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TILEC Discussion Paper

DP 2014-026

The generation mix, price caps and capacity markets

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July, 2014

ISSN 1572-4042

ISSN 2213-9419 http://ssrn.com/abstract=2466266

Electronic copy available at: https://ssrn.com/abstract=2466266

The generation mix, price caps and capacity markets[1]

Version: January 2014

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Abstract This paper derives the optimal mix of generation technologies in the electricity sector and discusses how this mix will be achieved in a perfectly competitive electricity market. It then studies the detrimental effect of a price cap on short-term profitability and long-run investment incentives of producers, and shows how a technology-neutral capacity mechanism can restore the efficient generation mix. Intermittent wind production or active consumer participation do not fundamentally affect this analysis.

1 Introduction

This paper provides an economic analysis of capacity mechanisms in electricity markets. It considers a single market distortion in the form of a price cap on the spot market, which limits the price that generators receive, and studies how this distortion affects investment incentives for the different generation technologies. We then discuss how a capacity mechanism can be used to improve market outcomes.

The goal of this paper is to provide a simplified analysis of generation investments and highlight some economic key-concepts. We show for instance that although a price cap affects investment levels in peak-load generation and not in base-load capacity, capacity mechanisms should be technology neutral, and provide the same incentives to base-load and peak-load generators. We further show that the introduction of renewable energy reduces the profitability of existing generators, but that this does not imply that capacity markets should be used to bail-out generation plants.

The papers's framework relies on a decades old pre-liberalization deterministic graphical analysis of optimal generation portfolios using load-duration graphs and

[1] This paper will be published as a chapter for the book "The Law and Economics of EU Capacity Markets" eds. Hancher, Hauteclocque & Sadowska.

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total cost functions. However, the inclusion of a price cap and capacity payments within this analysis is as far as I know novel.[3]

In this paper we will not discuss whether capacity markets should be part of a well-designed power market or not. One could think of several market failures that distort investment incentives and for which a capacity mechanism is only one of the many possible remedies. For instance: a price cap might be necessary to address market power of dominant generators, energy prices might be artificially low because of monopsony power of the network operator, financial markets might be insufficiently liquid for firms to hedge price and volume risk, regulators might have to determine the value of undelivered electricity as consumers do not participate sufficiently, and entry barriers in generation might lead to under-investments. An in depth game theoretical and extensive empirical analysis would be required to answer this question.[4]

Neither do we discuss which type of capacity mechanism would be optimal. We show how a simple capacity payment can restore market efficiency, but assume that firms do not behave strategically. An optimal capacity mechanism addresses the market failure it wants to correct, and takes into account the incentives it creates for the participating firms.

The structure of the paper is as follows: Sections 2 and 3 discuss the specificities of electricity markets, explain why a mixture of generation technologies is optimal and how this optimal generation mix can be achieved in a perfectly competitive market using peak-load pricing. In Section 4 we introduce a price cap and show how it distorts electricity prices, its effect on the profitability of peak and base-load power plants and on long term investments incentives. Section 5 shows that technology neutral capacity payments can restore investment incentives. Section 6 discusses the effect of a larger share of renewable energy and demand side participation on the capacity markets and the generation mix. Section 7 concludes.

2 Optimal generation mix

Any handbook on electricity markets starts from three fundamental characteristics of electricity markets: (1) demand varies over time and is very inelastic, (2) storing electrical energy is expensive, and (3) production capacity is fixed in the short run and capital intensive in the long run. Based on those characteristics it is then explained how electricity markets rely on a form of peak-load pricing to or-

[3] See for instance Appendix E in (Hunt, 2002), Chapter 8.2 on load duration curves in (Wood, 1996).

[4] (Joskow, 2008) gives an overview of market failures in U.S. markets that could justify the use of capacity markets, but those conditions might not necessarily hold in the E.U. given that power exchanges are not obligatory and retailers are competitive in the E. U. (Hogan, 2005) argues that power markets should not include capacity markets and price caps and that there might be alternative forms of regulation than capacity mechanisms to address market failures such as insufficient contracts. (Willems and Morbee, 2010) and (Willems and Morbee, 2011) study the effect of missing financial markets on investment incentives.

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ganize the spot market for electrical energy and how a mixture of base-load and peak-load power plants is optimal.[5] We will provide a condensed version of this theory here.

