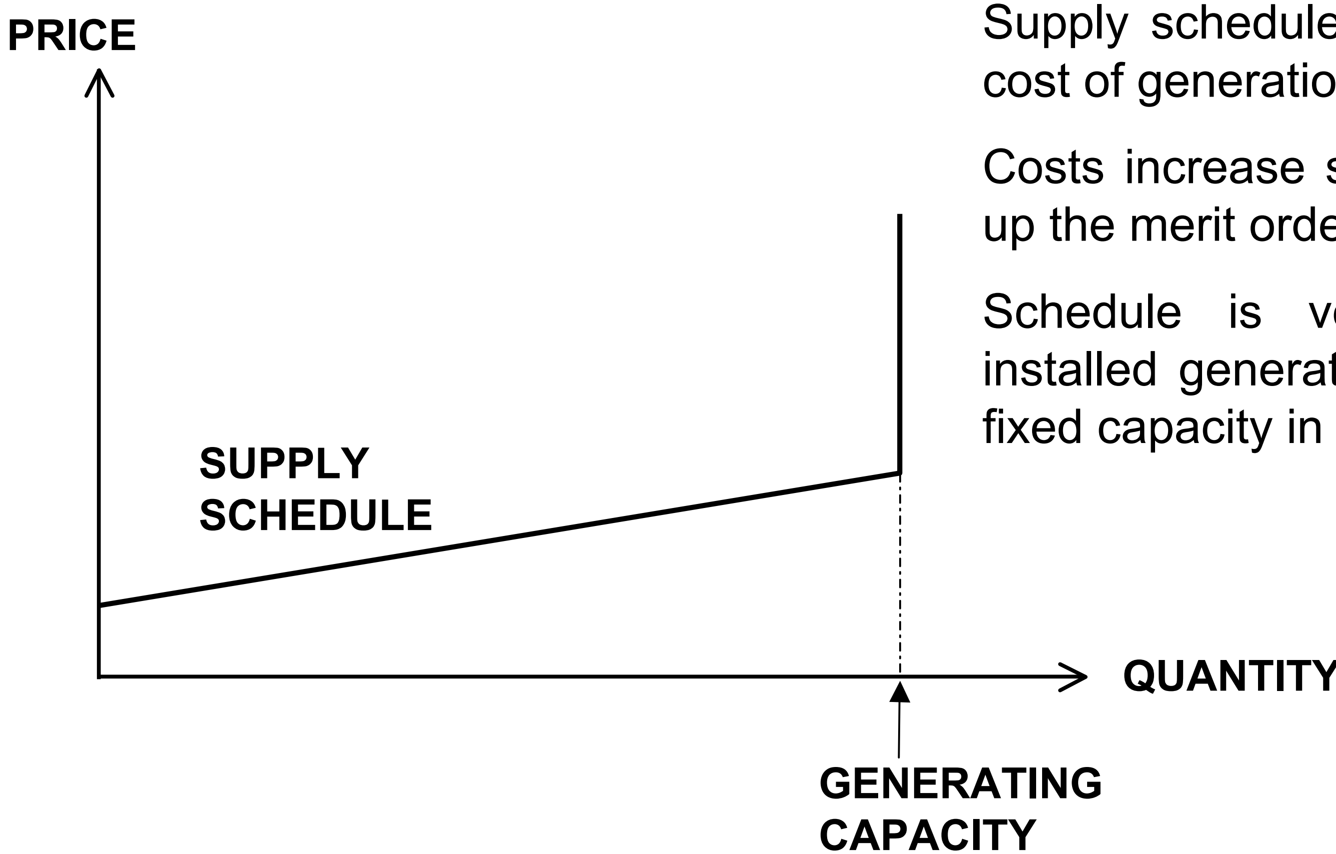


Residential and inflexible industrial demand fluctuates daily and seasonally.

Profile of flexible demand is assumed to remain constant.

→ Fluctuations can be represented by oscillations in kinked part of schedule.

