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First Principles, Market Failures and Endogenous Obsolescence

The Dynamic Approach to Capacity Mechanisms

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CRM: First Principles and Market Failures

When it comes to CRMs, we observe an embarrassing gap between theory and practice.

Theory and First Principles:

The combination of marginal (variable) cost pricing during normal operations and VOLL pricing during scarcity situations in energy only markets is always the first best solution.

This holds both for competitive markets (Stoft (2002), Oren (2003), Léautier (2013)) and for monopolist intent on maximising social welfare (Boiteux (1949), 1960)).

Practice:

The majority of electricity markets have provisions to support capacity investment and to avoid scarcity situations (demand > capacity) in one form or another.

Market Failures:

The purpose of this article is to identify and rigorously characterise the real or perceived market failures to which these policy interventions respond and to close the gap.

It also shows how CRMs dynamically move real-world markets closer to theoretical ideal.

Identifying the Two Basic Market Failures Addressed by CRMs

Market failures and the justification for CRMs arise from the non-storability of electricity and the resulting inelasticity of the demand curve.

1. Security of supply externalities

One electricity consumer's security of supply affects **others that are not party to the contract with his supplier** (definition of externality). Incomplete markets, less than perfect information and transaction costs prevent recuperating the full value of capacity in energy-only markets. Crucial distinction between voluntary and involuntary DR.

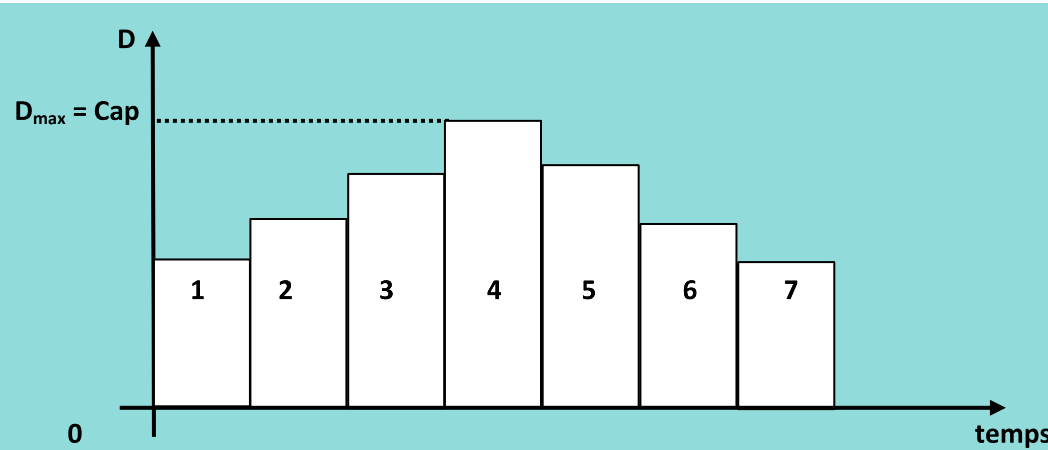
2. Asymmetric investment incentives with "lumpy" investments

With inelastic demand and discretely-sized capacity investments, producers have incentive to under-supply capacity even with free entry. This is compounded by risk aversion

Well-designed CRMs address these market failures sacrificing some economic efficiency (narrowly understood) in the process.

CRMs also promote structural change increasing storage and demand elasticity. "Ratchet effect" and technological change will render CRMs obsolescent over time, but not now.

VOLL pricing: The Basic Idea



Optimally regulated system for single non-storable good sets prices such that

$$\sum_i q_i * CV + CAP*r = \sum_{i\neq 4} q_i * CV + q_4*(r + CV) = \sum_{i\neq 4} q_i * p_i + q_4 * p_4$$

