Renewable Energy Integration – Analytical Approach

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SAFER, SMARTER, GREENER

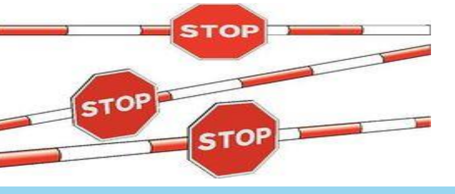
Introduction

- Across the region – relatively slow progress towards RE targets
- The 2020 targets look not achievable in many cases
  - Ukraine: Target set in 2014 – 11% of its energy from RES by 2020 (includes Crimea); Actual January 2017 – 4.6%
  - Azerbaijan 20% of electricity by 2020 (includes large hydro) = 2000 MW installed RE – currently 1247 MW;
  - Kazakhstan: Target 3% in 2020 (1145 MW), 10% in 2030 (5242 MW)
- "Integration" difficulties are sited as one of the important barriers
- However, detailed analysis of these difficulties is often not undertaken
- Such analysis would show that the problems are often due to the general energy sector and market framework and operation

Renewable Energy Integration is a certain "test" for the reformed electricity sector

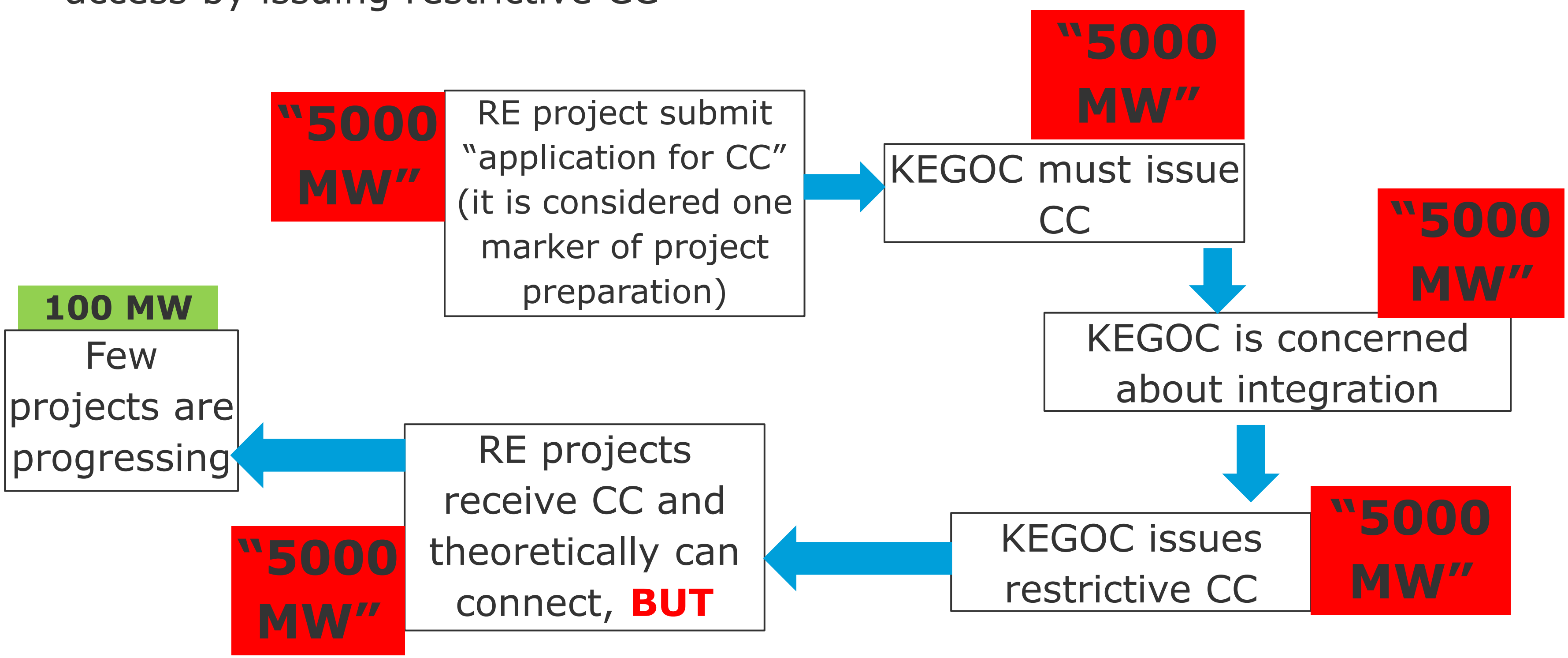
- Many countries of the region have undertaken electricity market reforms, including
  - Competitive wholesale markets,
  - TPA – Third Party Network Access, Grid Codes
  - System of economic regulation of network companies (Natural Monopolies)
- And it seems the new system is working fine. However, when the "RE Test" comes, reforms turn out to be shallow. In reality:
  - The wholesale market has not created the mechanisms for providing flexibility, balancing …
  - The network companies continue to behave in an administrative manner and not as the responsible System Operator, tasked with serving the interests of all network users, for example to plan the network development for the users
  - The regulator does not consider the legitimate needs of network companies' investments in the tariff setting