The Model - Supply

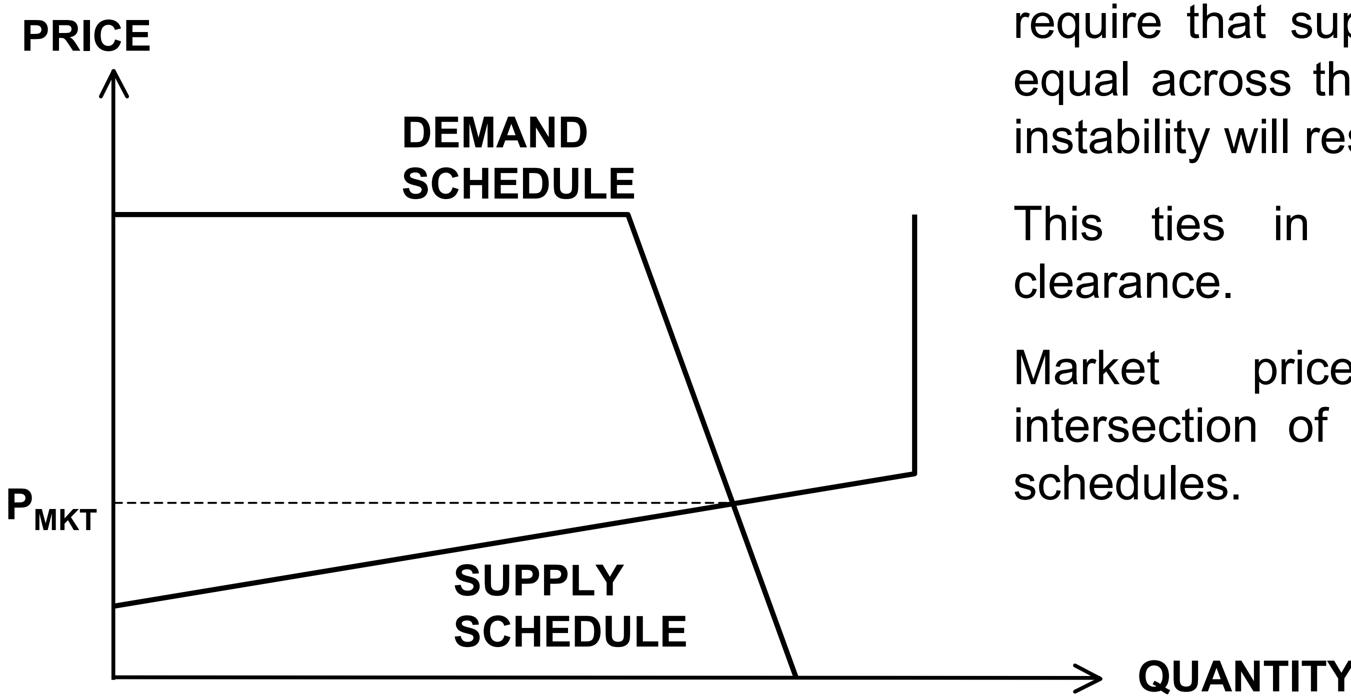


Supply schedule based on marginal cost of generation.

Costs increase steadily as we move up the merit order.

Schedule is vertical at level of installed generating capacity, due to fixed capacity in short-medium term.

The Model – Supply and Demand



Physical properties of electricity require that supply and demand be equal across the network, otherwise instability will result.

This ties in nicely with market clearance.

Market price generated by intersection of supply and demand schedules.

