Market design with one hundred percent renewable electricity

A contribution toward MDAG's problem definition and approach

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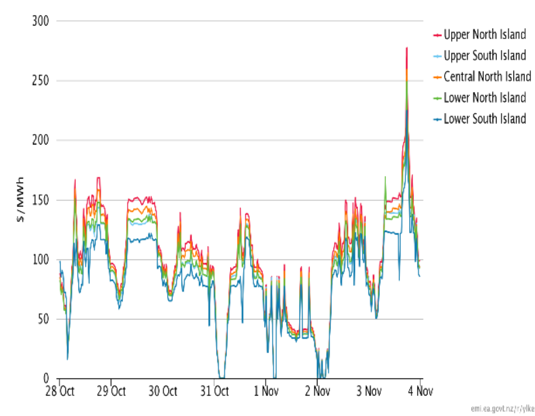


Two parts to our discussion

- Part one: price discovery in markets with low marginal cost
- Part two: the purpose of the market and approach to reviewing market design with a 100% renewable electricity market and a number of other considerations

100% renewable associated with low marginal costs

- One context for MDAG’s work is that in 100% renewable energy market, “observable” cost of additional unit of supply may be close to zero
- Alternative terminology to “observable cost” might be ‘SRMC’ or ‘incurred cost’; all terms have their definitional problems
- There may also be scenarios where marginal unit in 100% renewable is not low cost—hydrogen fuelled turbines, demand reduction, etc
- This part of our discussion considers whether concepts of price discovery change in markets where observable cost of marginal unit is low
- Second part extends these concepts into the specifics of electricity market design

Low observable unit costs common to pricing

- Many markets establish prices when the observable cost of an additional unit is close to zero:
  - a seat on a scheduled plane trip
  - a night in a hotel
  - broad band over fibre
  - exchange traded forex or commodity futures
- Prevalence of market prices in sectors where observable cost of additional unit is approximately zero suggests this characteristic is not a barrier to effective pricing
- Examples from other markets also suggest principles for market design

Calculated price or discovered price

- Pricing approaches in sectors with low observable unit costs suggests MDAG faces design/directional choice of:
  a) calculated price
  b) price discovery
- Either design path is technically feasible:
  - airlines, hotels are examples of calculated prices—sophisticated yield management in case of airlines
  - exchange traded commodity futures and forex examples of price discovery
- As these examples illustrate, the design choice leads to very different market designs—MDAG will want to be clear which design path it is pursuing and why

Prices not linked to observable costs

- Prices, in workably competitive markets where additional unit cost approaches zero, are not linked to observable costs
- This observation applies whether price is determined by calculation, or price discovery; e.g.,
  - additional fuel burn because of weight of additional passenger immaterial to price of seat
  - value of currency not linked to any commodity (since gold standard collapsed in 1930s)
- Efficient pricing delinks from observable cost because observable costs contain insufficient information for efficient pricing over time

Prices collate and convey large volume of information

- Prices are primarily a means of collating and conveying information
- Prices aggregate dispersed information into a signal of value and scarcity:

  Prices solve the central problem of economics — how to secure the best use of resources known to and controlled by individual members of society for ends whose relative importance only these individuals know.[1]

- The information needed to solve this central problem is not observable, nor knowable by any one entity; it must be discovered

1. F.A Hayek, (1945), *Use of Knowledge in Society,* AER.

Relevant information is opportunity costs

- Information required for efficient pricing is opportunity cost ("economic costs") of both demand and supply
- Basic theme of economics is that resources are limited and, as a result, everyone has hard decisions to make –a decision to have more of something is simultaneously a decision to have less of something else
- Hence, opportunity cost of any decision is the foregone value of the next best alternative that is not chosen:

  "*opportunity cost is the anticipated value of* '*that which might be*' *if choice were made differently*"
- An efficient price collates and conveys information on the opportunity cost of resources available to individuals for their preferred ends

2. James Buchanan (2008), *Opportunity Cost,* The New Palgrave Dictionary of Economics

Opportunity costs in constant state of flux

- In workably competitive markets, opportunity costs are continually updated
- As new information (always incomplete) becomes available, expectations adjust, and individual values of next best alternative change
- Updated expectations in turn reflect how others are expected to respond, and their expectations change in response to others, and so on in a potentially infinite regress
- Continuous updating means efficient economic costs —e.g., return on investment, scarcity rents, allocation of fixed costs, premiums for risk, etc — are revealed in the process of price discovery:

  economic costs and prices are jointly and simultaneously discovered/determined via the competitive process[3]

