RES INTEGRATION CHALLENGES, REGIONAL COORDINATION AND MARKET REFORMS: LESSONS LEARNT FROM EUROPE

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EXECUTIVE SUMMARY

Policy targets in the Gulf States region are aimed at a fundamental transformation of the generation mix in the coming years, by introducing variable renewables (such as solar and wind) and nuclear energy. Due to their economic potential, RES could drive the diversification of the power mix as the cheapest and domestic energy source. The key to this is to enable RES integration, by changing the operational concept of power systems, where RES form a kind of "baseload" generation, and flexible conventional units provide the required flexibility to balance remaining load.

Regional coordination brings significant benefits for systems with higher RES share. It enables a reduction of RES variability through statistical smoothing and allows resource sharing, favoured by the increased regional variability due to the RES local activity. The establishment of markets opens up the potential of regionalisation, by increasing liquidity, competition and providing robust price signals. These benefits are magnified when considering inter-regional coordination, e.g. coupling of the Gulf area to Europe.

There are key parallels between the current situation in the Gulf region with Europe at the start of its market integration process, e.g. low level of interconnection, no markets and low regional trade and a trajectory towards higher RES shares. The paper presents the key steps in the implementation process that can form a basis for lessons learnt: i) the legislative framework, ii) the development of cross-border infrastructure, iii) the role of key implementation bodies and iv) the role of Transmission System Operators on guarding this process. Starting this evolution later and confronted with the similar challenges, the Gulf region could avoid a trial and error approach, by taking into account key lessons learned from the implementation in Europe. The paper presents such lessons learnt in the form of a checklist of potential actions in the coming years.

KEYWORDS

RENEWABLE ENERGY SOURCES, REGIONAL COOPERATION, POWER MARKET DESIGN

1. INTRODUCTION

Electricity generation in the Gulf States is currently dominated by conventional thermal generation, namely oil and gas. The region however is faced with a fundamental transformation of the power mix, by the introduction of variable renewable energy sources (VRES, mostly solar and wind) and in some cases nuclear. Although the proposed RES targets seem very ambitious based on the current situation, they could easily be reached taking into account the market dynamic. RES cost projections show that wind and solar power could become cheaper than conventional technologies within these timeframes (already solar PV and CSP auctions in the region have achieved world record prices). This paper highlights the importance of regional coordination and market reforms in supporting this fundamental shift in generation mix, by drawing some parallels to the experience gained in Europe in the last decades during a similar transition.

The paper is structured as follows: section 2 presents a synthesis of the common challenges faced by the power sector in the Gulf region; section 3 discusses the implications of introducing higher RES shares in the energy mix and the expected benefits from increased regionalization and market integration; section 4 presents key experiences from Europe in this regard; section 5 concludes by presenting the key lessons learnt that could serve as a guidance to address the challenges faced by this energy transition in the Gulf region.

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2. CHALLENGES OF THE POWER SECTOR IN THE GULF REGION: A SYNTHESIS

There are some common challenges that are faced by most of the countries in the region. These challenges could be summarised in the following 5 categories:

1. Growing Demand and high peak/off-peak ratio

Demand growth in the region is rapid, exceeding 5% p.a., driven by economic and population growth. (see e.g. in Figure 1 the load growth in several Gulf region countries for the period 2000-2014). There is a large gap between peak and off-peak load during the day and between seasons (e.g. due to air conditioning), and a relative coincidence in peaks regionally (same time zone and similar climate). This leads to a high need of reserve capacity for satisfying the peaks and a low utilization rate for peaking plants.