With $p_1 = p_2 = p_3 = p_5 = p_6 = p_7 = CV$,

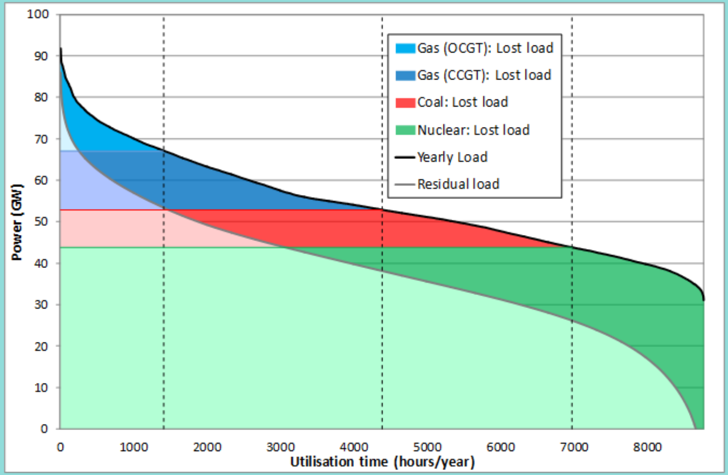
$p_4 = r + CV$ (VOLL) and $q_4 = CAP$. **With r = cost of capital/kW.**

In principle, liberalised market can replicate such non-linear prices even with multiple technologies by eliciting demand response at VOLL.

Why Electricity?

Capacity issues and short-term demand inelasticity affect all industries for non-storable goods (e.g., bandwidth, traffic). Why is the capacity issue in electricity a policy priority?

1. High costs as well as long lead-times and lifetimes for capacity investments.
2. Low carbon generation technologies (a policy priority) have even higher fixed cost to variable cost ratios than other technologies.
3. Contrary to other service industries, demand cannot be easily deferred.
4. The public good of security of supply in electricity has very high value.
5. Variable renewables, wind and solar PV, have complicated implementation of the "VOLL-pricing in energy only markets"-paradigm. No new theoretical issues but full capacity finance would require unsustainably high number of VOLL hours in low price, low load-factor environment.



VOLL Pricing: A Clarification

How can economic optimality in industries for non-storable goods be squared with standard microeconomics?

- Optimality in industries for non-storable goods, such as electricity, implies VOLL or peak-load pricing, *i.e.*, during peak consumption prices are equal to average cost or "long-run marginal cost" (variable plus the capital costs of the marginal technology).

- Optimality in standard Walrasian microeconomics implies prices at all time are equal to short-run marginal cost. If need be, fixed costs should be paid for by general taxes.

This contradiction dissolves once understanding that in industries for non-storable goods long-run marginal *is* short-run marginal cost. At peak demand, producing an additional unit implies additional capital investment.

In storable goods industries, investors must take into account total demand, not peak demand and pricing at variable cost (MC = MU) is optimal.

It is impossible to move away from VOLL pricing on theoretical grounds.

Missing Money: A Clarification

"Missing money" is one of the most frequently misused terms in electricity economics. The reason, quite simply, is that it does not exist. Or better, there exists no coherent economic long-term model in which generators experience "missing money".

Missing money is usually understood as incomplete fixed-cost recovery, but

> "Fixed-cost recovery… depends only on the ability of generators to enter and leave the market (Stoft (2002), p. 123)."

Why then popular? Because it fudges two desirable but incompatible normative ideals:

1. Decentralised energy-only markets;
2. Capacity provision at socially desirable levels with minimum VOLL hours.

This is precisely the theory/reality gap alluded to earlier.

Therefore:

1. Price caps neither cause missing money nor capacity issues. They will however increase the amount of economically optimal VOLL hours.
2. CRMs do not solve any "missing money" problems but imply socially desirable support for extreme peak-load consumption at the expense of other consumption or taxpayers.

Market Failure I: Security of Supply Externalities (1)

Security of supply externalities arise due to the *involuntary* nature of demand response during VOLL-hours, which in the absence of commercial DR correspond to rolling brown-outs. This however is akin to market breakdown:

> "There are a number of wholesale market imperfections… that… suppress spot market prices… during the small number of "scarcity" hours… Since the market also collapses in these situations, wholesale market prices are effectively zero and do not reflect consumer preferences to buy or generators' cost of supply (Joskow (2006), p. 165)."

Market Failure I: Security of Supply Externalities (2)

The view of the theorist: **"Security of supply is over-rated!" (Mike Hogan at IEA)**

This requires reality to conform to theory rather than the other way round.

The view of the public and politicians is that current electricity markets do not value the security of electricity supply enough.

The gap exists because standard theory cannot adequately capture **security of supply externalities**, when one person's consumption affects another that is not party to the first person's supply contract.