Demand vs. Capacity

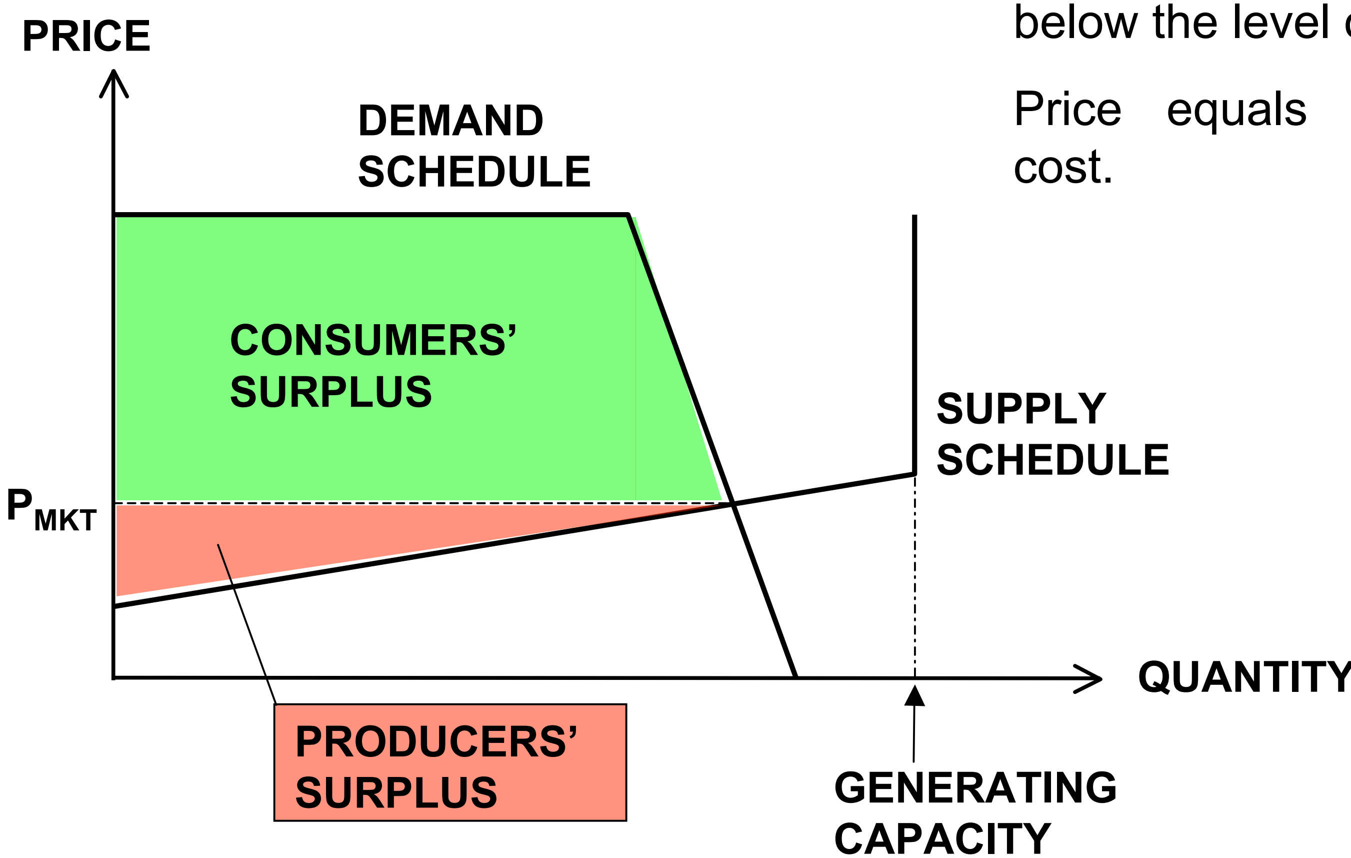
Use notions of consumers' and producers' surplus as approximations of gains to trade, and measure of the "welfare" accruing to parties.

Each diagram is a "snapshot" of the situation in the market over a (say) 1-hour period.

In each hour, one of three possible scenarios will describe the relationship between demand and generating capacity.

Welfare implications of each will differ.