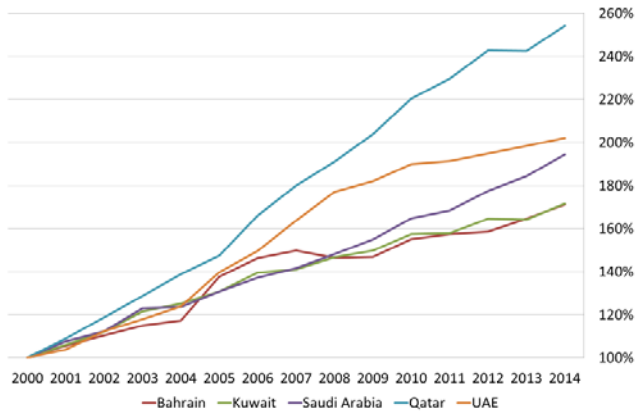

Figure 1 – Load growth in several Gulf region countries (2000–2014) [1]

2. Supply: shift to RES combined with inflexibility

Policy targets and market dynamics dictate a major transformation of the generation mix from oil and gas to variable RES and in some cases nuclear. At the same time, due to desalination, a part of the generation fleet is inflexible (power is a by-product of water production). In general, there is an increasing need of sharing cross-border reserves and generation capacity to overcome electricity variability.

3. Grids: rapid internal expansion, low regional interconnection

Power grids are rapidly developed in all Gulf States to keep up with growing electrification needs. The level of interconnection between the countries is low, at an average of 7% of installed capacity in 2018.[1] The GCC interconnection project is the key regional interconnection infrastructure, which is currently mainly used for system security purposes (low levels of energy trade through the interconnector take place).

4. (Non-) Markets: incomplete liberalisation and subsidies

First steps of deregulation are in place, even if the domestic markets' liberalization is at an incomplete stage and no power markets are yet introduced on a large scale. Generation is dominated by state-owned vertically integrated utilities following a single buyer model without competitive demand/supply contracting. Attracting investments in generation is achieved mainly through long-term PPAs (in several cases as public-private partnerships) where part of the risk is guaranteed by the state. Subsidies (hidden or not) keep energy prices low for the final customer, which in turn create distortions to market signals and lead to inefficient electricity usage and no energy saving.

5. (Non-) Harmonisation: lack of global legal and operational harmonisation

There is a lack of complete and detailed legal framework at GCC level that could guide a harmonisation of legislation at each state. As for example, although grid codes are reviewed in all states, there is a lack of a structured harmonisation, albeit better use of the GCC interconnection requires such a legal and technical harmonisation.

These challenges will frame the power sector transition in the Gulf region in the coming years. In the next section we discuss the challenges imposed by RES deployment and possible benefits expected by regionalisation and market development.

3. RES CHALLENGES AND BENEFITS FROM REGIONALISATION AND MARKETS

3.1. Challenges for shifting to "RES as baseload"

Although currently GCC States RES policy targets seem ambitious, market dynamics could even exceed them in a near future, for two main reasons:

1. **Impressive RES economic potential in the region:** RES is one of the cheapest energy sources in the region. Already solar PV and CSP auctions achieved world record prices and market projections show increasingly falling RES costs. [3]

2. **Need for power mix diversification**: the reliance on gas and oil implies risks, as domestic production should keep up with the rapidly

[1] Load growth leads to reduction of interconnectivity percentages in absence of new investments, e.g. with a 5% annual load growth, interconnectivity is reduced by more than 50% in 10 years.

growing demand. This firstly raises the issue of opportunity costs related to the domestic use of oil that could otherwise be exported. Furthermore, several States face risk to turn into gas importers in the future as domestic gas production is not sufficient (see e.g. the case of Saudi Arabia [3]).[2]

Due to their economic potential, RES could drive the diversification of the power mix as the cheapest and most reliable domestic energy source. [4] The main precondition is the development of power systems that can optimally integrate increasing RES shares. This context brings a change in the operational concept of the system: RES should become a kind of "baseload" generation, while flexible conventional thermal generation would provide the required flexibility to balance the remaining net load (i.e. load minus RES).