Security of electricity supply has been treated by Oren (2003), de Vries and Hakvoort (2004) or Kiessling and Gibberson (2004). Papers attribute SoS shortfalls to voluntary misstating of preferences, excessive risk taking and free-riding. This is misunderstanding the nature of externalities which are due to necessarily incomplete contracts as transaction costs of internalisation would be too high.

Unfortunate tendency in electricity discussions to moralise structural issues.

Market Failure I: Security of Supply Externalities (3)

The crucial distinction is between involuntary and voluntary demand response (DR).

Voluntary DR internalises SoS externalities. Involuntary DR cannot.

With sufficient voluntary DR, the capacity issue and the need for CRMs fades away.

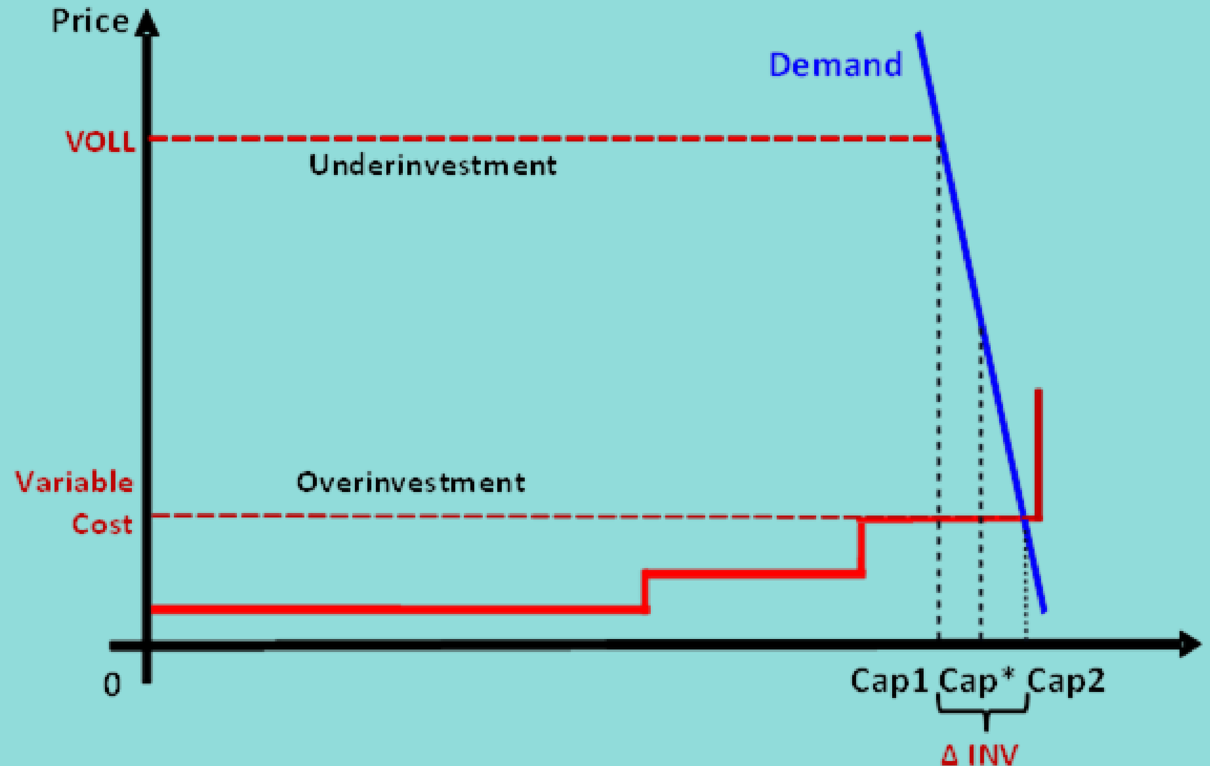
Scarcity hours at VOLL with involuntary DR

Scarcity hours with voluntary DR

Consumers and politicians have an intuitive understanding of this, pure theorists do not.

Market Failure II: Asymmetric Investment Incentives (1)

Incentives for under-supplying and over-supplying capacity are not symmetric. In markets for non-storable goods (inelastic short-term demand) with discretely-sized ("lumpy") investments the costs of over-investing are far higher than the lost opportunity costs of under-investing .



