2021 Energy Exemplar User Group Meeting

Modelling imperfections - Lessons from Israeli Power Market

April 2021

ECONOMIC
CONSULTING
ASSOCIATES

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Agenda

- About ECA
- The Project
- Capturing market imperfections
- Conclusions

ECA are infrastructure economic consultants specialised in the energy and water sectors

20 years
in business

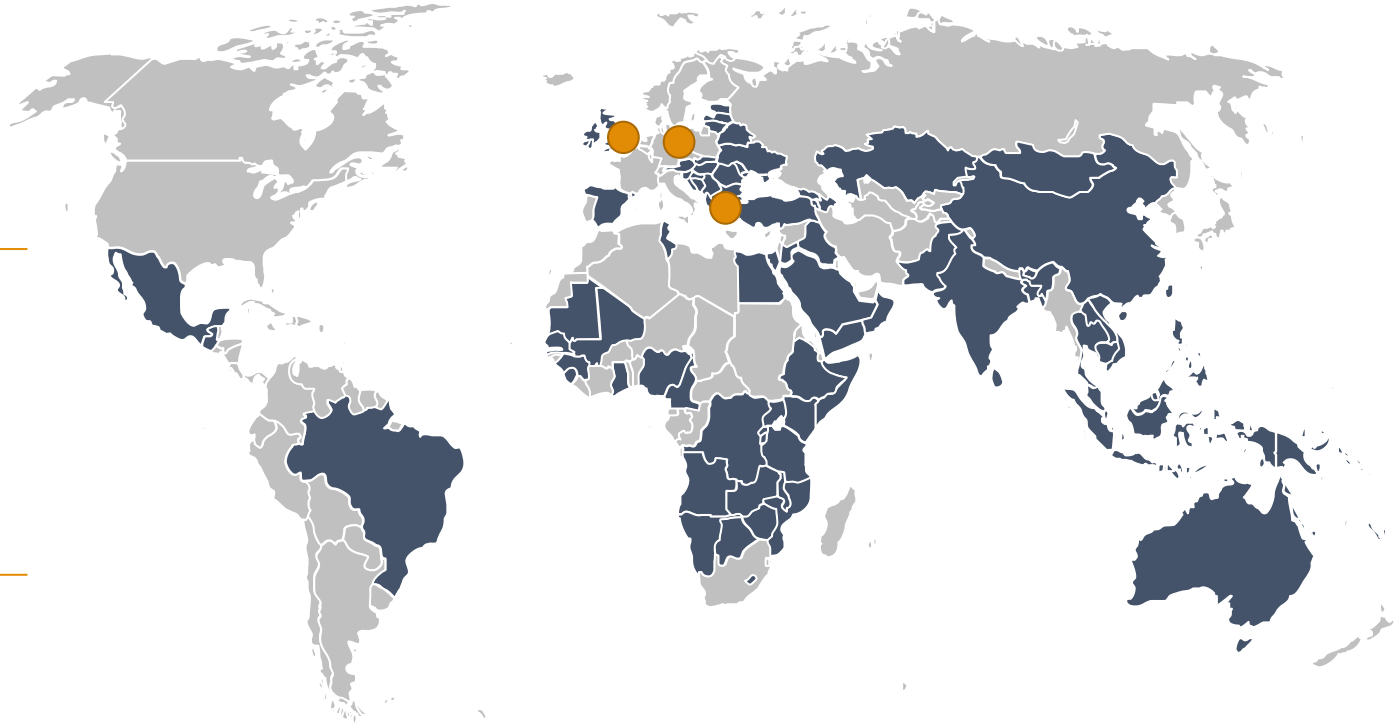
60+
assignments annually

15+ years
average experience

27
Economists

100%
Employee owned

40+
Regulators advised



65+
Countries worked in

3
Locations

20+
National utilities advised

Advice focused on energy market assessment, economic regulation, investment strategy and decarbonisation

Markets & Commercial

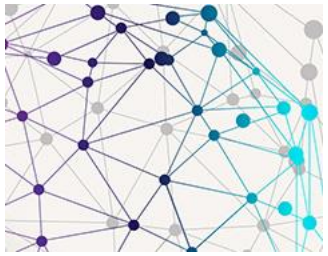
- Market studies and Investment strategies
- Project due diligence
- Market modelling (PLEXOS and inhouse models)
- Energy sector reform
- Contracts

Economic Regulation

- Regulatory support to utility regulators
- Cost of service and allowed revenues
- Energy and water tariffs
- cost of capital (WACC) and utility funding requirements
- Regulating offgrid networks

Investment Planning

- Least cost infrastructure development plans
- Investment prioritisation tools
- Electricity load forecast
- Energy and water sector masterplans
- PPP policy and regulation frameworks



Decarbonisation

- Renewable energy market integration
- Low carbon development trajectories
- Corporate decarbonisation strategies
- Designing energy efficiency regulation and policy

The project

Israel Context

- Israel is reorganizing the power sector to
  - introduce wholesale competition
  - increase security of supply
  - expedite the introduction of clean energy sources
- Changes include
  - Creation of a competitive wholesale power market in 2018 operated by a new independent System Operator (SO).
  - Incremental divestment of 4.5 GW of IEC gas plants to independent Power Producers (IPP) by 2023 .
  - Phasing out of all coal units by 2028 to meet emission targets.