The implications on the system flexibility are central for the introduction of "RES as baseload" concept, especially for constrained systems (due to e.g. nuclear and/or water co-production). Significantly higher RES shares create conditions for the so-called "flexibility gap", due to a dual effect of increase in the need for flexibility and decrease of existing flexibility in the system [9]:

a) **Increasing need for flexibility:** high level of variable RES strongly increase the variability in the system operation. This is manifested as higher ramping rates for the system net load and increasing load forecast uncertainty due to RES forecast errors. This leads to an increasing need for flexibility to manage the system.

b) **Decreasing existing system flexibility:** at higher shares, RES reduces the profitability of existing units. This impact is higher on units with higher marginal costs (peaking plants), which start being unprofitable. In practice, flexible peaking power plants are not kept sufficiently in merit order activation, with the consequence to be shut down on a final stage. As these are the traditional providers of flexibility, this leads to a rapid reduction of the existing system flexibility, affecting the available ancillary services for grid operators.

Enabling larger geographical integration and market-based systems can help on reducing these impacts.

[2] Plans of diversification of power mix are already in place, see e.g. the cases of Abu Dhabi and Saudi Arabia where RES and Nuclear energy are already introduced as major alternatives [5],[6],[7],[8].

3.2. Towards higher RES shares: Benefits from regional coordination and markets

Regional coordination benefits: regional coordination brings significant benefits for systems with higher RES shares on two dimensions:

1. **Reduction of RES variability:** larger geographical integration reduces the impact of RES by the so called "statistical smoothing". In practice, RES fluctuations even out each other more when spread across larger geographies. This reduces global ramps and counterbalances forecast errors. [10] To enhance this positive effect, a strategic development of a combination of RES resources is considered as a key strategy on shifting to higher RES shares. This increased geographical reach should ultimately be combined with a shift in system operation closer to real time, which enables the forecast ability of RES.

2. **Increase in sharing of resources:** regional integration allows better sharing of resources. Significant benefits are already manifested in studies on the economic efficiency of the GCC interconnector [11], even though electricity demand between regions follows similar daily and yearly patterns. RES introduction magnifies this economic efficiency, as local RES fluctuations increase the relative variability of demand between zones, creating more arbitrage opportunities. Furthermore, sharing of resources improves system reliability, as the simultaneous loss of generation units in different zones is very rare (see e.g. the LOLE analysis in [12] for Europe where it is shown that sharing of reserves can reduce the need for backup capacity by 50%).

Role of markets: The establishment of markets enables the full potential of regionalisation. Expanded and liberalized markets enable the increase of liquidity by allowing the entry of new players, increasing competition. Furthermore, markets establish price discovery mechanisms that enable robust price signals needed for the assessment of regional arbitrage opportunities.

Inter-regional coordination benefits: the above-mentioned benefits are magnified when considering inter-regional coordination [13], e.g. coupling of the Gulf region to Europe. This would allow increased arbitrage opportunities due to the diversity in climate and differences in RES activity and structure of generation. Taking into account the central role that RES should play in the future European energy mix,

coupling the regions will allow both regions to reach their targets in a more cost-efficient manner. In this respect, the regional coordination at GCC level should be seen as part of a vision for a further expansion.

RES deployment, regionalisation and market development have been the cornerstones in shaping the power sector reform and reorganization in Europe. In the next section, key experiences on how this transition was organised in Europe are presented.

4. RES, REGIONAL COORDINATION AND MARKET REFORMS: THE EUROPEAN CASE

In order to liberalise the EU's internal energy market and in a second phase to harmonise it, a process has been adopted since 1996 as part of a wider political commitment on the market integration in Europe [14]. Measures aimed to address market access, transparency and regulation, to enable the approximation of tax and pricing policies, to harmonise norms and standards, to remove obstacles and barriers, to develop needed interconnection infrastructure and to ensure adequate levels of supply. A "top-down" approach was adopted, by imposing the change through EU legislation.

This section starts by discussing the parallels between the Gulf region case and how the European system evolved in the last decades. Further, we present the key steps in the implementation process that can form a basis for lessons learnt for the Gulf region: i) the legislative framework, ii) the development of cross-border infrastructure, iii) the role of key implementation bodies and iv) the role of Transmission System Operators (TSO) on guarding this process.