Market Failure II: Asymmetric Investment Incentives (2)

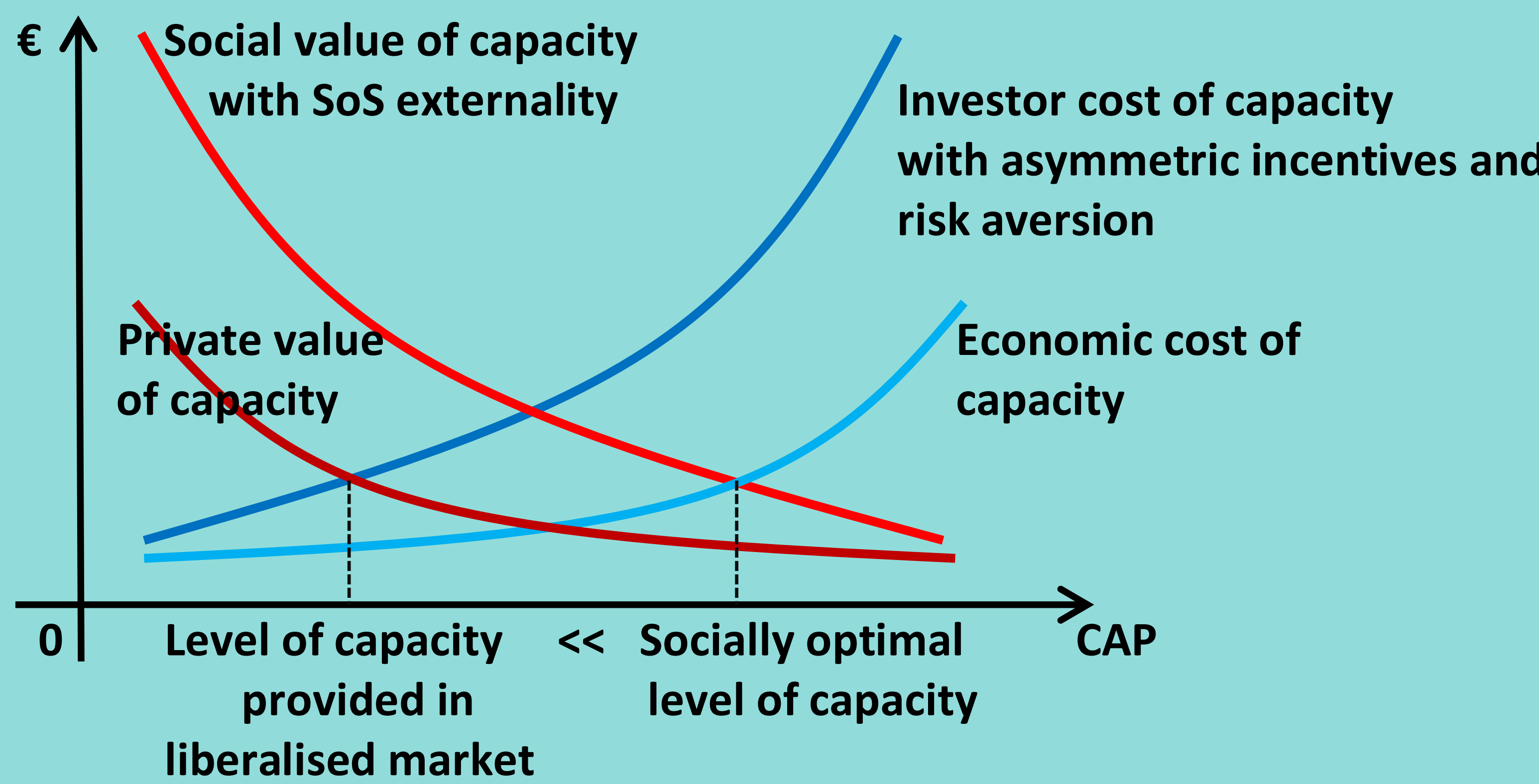
- **Asymmetric investment incentives are a structural issue linked to non-storability, not a moral or a legal issue related to exercise of "monopoly power".**
- When demand is completely inelastic, *everyone* has monopoly power even with competition and free entry and exit. When cost-efficient investments are lumpy (IRTS), even competition will not provide optimal capacity.
- The issue is exacerbated by risk aversion, which will force investors even more to "err on the side of caution", i.e., under-investment. This is why VRE have not only direct but also indirect impacts on the level of dispatchable capacity though increased volatility.