3. Yarrow, Dr Chris Decker, (2014) *Bidding in energy-only wholesale markets*

Highly simplified example

- A simple market, two suppliers:
  - generator A with observable cost of $5MW
  - generator B with observable cost of $80MW
- Suppose demand is uncertain
- Generator A could offer at a price close to $80MW, and expect to be dispatched
- If generator B expects demand to be high, or output from generator A to be low, it might offer above $80MW (as might generator A); the higher price would be necessary, in this scenario, to balance demand to supply
- Hence, efficient price may lie within a range from $5MW to above $80MW, with demand conditions picking out the efficient price—that efficient price needs to be discovered

Path toward(?) price discovery

Political pressure – short-term conflicts with long-term objectives:[4]

- large fixed assets (govt opportunism)
- pricing in the public sphere
- need for certainty with security of supply, explain price changes

- DER
- Internet of things
- Information technology
- Consumer awareness/ climate change

Cost based offers: England & Wales

NZEM: priced based offers, co-optimising energy & reserves: 1996

Market improvements: futures, FTRs, etc

Discovered prices reflecting opportunity cost of demand and supply

4. Pablo Spiller, (2010), *A tribute to Oliver Williamson: Regulation: A transaction cost perspective*

Some principles for price discovery

- Think carefully about market definition in competition sense—field of exchange (or potential exchange) in which services are substitutable:
  - energy, ancillary, derivatives, are elements of one product market (not separate markets)
  - market operates continuously through time (except in defined circumstances), not temporally limited
  - national market (with nodal prices showing location difference from national price), not collection of regional markets
- History shows that detail rules necessary for markets to approach competitive ideal[5]—look to lessons from exchange traded markets; well over 100 years of evolution to learn from
- Prioritise lowering barriers to entry (in Bain sense)—removing any cost not necessary for an entity to participate in the market
- Maximise opportunity to revise offers/bids—improve information content of prices

5. Ronald H Coase, (1988), *The Firm, The Market and The Law*

Part 2 The purpose of the market

1. The purpose of the market
2. The original design of the market and
3. Approach to reviewing market design with a 100% renewable electricity market and a number of other considerations

The market delivers public policy objectives including investment

One way to assess outcomes from the electricity sector is to analyse those outcomes against the following five public policy objectives—objectives that are enduring for policy makers across countries and time:

- security of supply – in the sense of supply meeting demand continuously without involuntary cutting of supply, or a heightened threat of cuts to supply
- efficient operation of the wholesale and retail sectors, with competition a primary tool for achieving efficiency
- efficient use of, and investment in, long-life assets (including transmission and distribution), guided by economic regulation
- meeting community or social minimums, including universal access to electricity and support for those who can't pay
- integrating environmental objectives while mitigating the impact on the industry of achieving these objectives, with a current focus on climate change.