The legitimate concern about network integration of RE turns into a barrier



Example Kazakhstan 2016

- The system of Fixed Tariffs (FiT) and "free access" to the RE market
- Many interested investors approached KEGOC
- KEGOC and other network companies, legally obliged to issue so called "Connection Conditions" CC) after short intervals, started to "regulate" the RE access by issuing restrictive CC



DNV·GL

«Vice versa example» - Ukraine 2017

- Since 2002 – plan to move from currently existing Pool/Single Buyer market to a Bilateral Contracts and Balancing Market (BCBM).
- The new Energy Market Law was finally ready in 2015 В 2015 г. – but it became law only last week.
- For more than a year, a crucial question delaying the adoption of the law was the issue of Renewable Energy generators, in particular
  - The responsibility of RE generators for balancing (in the end this responsibility was determined as increasing steadily, reaching 100%);
  - The mechanism for the creation of a special Green Energy Balancing Group and a Guaranteed Buyer for renewable energy.

«What is to be done?»

- To systematically research and assess (including quantitatively) the integration issues;
- To analyse the deeper reasons for the issues, which often might not be technical, but instead issues of market and regulatory frameworks;
- To determine concrete and optimal measures for overcoming the RE integration problems;
- To remember and show the positive effects of RE, including on the overall investment needs;

An example of such analysis was undertaken by DNV GL under a World Bank Project

«Integration of RE into the electricity sector of Kazakhstan»

Example (1) Technical challenges of RE integration

(Variable) RE have specific technical characteristics, which are the source of different challenges for system and network planning and operation

Temporal Variability

(Variations across minutes, hours, day, weeks, seasons, years…)

Uncertainty

(Output at each point can only be predicted with limited certainty)

Locational distribution

(Uneven geographical distribution, sometimes in remote areas)

Different technical design and standards

(Lack of synchronous mass, potentially subject to different technical standards)

Example (2) Technical challenges of RE integration
Temporal Variability

Volatility of wind and solar power creates significant challenges mainly for system operation and conventional generators

Dimension of reliability	Potential issues	Impact / Measure
Adequacy	Limited firm capacity	Need for back-up capacity
	Seasonal to daily variability	Reduced operating hours
Security	Diurnal variability	Cyclical operation of conv. Plants
	Short-term variations (seconds to hours)	Increased ramp rates Increased need for frequency control / fast reserves

Example (3) Technical challenges of RE integration Uncertainty

Forecast errors of wind and solar power may require additional operating reserves as well as more frequent intra-day adjustments of generation schedules

Dimension of reliability	Potential issues	Impact / Measure
Adequacy	N/A	N/A
Security	Increased forecast errors across different time horizons	Need for intra-day adjustment of generation schedule
		Increasing need for synchronous and standing reserves

Example (4) Technical challenges of RE integration
Locational distribution

An unbalanced locational distribution of (variable) RE may create various issues at the transmission and distribution level

Dimension of reliability	Potential issues	Impact / Measure
Adequacy	Increase / Decrease of network losses (T&D)	Increased / Reduced fuel costs
	(Thermal) overload	Network reinforcement (transmission & distribution)
	Phase imbalance	Network reinforcement (distribution)
Security	Network stability (voltage / reactive power)	Compensation equipment Distribution reinforcement
	Malfunctioning of control & protection	Adjust and/or replace (distribution)
	Malfunctioning of anti-emergency protection	Adjust and/or replace (transmission)

Example (5) Technical challenges of RE integration
Different technical design and standards

Technical differences and insufficient consideration thereof by current technical rules may cause further challenges for system security

Dimension of reliability	Potential issues	Impact / Measure
Adequacy	N/A	N/A
Security	Reduced availability of ancillary services from conventional plants	Ancillary services provision by RE plants
	Lack of rotating mass	Synthetic inertia
	Exceptions for small plants under current technical rules (e.g. fault-run-through)	Adjust technical rules
	Insufficient consideration of small units (e.g. over-frequency disconnection, ‘50.2’ problem)	Adjust technical rules

Example (6) Market design and RE integration

Power market design and RE support scheme need to comply with five general criteria for an efficient market

- Provision of sufficient incentives to efficiently invest in generation
- Promotion of efficient dispatch
- Supporting real-time balancing and system operation by the TSO
- Ensuring sufficient funds to invest into network expansion
- Non-discriminatory distribution of RE-related costs

Example (7) Market design and RE integration
Assessment of power market

Price caps and other regulatory restrictions lead to fundamental distortions and inefficiencies of the power market

	Power market design		
	Current market design (2015)	Introduction of balancing market ?	Introduction of capacity market (2016)
Provision of sufficient incentives to efficiently invest in generation	• Potentially scope for sufficient investments • Efficiency undermined by price caps		
Promotion of efficient dispatch	• Efficiency fundamentally undermined by price caps and ban of generator-to-generator and supplier-to-supplier trades		
Supporting real-time balancing and system operation by the TSO	• Arbitrary and ad-hoc	Detailed design unclear?	N/A