  "Downward pressure on day-ahead electricity prices… leaves generators exposed to insufficient returns to cover their fixed costs… however, when intraday, balancing and ancillary services markets operate efficiently… prices in those markets should be allowed to raise [sic] above short run marginal cost, enabling generators to cover also part of their fixed costs (European Commission (2013), p. 13)."

- Unfortunately not enough. Short-term flexibility markets work already rather well. The asymmetric investment incentives remain unaffected.

Market Failures in Capacity Provision: Putting It Together

Optimal and Actual Levels of Capacity in Liberalised Electricity Markets



No Ideal-Type I

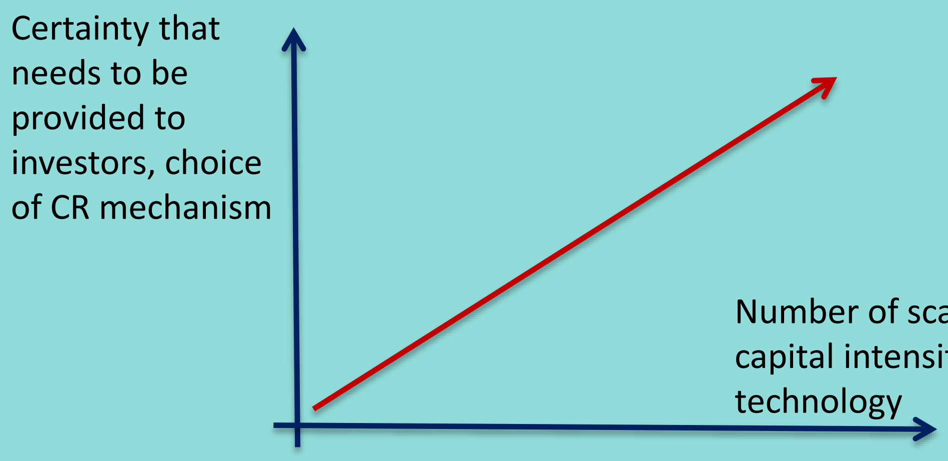
CRMs are place-, time- and context-dependent! No need for CRMs in all systems (Norway). Even context can *change* in a given country. Key parameters are:

1. Shape of the load curve
2. Supply structure, existing capacity, mothballed capacity
3. Number of potential scarcity hours
4. Amount of flexibility resources (storage, demand response, interconnections)
5. Private and public risk preferences.

Source of capacity shortfall → Amount of expected scarcity hours → Technology and its capital-intensity → Investor risk → Financing mechanism (CRM). Three examples

1. France : flexibility provision at extreme peak hours (< 500 h/a) → demand response and gas turbines → decentralised capacity obligations .
2. Germany: back-up for variable renewables (500 h/a < 3000 h/a) → CCGT and coal (some mothballed capacity available) → centralised capacity auctions.
3. United Kingdom: shortfall in capital-intensive baseload capacity (> 4000 h/a) → Contracts for difference or feed-in tariffs.