Market design has to provide revenue adequacy

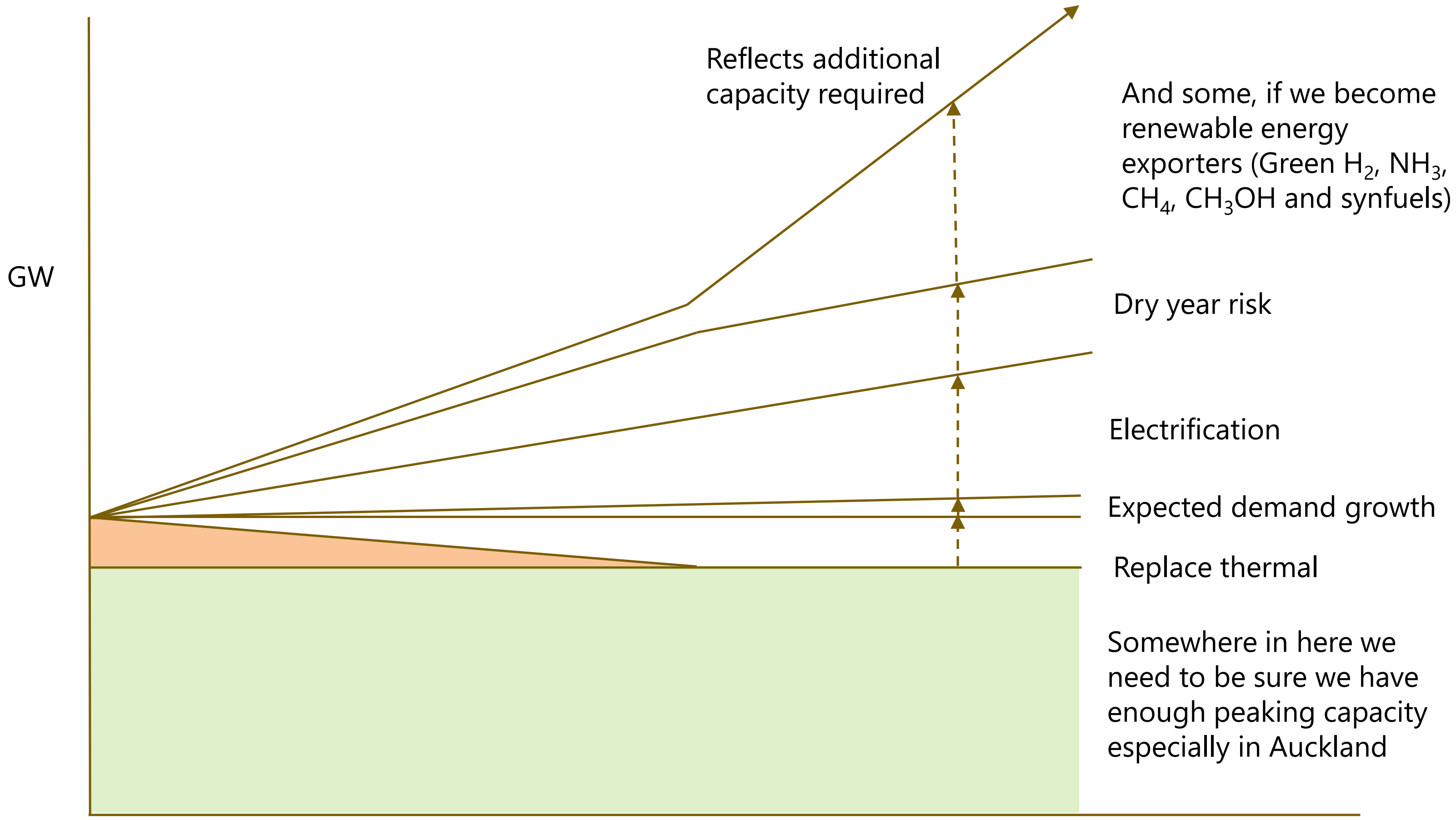
- At its conception the wholesale market made no preference for the fuel type of the generation providing base load, mid merit, peaking or dry year risk. (But weak on wind and DR)
- Spot price formation reflected all of the different types of generation, financial contracting does too.
- The 100% renewable policy will have a significant impact. The option of thermal generation is removed so contributions to price formation can only come from renewables or DER.
- Renewables tend to have high capital, low operating cost, and intermittent with a much lower storage factor.
- The question for market design is whether the outcomes will still attract sufficient investment for all of the jobs

Investment in new renewables must serve several jobs

Investment in renewables has to:

- replace thermal *and*
- support electrification *and*
- cover dry year risk *and*
- provide instantaneous security 24/7

Additional capacity required



From our Productivity Commission work – the questions we left with

The regulatory challenges are to assess:

- whether the evolution of exchange traded and over the counter (OTC) financial instruments will be sufficient to deliver resource adequacy and the necessary investment in renewable solutions in a very low emissions sector
- whether a mechanism accompanying the energy only market will be required as the sector moves to very low emissions supply side.

(This last point is too narrow as we conclude today.)

NZ Battery

In the 2030 factual of 100 per cent renewable, two things are different from today:

- There is a significant amount of generation, such as geothermal and wind, that has no opportunity or variable costs above its costs of operations and maintenance, which are low.
- To clear any volume, hydroelectric operators will have to factor in these low opportunity costs. Prices will factor in risk and scarcity

Why wouldn't the current electricity market deliver 100 per cent renewable by 2030, and security of supply with equity, transaction efficiency and investment adequacy?