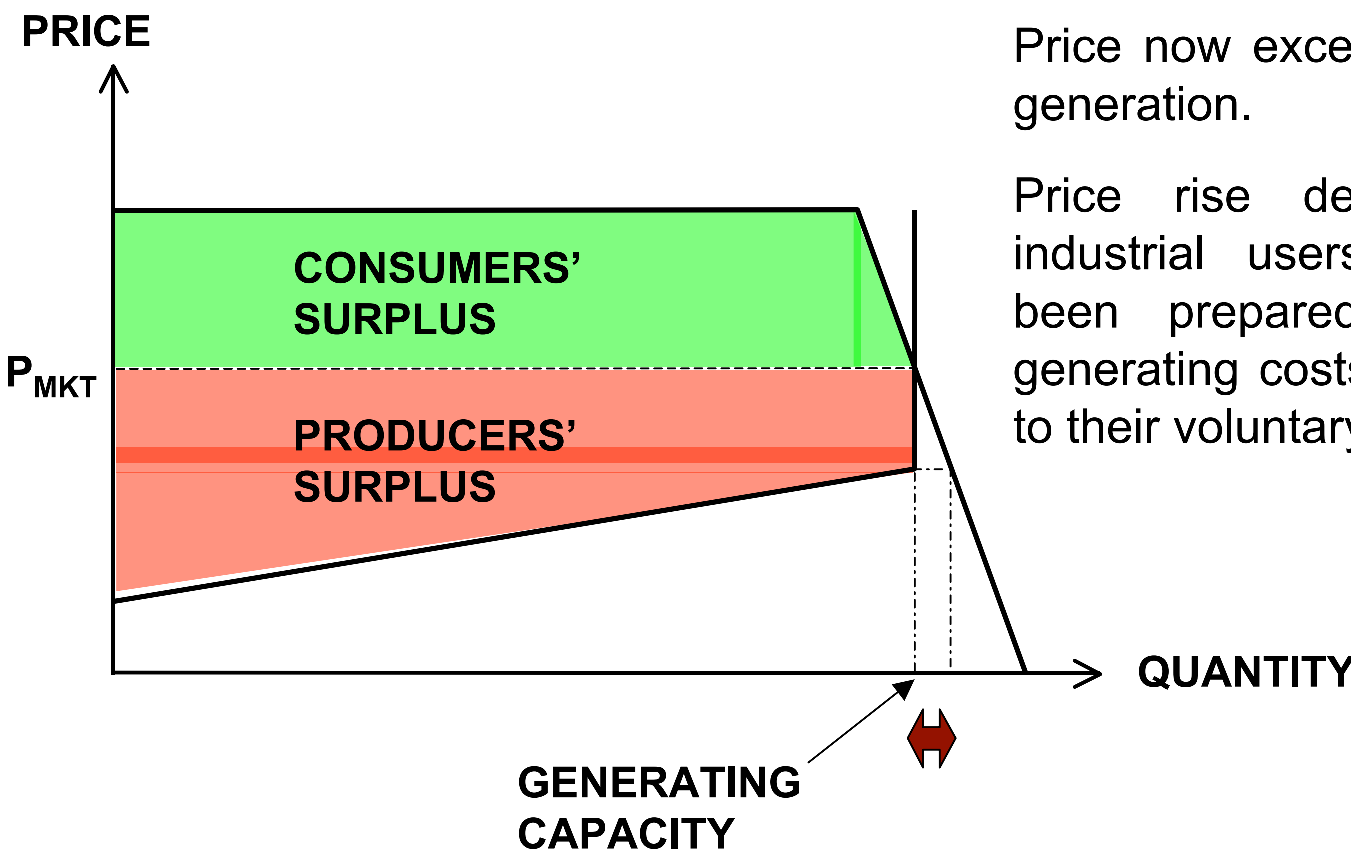
Scenario 1: Low Demand



Demand equals supply at output below the level of installed capacity.

Price equals marginal generating cost.