Given that electricity cannot be stored, total production needs to be equal to total consumption at each moment in time. This is achieved (1) by constructing a sufficiently large amount of generation capacity such that production output can follow demand most of the time, and (2) by rationing demand when production capacity is insufficient.[6] Some production units will only be used in a small number of hours every year when demand is large, while being idle the rest of the year, *i.e.* they have a low *load factor*. For those production units it is optimal to use power plants with low capital costs (so called peak-load power plants). Other production units will be used for a large number of hours every year and almost never run idle, *i.e.* they have a high load factor. For those production units, power plants that convert primary energy (gas, coal) very efficiently into electrical energy are used (so called base-load power plants). They have higher capital costs than peak-load power plants, but their production efficiency gains outweigh those capital cost disadvantages for the high load factors they are used for. For a very small fraction of the year even the capital cost of the peak power plants is too high to justify building additional capacity to meet demand. Instead it is more efficient to ration a small fraction of total demand and to pay consumers that are rationed to forego electricity consumption entirely. Typically those compensation payments are relatively high, reflecting the importance of electrical energy, but only have to be paid out during a small number of hours to a small subset of consumers. The price for not receiving electricity is often called the *Value of Lost Load* or VOLL.

When demand is perfectly inelastic, and neglecting some technical constraints, such as start-up costs, ramping constraints, transmission constraints and the unavailability of generation plants, the optimal generation mix and the optimal amount of rationing can be illustrated graphically. We first sort all 8760 hours of a year from the hour with the highest level of demand (which is expressed in MW) towards the lowest level of demand, and represents this in a *load duration function*.[7] One such load duration function is presented in the upper-half of Figure 1. The graph shows for instance that demand is at least 3,274 MW for 7,000 hours per year and that the maximal level of demand is equal to 7,961 MW.

[5] The theory of peak load pricing and investments dates from (Boiteux, 1964, 1960). (Crew et al., 1995; Joskow, 1976) review the literature on peak load pricing and describe several extensions of the simplest models.

[6] In the text we will use the term 'demand' for the amount of energy consumers would like to consume, and 'consumption' for the amount of energy consumers actually consume. If demand is rationed, then the consumption will be smaller than demand.

[7] To improve readability of the graph in Figure 1, the load duration curve is assumed to have a relatively high downward slope. In practice, load duration functions are often much flatter.

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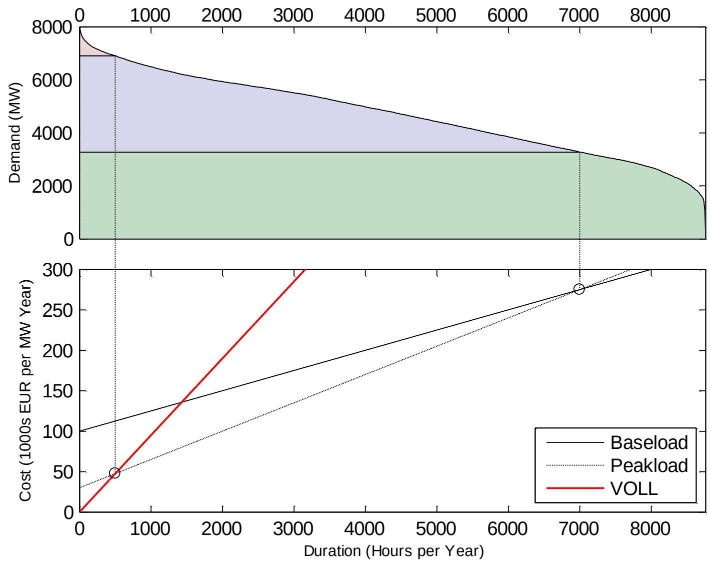

Figure 1: Optimal generation mix

The total production cost of a generation plant consists of a fixed capital cost, which is incurred even when the power plant is not used, and a variable cost which is proportional to the number of hours the power plant is actually producing electricity. Those variable costs consist mainly of operating and fuel costs. The bottom half of Figure 1 presents the total production costs of a base-load plant and a peak-load plant each capable of producing 1 MW, as a function of the number of operating hours in a year, for the parameters shown in Table 1. Those lines are also called the screening-curves. When the power plants do not operate (left side of the figure), they occur only their capital costs, but no operating or fuel costs. Capital costs for the peak-load power plant are 30kEUR, while they are 100kEUR for the base-load power plant. Total production costs will increase with the number of hours that plants operate, but they will increase faster for peak-load than for base-load power plants. At the intersection of those two costs lines (which occurs at 7,000 hours per year) their total costs are equal. The bottom graph shows that a peak-load power plant is cheaper than a base-load power plant whenever it has to run less than 7,000 hours per year. Above this number, the base-load power plant is less expensive.