4.1. The European internal energy market: an example not so far away from the Gulf region situation

Currently, the power industry in Europe presents significant differences from the one in the Gulf region: high level of international trade takes place and high levels of RES have been reached in some countries. However, parallels can be drawn by comparing the current situation in Gulf region with Europe at the start of its market integration process. The analysis of its main similarities and differences can help to propose a guidance to address the challenges raised by the energy transition in the Gulf region.

Its main similarities can be found in the situation of grids, the market before the liberalization phase and the RES deployment trajectory. Europe was a conglomerate of weakly interconnected islands, where interconnections were used mainly as national back up for security reasons and no large scale trade was taking place (mostly Over-The-Counter (OTC) contracts). The power market landscape was dominated by vertically integrated utilities, mostly state-owned, according to a single buyer/producer model with market distortions. Energy diversification fuelled the decision for a transition to variable RES and the need for alternative producers and suppliers was central for a shift towards markets.

However, significant differences can also be observed. Europe is an energy importing region with exposure to risk of high prices. Demand growth has been stagnating and market integration was driven by the need to increase competitiveness and reduce prices. This non-expanding market magnified impacts to market players (i.e. plants were not dispatched and had to shut down). Finally, the existence of significant differences in generation portfolios between the countries (e.g. nuclear in France, hydro in the Nordics) supported arbitrage trading opportunities.

4.2. Regional integration legislative framework in Europe: the Internal Energy Market (IEM)

The legislative process led to a phased approach, with key steps the so-called "Energy Packages" (Energy Directives). A 6-7 years period was left between the steps for the detailed implementation at Member State level. The 1st Directive set the grounds for liberalisation, the 2nd Directive moved to the improvement of degree of integration between markets, the 3rd Directive set up the key governing bodies and the ongoing "Clean Energy for all Europeans" package further aligned the market design. The key elements of this process are presented below (see e.g. [14] for more details).

4.2.1. First Legislative Energy Package (1996)

During the 1990s, when most national electricity and natural gas markets were led by vertically integrated utilities, the European Union and the Member States decided to open these markets gradually to competition. The European liberal vision was a key driver to restructure key economic sectors in the 90s: i.e. telecom, health, transport, post, etc. The energy sector was subject to the similar approach under the general concept of 1) introduce competition in production, trading and consumption of energy, 2) keep networks under a regulated regime (as it is too costly to have parallel and competitive power grids) (see Figure 2). The first liberalisation directives were adopted in 1996 (electricity) and 1998 (gas), to be transposed into Member States' legal framework by 1998 (electricity)

and 2000 (gas). The key provisions can be summarised as follows:

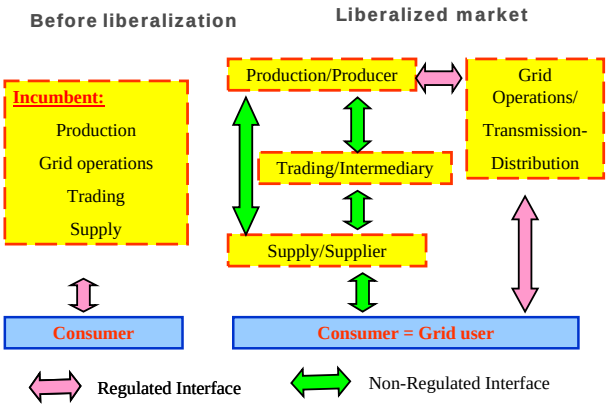

Figure 2 – Key steps in market liberalisation in Europe

- Progressive unbundling of national monopolies
- Designation of TSO, DSO (no competition in grids, regulated monopolies)
- Introduction of competition in production and supply segments (free production, freedom to choose supplier)
- Non-discriminatory third party access (TPA) to the grid, choice between Negotiated TPA between the grid and the consumer Regulated TPA
- Consumers with consumption above 100 GWh/Y eligible as market participants as from 19.02.2000