New Zealand Electricity Market

- Comprehensive studies (WEMS and WEMDG) were done to study electricity market design – tended to be a cost based approach
- EMCo and industry experts explored and demonstrated feasibility and desirability of price based approach
- Wholesale market algorithm developed with the rulebook (expert modelling team within Transpower)
- Guided by international and local research and experts (Schweppe, Joskow, more directly by Hogan, University of Canterbury - Read)
- Professional advice on contract form, governance, competition, process, etc.
- Rules developed by separate industry committees
- Always under the governance of an industry group (Rules Committee of NZEM)
- Algorithm has stood the test of time as have many of the original rules – blueprint for other markets

Only short run capacity adequacy

- Capacity markets were considered in 1996, but it was considered likely to put investment risk on to consumers. This has happened internationally – capacity markets can fail badly
- New Zealand had plenty of peaking hydro capacity, opportunity costs of hydro would reflect value of peak capacity
- Our market dispatch does include capacity markets. IR ensures sufficient capacity is dispatched to ensure n-1 in the short run
- Other markets look at capacity adequacy on a longer term basis
- Philippines adds fast response (frequency keeping), slower response (IR), and standby reserve (plant that isn't running but can be fast started)
- Some American markets include an Operating Reserve Demand Curve (which adds a scaled price adder as the market capacity reserve is consumed)
- In fact, our scarcity pricing regime is similar in concept by administering a floor price in periods of scarcity and capping that price at VOLL, soon to be operationalised in RTP
- Is there now a basis for including longer term capacity adequacy (or seasonal firm energy adequacy) in our dispatch function either directly or indirectly, i.e. is there a product here to consider within the market design?

Electricity wholesale markets imperfect but workable

- Schweppe demonstrated a theoretical basis for offer based electricity markets
- New Zealand led the way in making this happen in practice, but there are challenges (from Paul Joskow)
  - Electricity cannot be economically stored and must be produced and consumed at almost exactly the same time
  - Physical laws govern network operation
  - Short run demand elasticity is very low
  - The network suffers occasional congestion
  - Loop flows introduce additional complex interactions between generators and demand
  - Demand fluctuates greatly over the day, over the week and over the year. There is a significant inventory of system capacity needed just to meet occasional peak demand.
  - These combinations of factors mean that the electricity supply-demand balance must be explicitly managed at every point on the system to meet all the constraints
  - The market relies critically on how the transmission network is operated, priced and how scarce capacity is allocated

Heed Joskow's warning

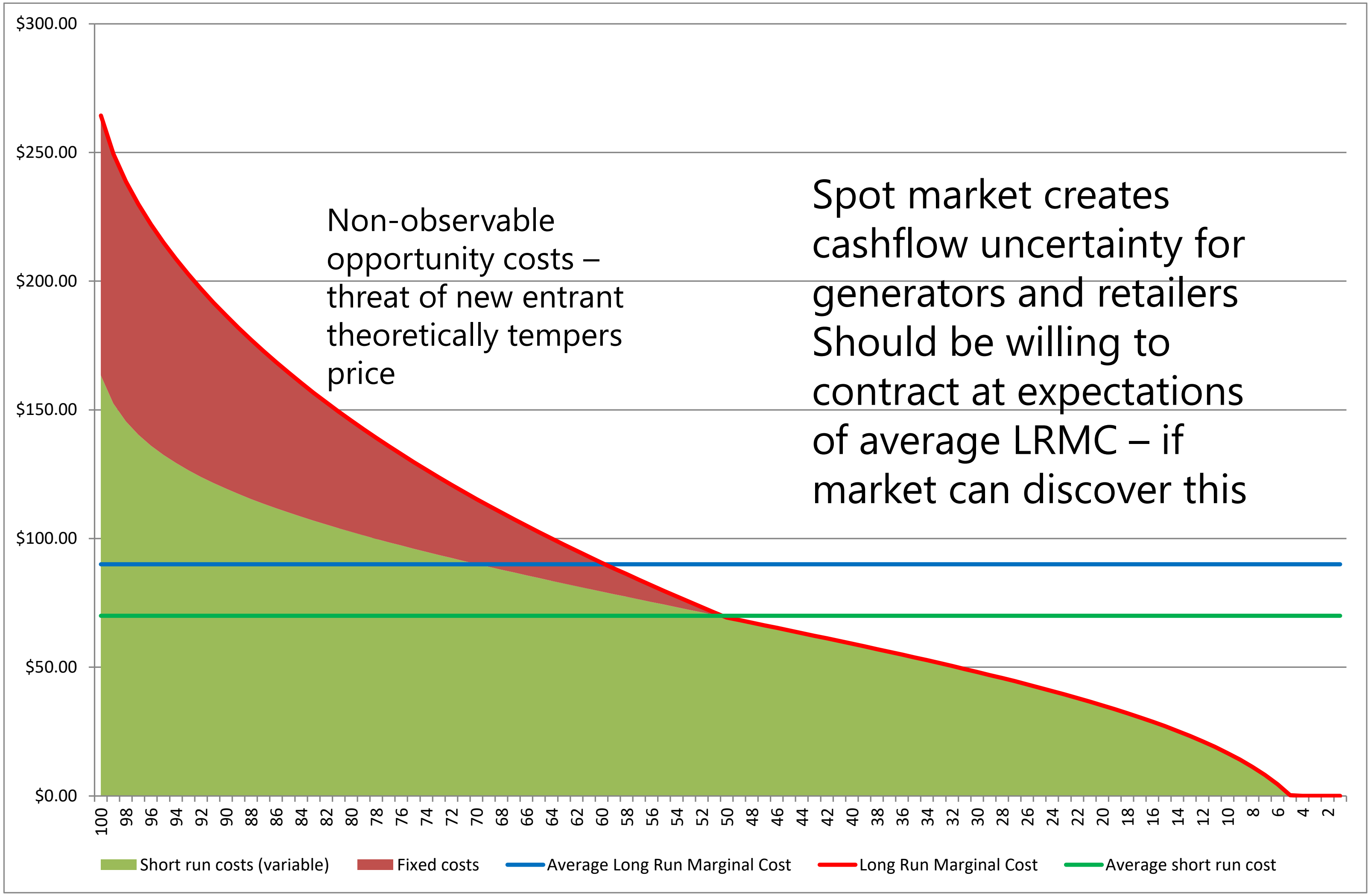
While there are many competitive industries that have one or perhaps two of these attributes, it is hard to think of any commodity market that has all of them