	Annualized capital cost EUR / (MW Year)	*Marginal cost EUR / MWh*
Peak-load Power plant	30,000	25
Base-load Power Plant	100,000	35
VOLL		95
Price cap		45

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Table 1: Parameters used in the example

If demand cannot be rationed, then the total capacity of base-load and peak-load power plants has to be equal to 7,961 MW to meet the highest demand level. So how much of this capacity should be built as base-load power plants, and how much as peak-load power plants? As demand is at least 3,274 MW for 7,000 hours per year, and base-load power plants are cheaper than peak-load power plants if they run more than 7,000 hours per year, we should invest this amount (3,274 MW) in base-load capacity, and allocate the rest to peak-load capacity (4,686MW = 7,961MW-3,274MW).

If we can ration demand and compensate consumers for being curtailed, it is efficient to reduce investments in peak-load, and save on investments costs (and some operating costs). Those cost savings will outweigh the disutility of not delivering electricity to a small fraction of consumers for a small fraction of the time. The optimal amount of rationing can be analyzed graphically. Demand rationing can be seen as a third 'production' technology with zero capital costs and a marginal cost equal to the VOLL. The total cost of rationing 1MW for a given number of hours per year is given by the red line in Figure 1. Typical VOLL estimates are in the range 10,000EUR/MWh, however, for illustrative purposes, a value of 95 EUR /MWh is used here.[8] This shows that it is inefficient to build peak-load power plants that run for less than 500 hours per year, as it would be more efficient to ration demand instead. So total installed capacity should only be 6,907 MW, of which 3,274MW base-load and 3,633MW (=6,907MW-3,274MW) peak-load production. Whenever demand is larger than 6,907 MW, some consumers will be rationed. The optimal generation mix is represented in the second column of Table 2.

	Scenario			
	No price cap	*Price Cap*	*No price cap Wind energy*	*Price cap Wind energy*
Base-load	3,274	3,274	1,609	1,609
Peak-load	3,633	2,233	4,418	2,383
Total capacity	6,907	5,507	6,027	3,992
Maximal demand	7,961	7,961	7,961	7,961

Table 2: Equilibrium investment levels

Hence, we have shown that in the social optimum, the generation mix consists of a mixture of base-load and peak-load production technologies. The colored horizontal bands in upper half of Figure 1 show which combination of the three technologies (base-load, peak-load and demand rationing) is used to ensure that consumption equals supply for each hour in the year. Base-load capacity is colored

[8] With a large VOLL, the red line would almost become vertical on the graph, and it would be hard to show the intersection of this line with the peak-load generation cost.

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green, peak-load technology blue, and demand rationing red. For high demand hours (left side of graph) all three technologies are used to meet demand, for intermediate demand hours (middle of graph) only base-load and peak-load plants are used, while for low demand hours (right of graph) only base-load technology is used.

3 A competitive market leads to an optimal generation mix

In this section we will show that the optimal generation mix and their usage as outlined in Section 2 will be achieved in a competitive electricity market.[9] Figure 2 shows the market equilibrium for three demand levels. The market price is given by the intersection of the demand and the supply function. Generation firms will produce as long as the spot price is equal to or above the marginal production cost. At low demand levels (left graph), the equilibrium price is low (25 EUR/MWh) and only base-load production is active. At intermediate demand levels (middle graph), the equilibrium price is 35 EUR/MWh, and all base-load power plants, and some peak-load plants are producing. At high demand levels, (right graph) the price is equal to the VOLL of 95 EUR /MWh, both peak and base-load produce at full capacity, and a fraction of demand is rationed as indicated by the arrow. Hence in the market equilibrium, power plants with the lowest marginal cost will always produce before power plants with a higher marginal cost come online. This is efficient as it minimized costs, and corresponds to the color scheme laid-out in Figure 1.