The Project

- ECA has assisted an investor in its bid for the ownership of gas to power assets
- The project focus was on revenue projections for the CCGT and OCGT assets :
  - Focus on future generation and wholesale power market prices
  - Definition of scenarios to capture a wide spectrum of possible outcomes from 2020 to 2040
  - Analysis of the trends and drivers that define the Israel day-ahead market prices
  - Capacity factors of the target power plants

Israel electricity market in transition: competitive market design rules coexist with uneconomic quasi-monopolistic rules

Characteristics	*'Imperfect' outcomes*
1 SMP not based on marginal unit but on spinning reserve units	• Generators operating at the margin may not be able to recover their costs • Requires increased 'out of market' settlements • Inefficient investment signal
2 IPPs can bid their part-load capacity outside of the market	• Not all available capacity is participating in the pool. • IPPs with excess generation can bid into the market. • Due to dispatching rules, they have no incentive to bid their true marginal cost but 'game' the market.
3 Uncertainty on treatment of IEC (state owned generation company) plants in dispatch	• Coal units not dispatch on economic dispatch rules - ad hoc based on security of supply and environmental constraints • Newly commissioned Hydro PS plants may be operated by IEC as reserve • Coal plants converted to steam gas turbines and CCGTs will be operated by IEC under security of supply constraints – timeline and modalities are not clear.

Modelling issue #1 – System Marginal Price (SMP)

From observed market rules to Plexos modelling

1 SMP not based on marginal unit but on spinning reserve units

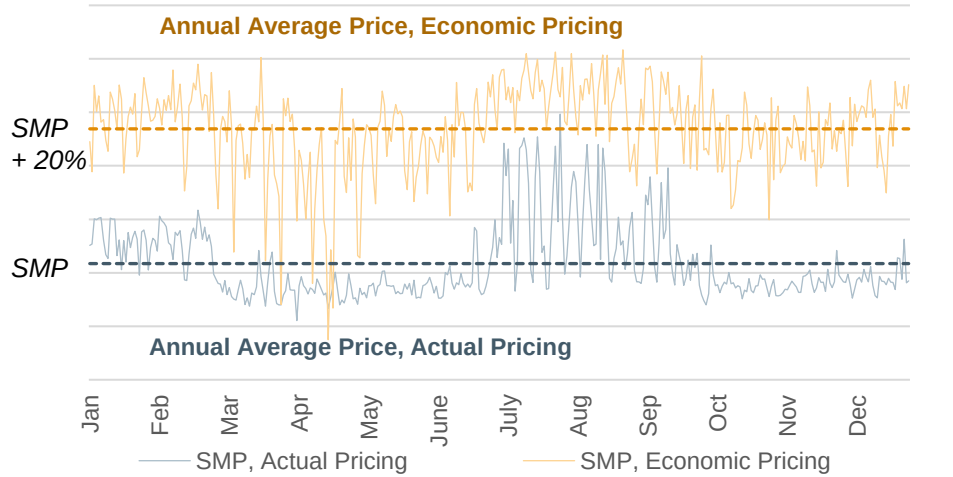
Market 'Imperfection'

- 'Standard' competitive wholesale markets prices set by the marginal unit
- Israel has different rules – prices set by spinning reserve
  - The Minimum Up Reserve (MUR) provision – 600 MW
  - MUR provided by plants that are able to offer spinning reserve
  - System Marginal Price (SMP) = bid of least expensive unit providing MUR

Modelling in Plexos

- Used Plexos to simulate 'economic' SMP, ie based on 'standard' dispatch rules
- Extracted information on spinning reserve units for every hour
- Replaced SMP with least cost spinning reserve unit
- Allowed us to compare 'economic pricing' and 'Actual pricing'

Plexos Model



Modelled Israeli market with Plexos on a unit-by-unit and hourly level to project two market outcomes for 2021:

(i) 'Actual' SMP, under the current settlement rules;

(ii) 'Economic SMP' under a traditional 'economic' gross pool pricing

Modelling issue #2 – IPPs bidding partload in the market

From observed market rules to Plexos modelling

2 IPPs can bid their part-load capacity outside of the market

Market 'Imperfection'

- IPPs are mainly operating based on bilateral contracts with industrial consumers
- IPPs can bid residual/incremental load - after their contracted industrial load
- IPPs represent ~3.4 GW of installed capacity (2.4 GW of CCGTs and 1 GW of gas CoGen)