Ignoring these unusual attributes of electricity, and ignoring how and why historical governance arrangements evolved for dealing with them (Joskow, 1997, 2002), is a very bad mistake.

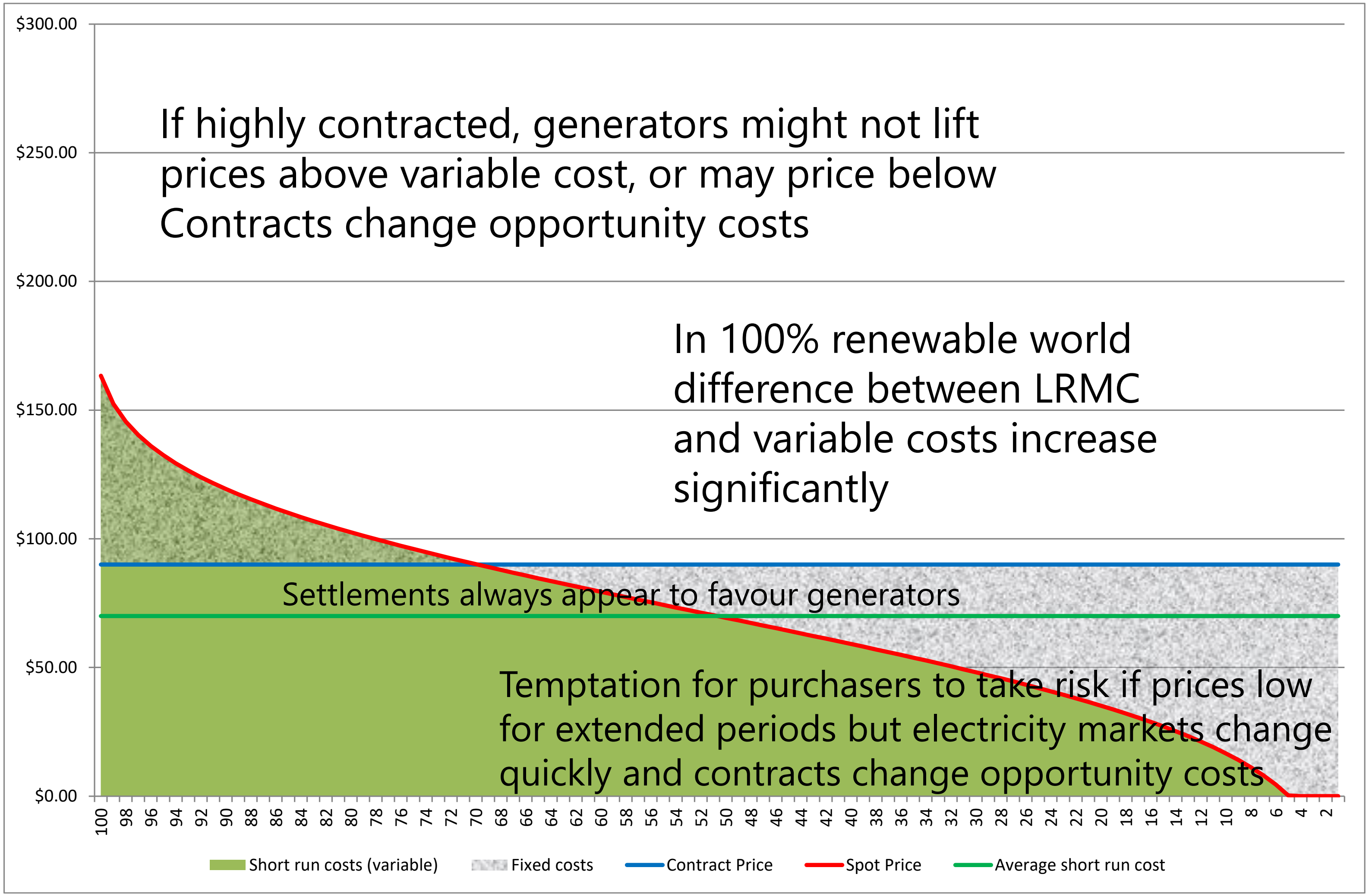
Contracts market was never comprehensively designed