Firms will invest as long as they can make some positive profit. Hence, in the long-run equilibrium investment levels, firms will make zero profit on base-load power plants and zero profit on peak-load power plants. We will now show that the investment quantities that correspond with this market equilibrium are the ones derived in Section 2. With other words, given the investment levels in column 2 of Table 2 generators make zero long term profit on peak-load and on base-load generation capacity.

As this might not be immediately obvious, we now discuss why it is the case. There are 500 hours a year in which demand is rationed and during those hours the electricity price is equal to 95 EUR/MWh as shown in the right graph of Figure 2. This price is exactly equal to the compensation that needs to be paid to consumers for rationing demand. However, for a load factor of 500 hours per year, the total production cost of peak-load production is equal to the total cost for rationing consumers, as can be seen by the intersection of the total cost lines in the bottom half of Figure 1. Hence, the price 95 EUR/MWh is also sufficient to pay for the total cost (investment cost plus variable cost) of peak producers operating 500 hours

[9] (Stoft, 2002) shows that competitive markets are efficient as long as prices can rise to the VOLL. The fact that a competitive market equilibrium is efficient is often called the *First Welfare Theorem* and has been developed by (Arrow, 1951; Lange, 1942; Lerner, 1934). (Joskow and Tirole, 2007) show that a competitive market equilibrium is constrained efficient in a more general setting with an imperfect rationing technology.

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per year. If peak producers operate more than 500 hours per year, then they receive 95 EUR/MWh during the 500 hours with the highest demand and a price equal to their own marginal cost (35 EUR/MWh) during the remainder of the hours. Hence, the first 500 hours are sufficient to pay for investment and for the variable costs, while the additional revenue for the hours above 500 is equal to the additional production cost. Peak producers make therefore zero profit.

If base-load generators operate 7,000 hours per year, their total cost is equal to the total cost of peak-load generators. The revenue that a peaker earns during those 7,000 hours is equal to the peaker's total costs (as it has zero profit); hence it is also exactly equal to the total cost of the base-load generator. If the base-load generator produces more than 7,000 hours per year it will receive a price for additional production which is equal to its marginal production costs. Therefore also the base-load generator will have zero profit in the long run at investment capacities shown in the second column of Table 2.

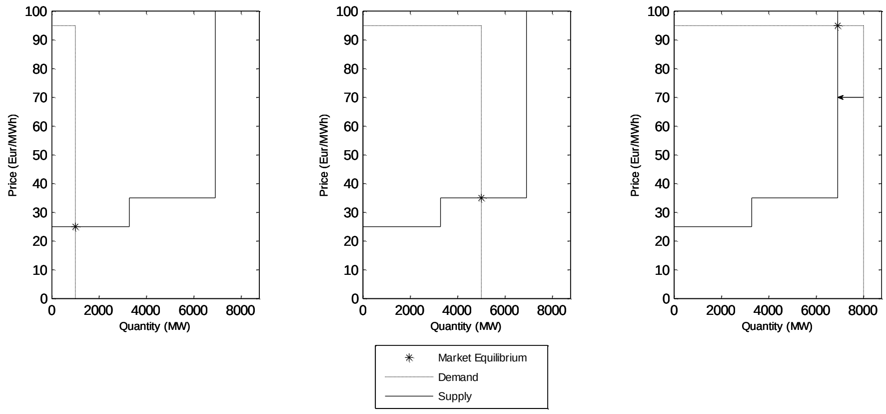

Figure 2: Market equilibrium for low, medium and high demand.

Summarizing: in a competitive electricity market private investment and production decision are such that the optimal generation mix will be achieved.

4 A price cap distorts investment levels

This section studies the short run and long run equilibrium effects of a price cap on a competitive electricity market.[10] We assume a price cap of 45 EUR/MWh as indicated in Table 1.

[10] Here we study the effect of a price cap on investments in a competitive situation. (Buehler et al., 2010) study the effect of a price cap on investments in a Cournot oligopoly with one technology and time varying demand. (Zöttl, 2011) introduces a base-load and a peak-load technology and shows that a well-chosen price cap might increase investments in an oligopoly model as the incentives for withholding capacity are reduced.