Modelling in Plexos

- Key challenge: apportion share of generation to direct offtakers
- Looked at historic SMP participation patterns from IPPs
- Used this to set hourly profiles for IPPs set as *Min Load*
  - Min Load sets a minimum unit dispatch level
  - Similar to a solar unit, the Min Load component is treated as 'must run'
  - Min Load units are committed in order to meet the minimum load subject to their availability.
  - Excess generation is assumed to bid into competitive market

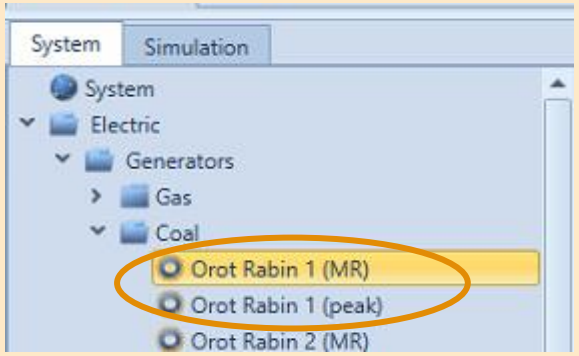
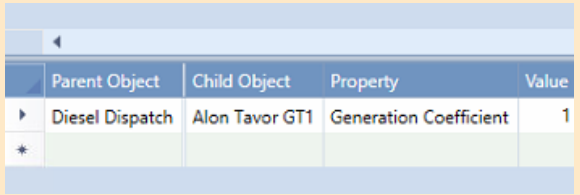
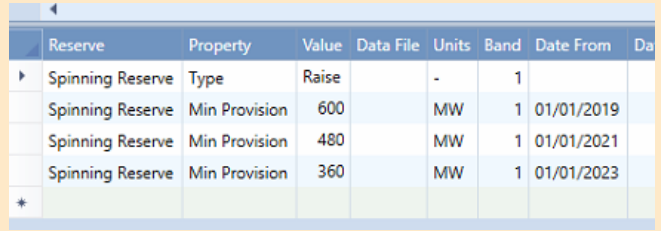
Plexos Model

Collection	Parent Object	Child Object	Property
Generators	System	Ashdod Energy CoGen	Min Load
Generators	System	Dead Sea Works Co-Gen	Min Load
Generators	System	IPP Alon Tavor	Min Load
Generators	System	IPP Delek Ashkelon Co-Gen	Min Load
Generators	System	IPP Ramat Gabriel	Min Load
Generators	System	Nesharim Co-Gen 2	Min Load
Generators	System	OPC Hadera Co-Gen	Min Load
Generators	System	Paz Co-Gen 1	Min Load
Generators	System	Paz Co-Gen 2	Min Load
Generators	System	Ramat Negev Co-Gen	Min Load

Modelling issue #3 – Uncertainty of IEC plant operation

From observed market rules to Plexos modelling

3 Uncertainty on treatment of IEC (state owned generation company) plants in dispatch

Market 'Imperfection'	*Modelling in Plexos*	*Plexos Model*
Treatment of incumbent state-owned generator assets (IEC) 1. Coal units are dispatched as must-runs up to their MSL. 2. Peaking units as last recourse; 3. Certain IEC assets will be retained under operation for strategic purposes;	❶ **Coal plants are operated at MSL by IEC - residual capacity dispatched after all other thermal units** - coal units are split in two units: • A *must-run unit* with an installed capacity equal to its MSL. • A *residual capacity* unit of the coal plant (the difference between the theoretical capacity and the MSL)	
	❷ **Diesel peaking units are operated as 'last recourse' by IEC.** A *generation coefficient constraint* is modelled in Plexos which defines that diesel units are activated after all other units	
	❸ *(i)* **Hydro PS operation regime is scenario dependent.** the level of MUR will reduce as new Hydro PS units are added *(ii)* **Converted coal units' operation regime –** In specific scenarios, converted coal units will remain under IEC management and be seasonally dispatched as must-runs. The *'Timeslice' approach* was implemented for these plants.	

Plexos as a flexible tool to accommodate with idiosyncrasies of imperfect markets

Plexos as a flexible tool

- Using PLEXOS Software, we were able to model the idiosyncrasies of the Israeli dispatch rules.
- Worked together with EE staff to overcome modelling issues
- Plexos as an intuitive and versatile tool in many markets ECA works in, where dispatch rules are not only cost based

Wider Israeli market conclusions

- Existing market set-up results in inefficient scheduling outcomes:
  1. skews incentives to deliver efficient short-term operation and long-term investment price signals and
  2. increases out-of-market settlements
- A move towards clearer market rules is needed:
  - a dispatch based on marginal cost only to avoid out of market settlements and provide the right investment signals
  - Market-based mechanisms to ensure security of supply are needed - capacity market or other capacity remuneration mechanisms

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