4.2.2. Second Legislative Energy Package

The Second Energy Package was adopted in 2003, its directives to be transposed into national law by Member States by 2004, with some provisions entering into force only in 2007 (deadline for full market opening). Industrial and domestic consumers were now progressively free to choose their own gas and electricity suppliers from a enlarging range of competitors. Market based interconnection capacity allocation and first day-ahead market coupling are introduced and power exchanges were established. Key provisions are summarised below:

- Setting up an national regulatory authority (mandatory regulator - NRA) independent from the government
- Regulation of cross-border trade
- Improving the degree of integration between the national markets
- Establish state responsibility to assure sufficient generation capacity
- Legal unbundling of TSO (transmission system operator) and DSO (distribution system operator)
- Mandatory Regulated TPA
- Market based capacity allocation

4.2.3. Third Legislative Energy Package

In April 2009, a Third Energy Package seeking to further and fully liberalise the internal electricity and gas markets was adopted, amending the second package and providing the cornerstone for the implementation of the IEM. Key provisions are as follows:

- Improving competition and consumer protection
- Choice for TSO models : Ownership Unbundling (OU) or Independent System Operator (ISO+) or Independent Transmission Operator (ITO)
- Set up ACER (Agency for the Cooperation of the Energy Regulators) and the ENTSOs (European Network for Transmission System Operators – ENTSOE for electricity and ENTSOG for gas)
- Initiating Electricity Regional Initiatives (ERI) project (TSOs enhanced regional cooperation)
- Setting up EU network codes

4.2.4. Clean Energy for all Europeans Package

In November 2016, the Commission put forward a set of legislative proposals for a new EU energy market design, covering energy efficiency, renewable energy, electricity market design, security of electricity supply and governance rules for the Energy Union. [15] These proposals are still under discussion between the European institutions and stakeholders.

- Clearer and more frequent electricity bills
- Protecting poor or vulnerable customers
- Engaging new market players, (e.g. aggregators and local energy communities), regulation of data exchange between market participants at Member State level.
- Facilitating electro-mobility
- Clarifying the tasks of DSOs and introducing a procedure for planning the development of distribution networks

4.3. Role of interconnectors for the development of regional trade for IEM

The core goal of the IEM is to enhance regional trade: “electricity should flow between Member States as easily as it currently flows within them”. Key obstacles for this were congestions on interconnectors due to insufficient physical capacity, but also due to uneconomic use of capacity and no equal access rights. The short-term solution has been to develop congestion management methods to maximise the use and ensure equal access. The long-term solution has been to build interconnectors and to better locate generation. In this

respect, congestion rents have been signals for new interconnection and market prices for new generation.

The development of interconnectors was promoted by the identification of projects of common interest (PCI) that have priority on European financial aid and benefit of simplified national procedures to grant administrative authorizations, as well as support for public acceptance. [16] Interconnectors developed by the implementation of the PCIs are truly European projects that stimulate and strengthen regional cooperation between Member States and increase global socio-economic welfare. In November 2013, a budget of €5.12 billion was set for the development of trans-European energy infrastructure projects. In October 2014, a target was set for all EU countries to achieve interconnection of at least 10% of their installed electricity production capacity by 2020 and 15% by 2030. [17]

4.4. Key IEM implementation bodies

Two cornerstones in the implementation of the IEM was the setup of the two main implementation bodies with the 3rd Energy Package, namely ACER for harmonising regulation at European level and ENTSO-E for coordinating grid development and harmonising grid codes. Finally the consequent establishment of regional security coordination centres (RSCs) to ensure regional grid operation coordination.

4.4.1. ACER: harmonising energy market regulation

ACER [3] is mainly responsible to complement and coordinate the work of NRAs at European level and to work towards the completion of the single EU energy market for electricity and natural gas. ACER coordinates regional and cross-regional initiatives, which favour market integration. ACER monitors the work of ENTSOs, notably their EU-wide network development plan and the functioning of internal electricity and gas markets in general, and of wholesale energy trading in particular. In 2011, ACER received additional tasks under EU Regulation N° 1227/2011 on wholesale energy market integrity and transparency (REMIT). Finally, ACER also has the competence to investigate cases of market abuse and to coordinate the application of appropriate penalties with the Member States. The responsibility for applying sanctions applicable to infringements, lies however, in the hands of the Member States.