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In the short run, investment capacities remain constant and are not affected by the price cap. However, the introduction of the price cap will lower electricity prices during peak hours from 95 EUR/MWh to 45 EUR/MWh. This price reduction will benefit consumers at the expense of producers. The price cap will reduce revenue for all generation plants with 50 EUR/MWh during 500 hours per year. This creates a yearly shortfall of 25,000 EUR per MW installed capacity, both for peak-load and base-load generation plants. This short-fall is called the *missing money* problem. Short run supply is perfectly inelastic at the price cap, and also demand is assumed to be perfectly inelastic.[11] Hence there are no short-term negative welfare effects of introducing price cap. Myopic policy makers (or network operators) might be tempted to impose such a price cap to transfer revenue from generators to consumers without any obvious negative effects on market outcomes.[12]

In the long run, supply is perfectly elastic, as we assume free market entry, and the price cap will therefore distort the market equilibrium and create dead weight losses. Given the missing money problem, generators are unable to cover their capital costs and installed capacities will decrease until the resulting higher prices are sufficient to pay for the capital costs. In the long run, the market will reach new equilibrium in which all generators break-even.

Given that those capital costs are sunk, power plants might not immediately be mothballed after the introduction of a price cap, as they are still making a profit on the margin, but power plants might retire earlier, and not all retired power plants will be replaced.

We can determine the long run equilibrium capacities graphically by lowering the value of VOLL to level of the price cap as illustrated in Figure 3, and use the same analysis as in Section 2. The Figure shows that peak-load capacity is reduced to the point where consumers are rationed about 3,000 hours per year. At this level, prices are sufficiently high to pay for the total cost of the peak-load capacity. The lower price during hours with demand rationing (45 EUR/MWh instead of 95 EUR/MWh) is off-set by an increase of the duration of demand rationing hours (from 500 to 3,000 hours per year). The markup of 10 EUR/MWh that the peak-load power plant earns on top of its marginal cost during those 3,000 hours are sufficient to pay for its yearly capital cost (10 EUR/MWh times 3,000 hours per year, or 30,000 EUR per year).

The total amount of base-load capacity remains, maybe somewhat surprisingly, unchanged. As the peak power plants break-even at a duration of 7,000 hours per year and as total production cost for base-load is identical to peak-load at this load factor, also the base-load power plants will break even. Hence, although in the

[11] In our model, short term supply is perfectly inelastic as long as the price cap is higher than the marginal cost of the peak-load power plant.

[12] In practice, production capacity and demand are not perfectly inelastic, and a price cap might therefore create some dead weight losses. For instance, a price cap might reduce incentives for generators to schedule maintenance in periods where demand is likely to be low.

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short-run, both the peak and the base-load power plants face the missing money problem, in the long run, investment levels will decrease only in peak-load capacity. The long-term equilibrium investment levels are given in Column 3 of Table 2.

As long run supply is elastic, the price cap distorts investment decisions, and creates a dead weight loss. Hence, from a social viewpoint total welfare is reduced, and demand is rationed too often.

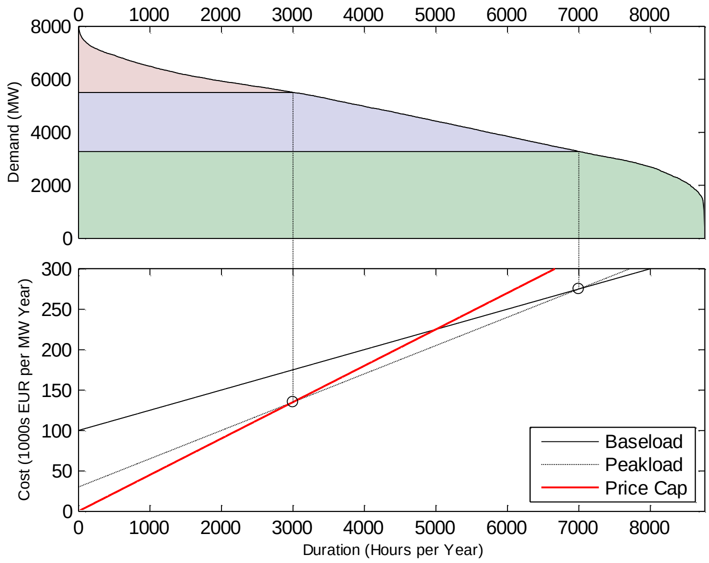

Figure 3: Long term effect of a price cap.