Scenario 2: "Brownout"

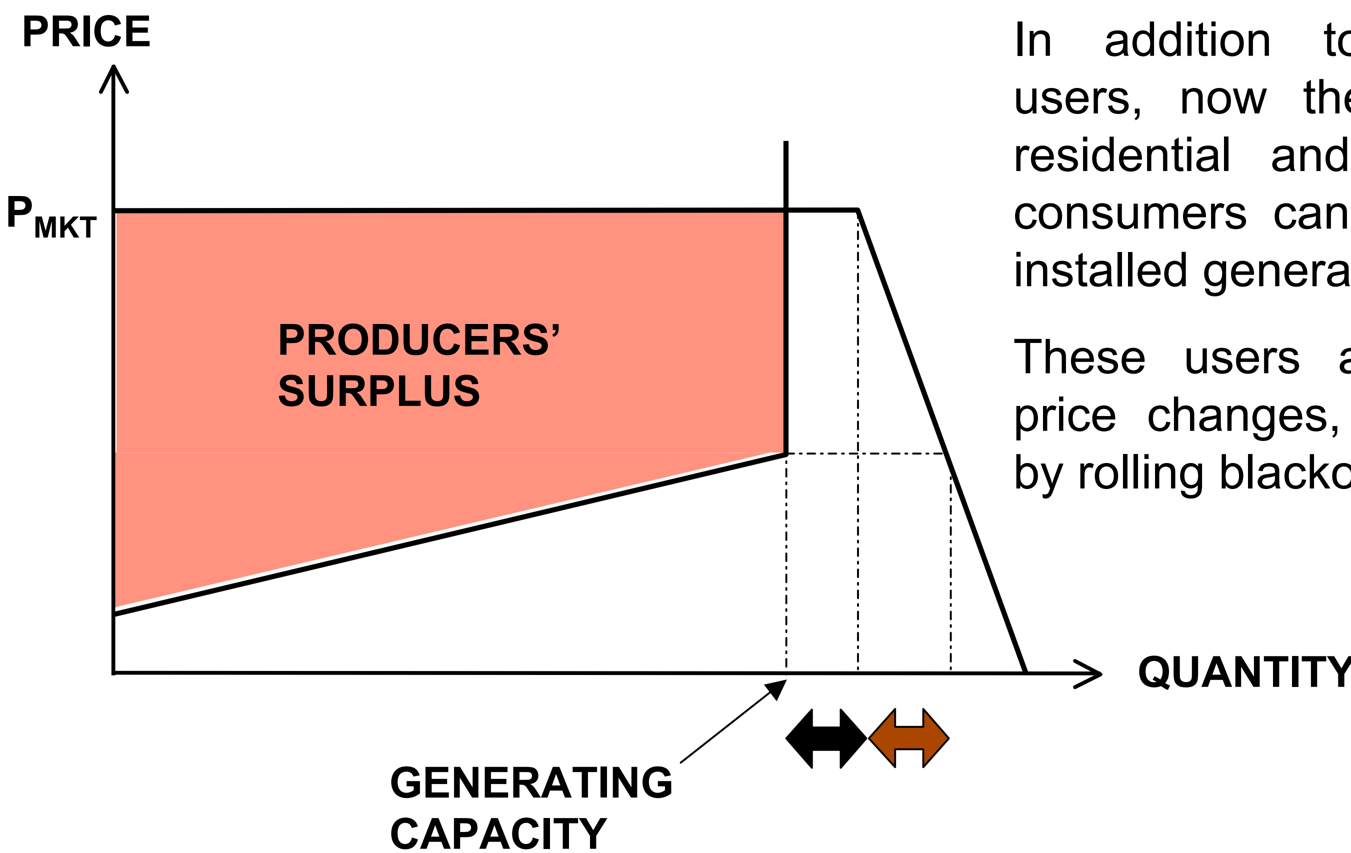


Demand has increased.

Price now exceeds marginal cost of generation.

Price rise deters some flexible industrial users who would have been prepared to pay marginal generating costs – "brownout" refers to their voluntary curtailment of use.