Example (8)
Promotion of efficient dispatch

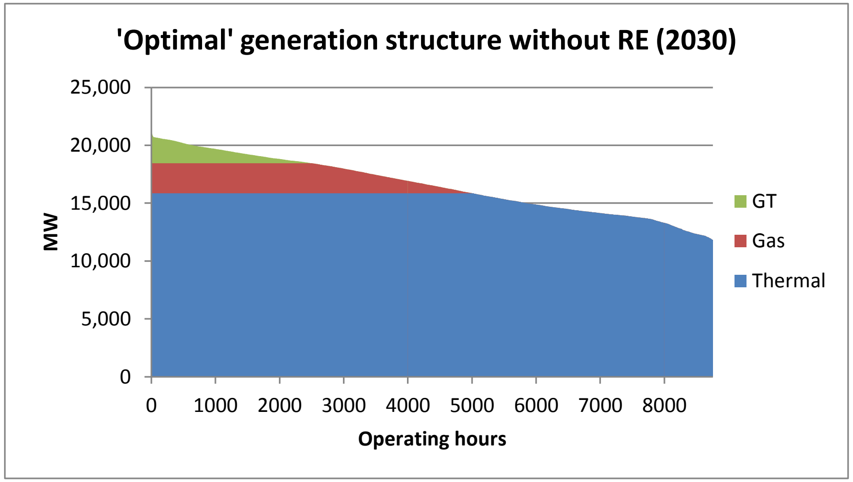
Integration of RE in the wholesale electricity market may be complemented by three specific measures in the current market environment

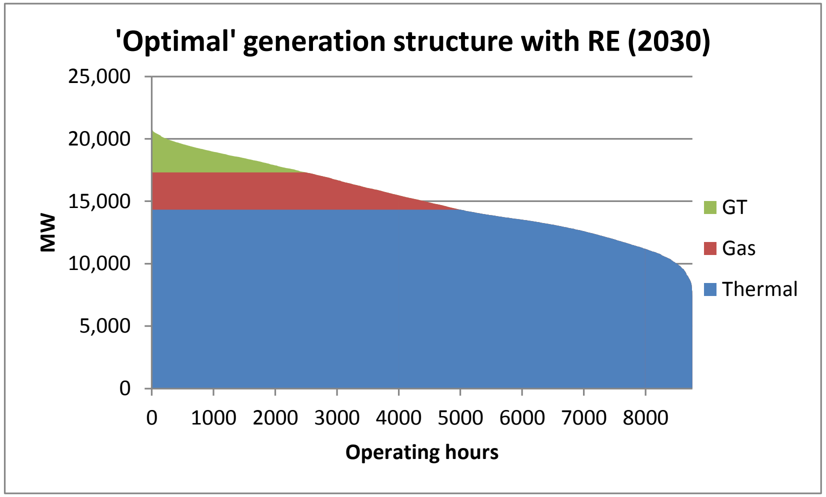
- Successful integration of an increasing share of variable RE basically requires the presence of a sufficiently liquid spot market
- As long as the fundamental deficiencies of the power market design have not been resolved, we recommend considering the following measures:
  1. Require conventional generators to offer a minimum volume of generation into the centralized spot market (within normal price caps)
  2. Removal of ban on generator purchases and sales by supply companies (at least in the spot markets)
  3. Explicitly accept a certain share of purchases in the centralized spot market as part of the annual price caps for regulated supply companies

Example (11) Impact of RE on conventional production

Variable RE leads to increasing shift from need for base load to mid-merit and peaking capacity

- Integration of variable RE leads to:
  - Substantial decrease of need for base load capacity
  - Additional need for mid-merit and peaking capacity
  - Declining operating hours in each category
- Development reflects more volatile nature of residual load in a power system with significant penetration of variable RE





Example (13) Impact of RE on conventional production

Depending on assumptions, RE may save between KZT 292bn and 388bn in investments into new conventional capacity by 2030

- To assess the costs of necessary investments into new conventional capacity, we apply two different approaches:
  1. Assume that all plants existing in 2020 will remain in operation until 2030 (and be used as cold reserves where applicable)
  2. Assume that 20% of thermal plants (‘base load’) are decommissioned by 2030
- In addition, RE saves an estimated KZT 36bn (USD 192) in fuel costs annually[a]

Need for investments (excl. RE)	No RE	With RE	Savings due to RE	
	KZT bilion	KZT bilion	KZT bilion	USD million
Assuming all existing plants stay in operation	676	384	**-292**	**-1,576**
Assuming 20% of base load plants go out of operation by 2030	1,566	1,178	**-388**	**-2,096**

(a) – Assuming 3 KZT/kWh

Conclusions

RE integration is not a problem. It is a task.

- The stability and reliability of the system and of electricity supply is a prerogative which is not up for discussion;
- However, when we discuss the methods for integrating RE into the system there must be no “taboos”. All modern mechanisms for market design, system planning and regulation must be considered.
- The TSOs and the conventional generators play a major role. Their attitude, and – possibly – interests must be changed, because they are holding the “key” to successful RE integration.
- A systematic approach to analysing the issues can create the necessary trust and help to determine optimal measures for integration