5 Capacity payments restore efficiency

The previous section has shown that a price cap will lower peak-load capacity, increase demand rationing, and lower overall welfare. We now discuss how a capacity payment can restore market efficiency.

The introduction of the price cap lowered the red VOLL-line in Figure 1 to the red price cap line in Figure 3. As a result the intersection of this line with the total cost line for peak capacity moved to the right, and the number of hours with rationing increased from 500 to 3,000 hours per year. By subsidizing investments in peak-load capacity using a capacity payment, the total cost line for base-load capacity will shift downwards, and the intersection with the price cap line will move to the left. If we give a capacity payment of 25,000 EUR per year to peak-load generators, then the intersection with the price cap line will be at 500 hours per year and the number of hours with rationing reaches the optimal level again. (See bottom half of Figure 4) However a subsidy to the peak-load generators will also affect the trade-off between base-load and peak-load generation. Peak-load generation becomes relatively cheaper than base-load generation and will be operating

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more than 7,000 hours per year as the intersection between the total cost line of peak-load and base-load has shifted to the right. Therefore, in order to obtain the optimal mixture of peak and base-load generation, also base-load generation should receive the same capacity payment of 25,000 EUR per year. This will shift the total cost line of base-load capacity downwards with the same amount as the peak-load plant, such that it intersects at the optimal level of 7,000 hours per year.

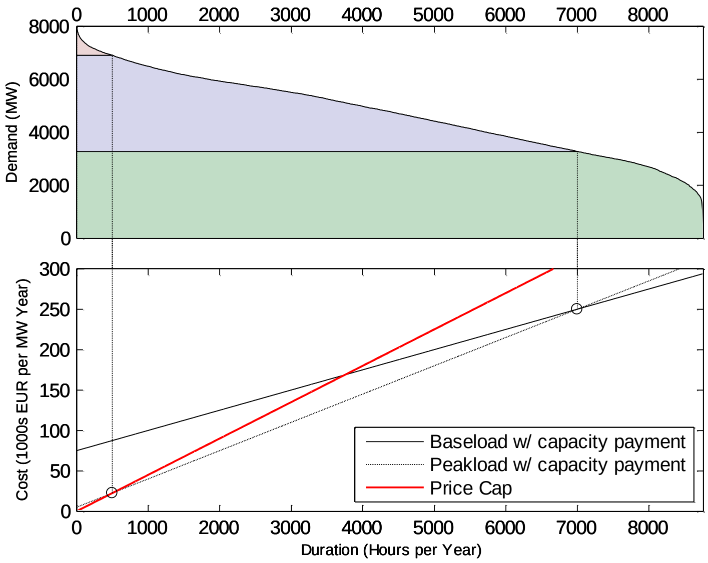

Figure 4: Price cap with capacity payment

Hence we have shown that a technology neutral capacity payment which is equal to the amount of the missing money (25,000 EUR/MWh per year) will correct investment incentives. If the capacity payment would only be given to peak-load power plants, then too few base-load power plants would be built.

6 Renewable energy and demand participation

In this section we discuss the effect of renewable energy and demand participation on the generation mix. We start by assuming that some producers with wind farms are present in the system.

As wind has a marginal cost equal to zero and will always be used whenever it is available, we can subtract it from the total demand level, and determine the optimal generation mix of the remaining technologies on net demand, that is demand minus wind output.

Figure 5 shows the load duration curve of net demand after the introduction of wind energy, under the assumption that that wind production is uniformly distributed between 0 and 3,000 MW and is not correlated with demand. The maximal

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level of demand is still as high as before as there is some probability that there will be no wind in the hour with the highest wind output. There are also a number of hours where production by the wind farm is sufficient to satisfy total demand, and fossil generation is not needed to satisfy demand.[13]

The optimal generation mix can be derived as before. Demand will be rationed 500 hours per year, and base-load will only operate if it can operate more than 7000 hours per year. The investment levels will however be adjusted in accordance with the new net load duration function. Base-load capacity reduces from 3,274 to 1,609 MW, while peak-load capacity increases from 3,633 to 4,418 MW. Total capacity reduces from 6,907 to 6,027 MW. (Comparing Column 2 and Column 4 in Table 2).