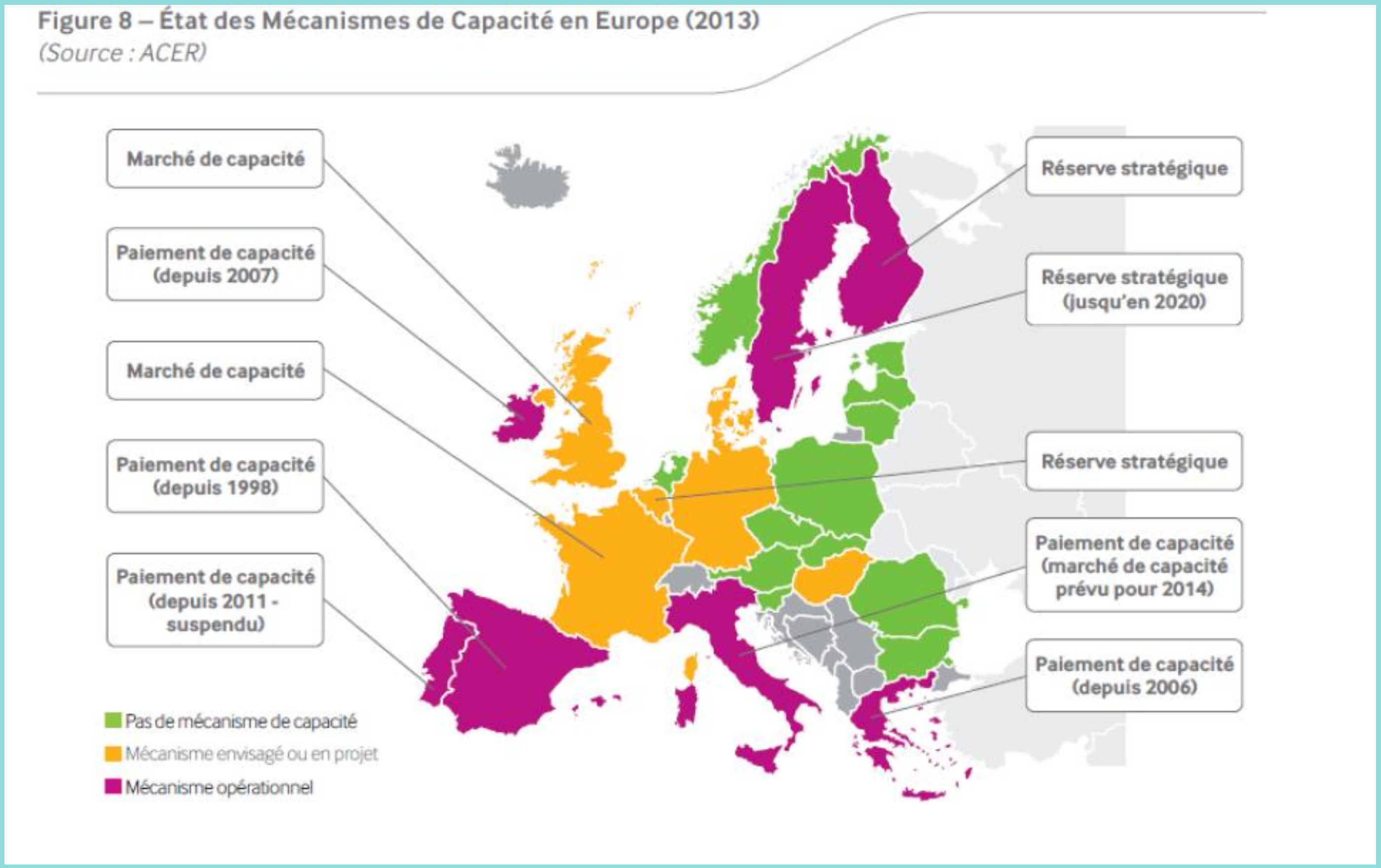
No Ideal Type II



No-ideal-type! Further remarks:

1. Strategic reserves are easy to implement, politically sellable, attractive to investors and have low transaction costs. They also have a big drawback: no increase in total capacity due to added private investment retention.
2. In capacity markets, physical trading should be favoured over financial claims. “Quality” and diversity of capacity is an issue. Paper claims for DSM not always a substitute for production capacity (see US experience during “polar vortex”).

No Ideal Type: The Case in Point



Conclusions

- Purpose of this research to bridge the gap between standard theory and practice in the area of capacity provision.
- In theoretical terms, the theory of scarcity pricing at VOLL during extreme peak hours remains valid. In standard theory, we will not be able to construct a theory of CRMs.
- However when broadening the theoretical approach two important reasons emerge that make for a tendency towards capacity provision below the social optimum:
  1. Security of supply externalities in the case of involuntary demand response;
  2. Asymmetric investment incentives in markets for non-storable goods.

  We currently do not have a comprehensive theory of markets for non-storable goods.
- CRMs are place-, time- and context-dependent. VREs have aggravated but not created the supply short-fall.
- The crucial parameter in these discussions is the elasticity of the demand curve. If CRMs contribute to rendering the demand curve permanently more elastic through technical and behavioural progress in storage and demand response. CRMs will over time render themselves obsolete.