Scenario 3: Rolling Blackouts



Demand has increased further.

In addition to flexible industrial users, now the demand of some residential and inflexible industrial consumers cannot be satisfied with installed generating capacity.

These users are not exposed to price changes, so rationing occurs by rolling blackouts.

Combining the Scenarios

What determines which of the scenarios will obtain for any particular hour?

1. Amount of demand (residential and inflexible industrial)

   Fluctuations: seasonal, daily, temperature

2. Level of installed generating capacity

   Determined by investment decisions of generators

Capacity Choice

Just what goal are generators pursuing? This will depend upon the structure of industry. Consider two alternatives:

"Benevolent central planner" - **maximises the total of producer and consumer surplus**, less installation costs.

Profit-maximising generator - **maximises its share of producers' surplus**, less installation costs.

Simulation for Ireland

Hourly demand data for Ireland in 2002 were used to compile estimates for hourly demand in 2003.

An uplift was applied to reflect expected economic growth.

There were no recorded instances of blackouts arising from excess demand → this demand data was taken correspond to quantities demanded in Scenario 1 situation.

Results – Central Planner

The model suggests that the socially optimal level of generating capacity for Ireland is:

3980 MW

This level of capacity meets system demand during 99.6% of hourly periods during the year.

Brownouts:	20 hours per year	(0.23% of time)
Blackouts:	22 hours per year	(0.25% of time)

Results – Private Generators

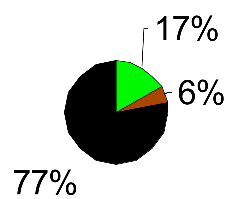
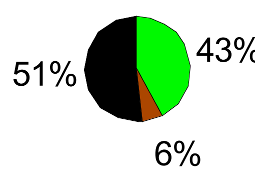
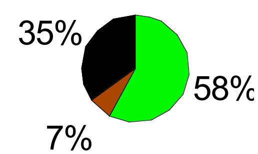
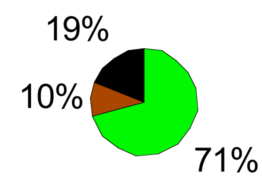
For tractability, assume that each profit-maximising generator is identical as to:

- Size
- Portfolio of generating plant
- Expectations as to demand fluctuations

Where *n* firms are present, each will also need to consider the capacity decisions of the other, identical, *(n-1)* firms.

Under these assumptions, maximising each firm's share of producers' surplus yields the same result as **maximising total producers' surplus**.

Results – Private Generators

Number of firms	1	2	4	10
Generating Capacity (MW)	1871	2446	2797	3006
Scenarios 1: Low Demand 2: Brownouts 3: Blackouts				

Results – Private Generators

Number of firms	10
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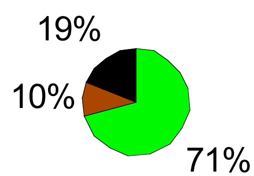
Scenarios 1: Low Demand 2: Brownouts 3: Blackouts	

As number of firms increases beyond 10, average firm size falls below minimum economic plant size.

← This is effectively the maximum capacity that decentralised market would install

Compare this with the socially optimal level of generating capacity:

3980 MW

Observations (1)

Identical-firm restriction precludes consideration of merchant plants.

Assumption of **monolithic grid** excludes possibility of distributed generation. Depends on tech changes, economies of scale.

Different form of intermediation by supplier will change result eg. why not expose consumers to all price changes?

Induced demand: dependence would not have developed if blackouts were a possibility.

Observations (2)

Despite these points, model serves useful purpose of illuminating some points that are usually overlooked…

Capacity shortages will be good for generators, if they can benefit from the associated price spikes.

Why should we therefore expect them to install enough capacity to avoid such spikes?

Observations (3)

Even with a legacy of over-investment, capacity can be tightened through managed obsolescence and failure to respond to organic demand growth…

… and the lights may indeed be allowed to go down!

THE END