In the short run, the addition of wind energy production reduces the revenue of both base-load and peak-load generation plants. Those power plants will see lower load factors, and will no longer be able to recover their investment costs. In the long run, base-load plants will be mothballed, and only a fraction of them will be replaced by new peak-load power plants. As a result total capacity will decrease.

Note, that although firms are unable to recover their capital cost in the short run there is no need to introduce a capacity mechanism, as those low profit levels are an indication that total capacity needs to be reduced and that the market is undergoing a structural reform towards a low carbon economy.

As capital costs are sunk, there will not be immediate mothballing of existing capacity, so in the adjustments are expected to be gradual. As base-load capacity has a longer life time and a lower marginal cost than peak-load capacity, some unexpected transition effects might arise. Peak-load capacity is mothballed first, but not replaced, because there is still overcapacity in the market (in the form of base-load capacity). So in the intermediate term the fraction of base-load capacity in the generation mix might actually increase. Only in a later stage, when base-load capacity reaches its economic end-of-life and starts being retired, one might see a gradual shift of the generation mix towards peak-load power plants. Such a transition stage, where new peak capacity is only built when sufficient base-load capacity has retired, is likely to be socially optimal, but might create some unease with policy makers, as in the transition phase little new peak power capacity is being built.

We can analyze the effect of a price cap in the model with wind energy in the same manner as the one without in Section 4 and would see that the price cap will affect investment levels to a larger extend, as the load duration curve is steeper. The price cap reduces peak capacity with 2,035MW in the situation with wind and with 1,400 MW in the situation without. (See Column 5 in Table 2). However, the same technology neutral capacity payment of 25,000 EUR per year is required to

[13] (Kennedy, 2005) studies the effects of wind energy on the long-term investment strategies using a similar method as the one used here, but takes into account correlation between wind production and demand in calculating the net load duration function.

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correct incentives, as the amount of missing money has not changed (500 hours per year times 50 EUR/MWh).

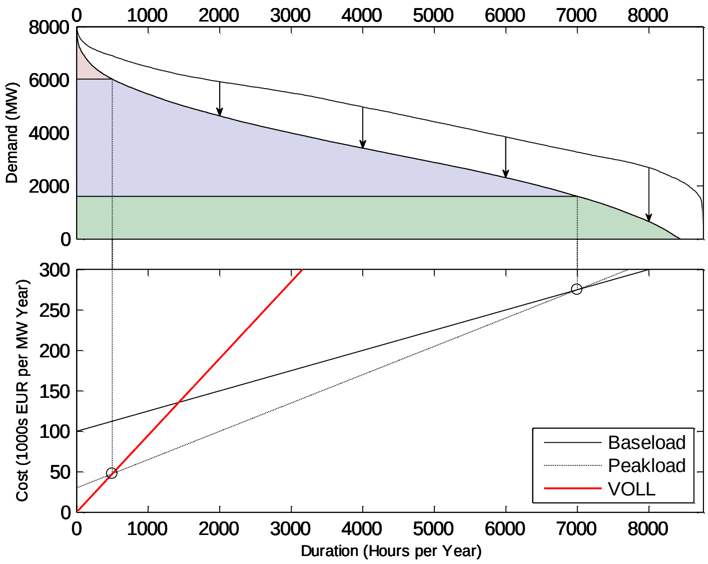

Figure 5: Optimal generation mix with 3,000 MW wind energy

In this paper we have assumed that demand is perfectly inelastic. This allows us to use to derive the equilibrium generation mix graphically. When demand is elastic (for instance due to the introduction of smart meter), the determination of the optimal generation mix can no longer be represented in a simple graph. The load duration function depends now on the price level and therefore on the generation mix.[14]

The load duration curve will be higher if prices are low (when base-load is producing) and lower if peak-load prices are higher (when peak-load is producing). The resulting load duration function is a combination the high and low price load duration functions as shown in the bottom half of Figure 6. The load duration function will become flatter and the relative fraction of base-load in the generation mix will increase at the expense of peak-load capacity. Hence demand participation might offset the effect of renewable energy which made the load duration function steeper.

[14] For the effect of risk aversion in input cost uncertainty using a graphical analysis see (Meunier, 2013).