- NZEM assumed the robust underlying assets (NZEM nodal prices) would lead to liquid derivatives
- They didn't
- Industry intervention to produce forward curve (EnergyHedge)
- Government intervention to change contract structure – Tekapo transfer, Virtual Asset Swaps, expectation of open interest in contracts, or else
- Industry intervention (under threat from s42 of Electricity Industry Act 2010) to set up liquid futures (market making)
- Regulatory intervention re-addressing market making

Electricity contract markets and spot market need to work as one



Contracts change spot market outcomes



Contracts market has difficulties too

- Can't put electricity in a warehouse to arbitrage over time and geography (particularly in New Zealand), which is a mechanism for commodity traders to trade away market inefficiencies
- Market is difficult to predict, it is complicated, e.g.
  - Few predicted extended gas supply concerns
  - Always get demand changes wrong
  - What is the LRMC with current market uncertainties?
- General imbalance between trading resources of generator vs purchasers – size, experience, engineering, information, capital
- Difficult for small retailers, and politicians, to understand price formation, which reduces trust in market
- Economies of scale – e.g. if small purchaser doesn't contract with Genesis it still has to maintain 250MW machine
- Tragedy of commons – e.g. if no-one contracts with Genesis it removes 250MW machine – or does it (political pressure)?

Contracts markets thoughts

- Availability of information, information asymmetry, and significant differences in the trading resources of MPs will probably always be an issue in the New Zealand electricity market
- The larger the risk premium the stronger the incentives to 'avoid' them, or game them, especially if there are question marks about market efficiency
- Politics always looms large in electricity
- The industry changes and the pending changes will be significant.
- The question whether change to the market is required and justified should be regularly asked as the industry evolves

Other market changes

- Our price formation algorithm still state of the art for LMP markets based on a Direct Current, constant voltage, power flow optimisation
- But new technologies are available, ACOPF, AI, machine learning
- More and more rules affecting market inputs and for new technology (e.g. trading conduct, intermittent generation), does this indicate an increasing deficiency in the current model?
- Case for integrated wholesale and contract market design? They both need to work well and together
- New derivative products?, e.g. useful contracts for intermittent renewables
- More co-optimised inputs? – frequency keeping, IR (short run capacity adequacy), voltage, intermittency, long run capacity and energy adequacy, transmission capacity (FTRs), distribution capacity, DER?
- Can long-run prices be made more observable, more competitive, more trustworthy, more globally accessible, less avoidable? With less input rules?
- Is this a marginal improvement, or a fundamental rethink?

Who is the decision maker?

- The market design we have had was carefully considered by industry participants and overseas experts at the time through a process which agreed the problem being solved and settled on the solution we currently have
- The current market design has led to sufficient generation investment with the bulk of it for the past decade being from renewable sources
- However, the 100% renewable policy removes solutions to peaking, mid merit volume and dry year cover plus price formation in the electricity market that derive from fossil fuel powered generation. Meanwhile many other considerations.
- Market redesign should consider all elements of industry change, not just absence of fossil fuel
- Some questions:
  - Will the market signals (spot and forward) and the degree of variability with 100% deliver adequate investment the way the market has to date?
  - If no, how would you design a market that would deliver the same result in 100% renewable world if you were starting from scratch today?
  - Do you revisit the market design and develop the solutions by going back to a representative set of stakeholders relevant to the market in future?