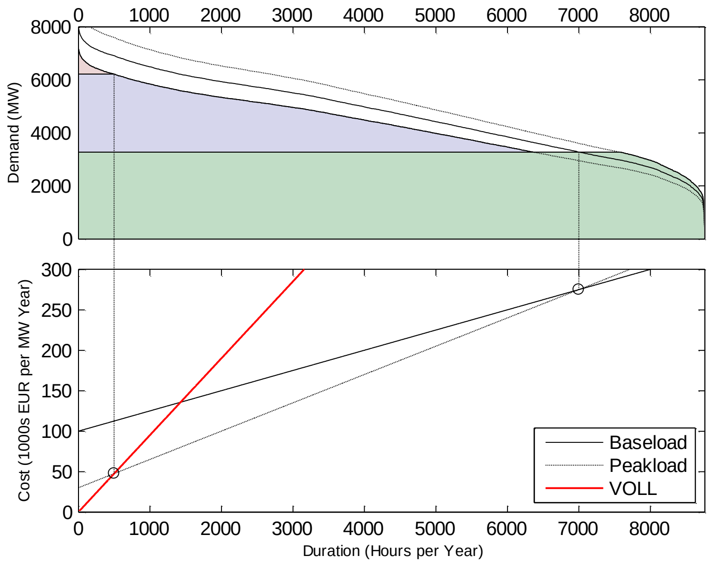

Figure 6: Effect of demand elasticity

The effect of a price cap will have a similar effect on the generation mix as when demand is inelastic: In the long run it will lower investments in peak-load capacity and in order to restore efficiency a technology neutral capacity payment needs to be made to base-load and peak-load capacity.

One difference with the previous analysis is that if demand is price elastic, the price cap will create a dead-weight loss also in the short run, as consumer will receive the wrong incentives to restrict demand.

7 Conclusion

This paper provides an economic analysis of capacity payment mechanism in a simplified perfectly competitive electricity market, with the goal of introducing some key concepts of electricity markets designs.

Given the inability to economically store electricity, energy consumption and energy production should be balanced at each moment in time. Such a balance can be achieved by producing electricity with peak-load and base-load power plants and by rationing demand. A perfectly competitive market will ensure both short and long run efficiency. In the short run, available technologies will used in an efficient way to balance demand and supply. Technologies will be used according to their marginal costs, *i.e.* according to the *merit order.* Base-load technologies are used first, followed by peak-load technologies, and as a last resort demand rationing. In the long run equilibrium, firms will invest in optimal mixture of generation technologies consisting out of an efficient mixture of peak-load and base-load technologies.

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Myopic policy makers might be tempted to introduce a price cap in the spot market, as it will reduce electricity prices for consumers without causing any welfare losses in the short run. However, it will reduce the revenues for generators, who will no longer be able to pay for their investment costs; a phenomenon which is called *missing money* problem. In the long-run a price cap will result in an underinvestment in peak-load power plants and lower welfare levels as there is too much demand rationing. In order to restore efficiency a technology neutral capacity payment can be introduced.

The shift towards a low carbon electricity system, for instance by the further integration of wind energy, will require a reduction of the total installed capacities of other technologies and a generation mix which relies more on peak-load power plants than on base-load power plants. In the transition phase some power plants will no longer be able to cover their capital costs. However this not a reason to introduce a capacity payment (there is *no missing money*), but is rather a consequence of a structural reform of the generation system which makes some power plants obsolete. As base-load power plants have a lower marginal cost and a longer economic life time than peak-load power plants, we might observe some unexpected transition dynamics: first a reduction of peak-load power plants, followed only in a later stage by a gradual replacement of base-load power plants by peak-load power plants. Hence the larger share of peak-power plants might only be achieved after this transition phase has passed.

Introduction a price cap in a low carbon electricity system still affect investment levels to a larger extend than in a system without renewable energy. However efficiency can again be restored with a technology neutral capacity payment, and the size of this payment is independent of the amount of renewable energy in the system.

Demand participation will offset the effects of wind integration, make the resulting load duration curve flatter and lead to a generation mix which relies more on base-load capacity and less on peak-load capacity.

Note that this paper did not discuss (1) whether a capacity mechanism is necessary for a good functioning power market, and (2) which capacity mechanism is best suited to address a particular market failure. With respect to the first question there is no consensus yet on whether market failures in the electricity market justify government intervention, as there are many other markets with capital intensive industries which seem to function without capacity mechanisms. With respect to the second question, some market based mechanism such as a *reliability options* might provide better incentives than administratively imposed *capacity payments*.

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