[3] See https://www.acer.europa.eu

4.4.2. ENTSO-E: coordinating grid development and harmonising network codes

The ENTSOs, ensure the coordination of grid operation through the exchange of operational information and the development of common safety and emergency standards and procedures. Launched as a voluntary initiative from European TSOs in the 1920s, ENTSO-E has given legal mandates and currently includes 43 TSOs from 36 countries. Its mission is directly linked to RES and market integration: “setting up the internal energy market and ensuring its optimal functioning, and supporting the ambitious European energy and climate agenda”. Important issues on today’s ENTSO-E agenda are the integration of higher RES shares, the development of needed flexibility and a shift to a more customer centric approach.

Main tasks are therefore RES integration, completion of IEM and ensuring security of supply and system reliability. Main activities are: drafting a detailed set of network codes on connection, market and system operation (based on ACER guidelines), development of pan-European 10-year Network Development Plan (the ‘TYNDP’[4]), increasing technical cooperation between the TSOs, coordination of R&D plans, publication of adequacy forecasts for winter and summer.

Key objectives of the Electricity Regional Initiatives (ERI) project introduced in 2009 is identifying and implementing practical solutions to remove barriers to electricity trade and facilitating regional market integration. Seven electricity regions were identified based on historical, geographical, and market cooperation. The key priorities set are: i) adoption of efficient congestion management methods (capacity calculation, capacity allocation, congestion relieve), ii) increase transparency of market information and iii) introduction of cross-border balancing market.

4.4.3. RSC: regional coordination for ensuring security of supply

The necessity to improve regional coordination to guarantee system security came as a priority following serious electrical power disruption in 2006 due to a lack of coordination between TSOs in the Central Western Europe area. As a result, two Regional Security Coordinators (or RSCs) were set-up in 2008 on voluntary base by several European TSOs. This role was officialised in the system operation guideline

[4] The TSOs plan ten years ahead how each national but also the European interconnected grid should evolve based on key power system evolution trends, in order to cover demand.

(SOGL)[5] and 3 other RSCs were set-up in 2015-2016, aiming to provide services to TSOs regarding operational coordination[6]. RSCs intervene from one year ahead to one hour before dispatch. Based on the multilateral agreement that ENTSO-E members have all signed, 5 mandatory services are delivered by RSCs: i) Individual Grid Model / Common Grid Model Delivery, ii) Coordinated Security Analysis (including Remedial Actions-related analysis), iii) Coordinated Capacity Calculation, iv) Short and Medium Term Adequacy Forecasts, v) Outage Planning Coordination. As they are a flexible organisation, RSCs are service providers to TSOs, with staff & budget coming from TSOs, RSCs can develop their services as much as is needed to make grids more efficient.

RSCs must respond to regulators through the fact that they are service providers of nationally regulated TSOs. Since 2016, the system operation guidelines and through ENTSO-E they must increase reporting on their work. [18]

4.4.4. Role of TSOs: a pivotal role for liberalization and market coupling

TSOs played a pivotal role throughout the liberalization process, the development of regional market and RES integration, as the key stakeholders to ensure system security during this transition, to develop interconnection and allow market couplings. [19] Most of the TSOs' voluntary initiatives started on a bilateral or multilateral way, as initiating key developments, and helped the political process of giving to appropriate bodies official mandates for market integration and security of supply.

As a result, TSOs are the constituting members of key IEM implementation bodies, i.e. ENTSO-E, and RSCs. They have an active role in the market as they are in most cases responsible for the operation and development of balancing markets. Furthermore, TSOs and power exchanges developed together the market coupling rules.

5. CONCLUSIONS: LESSONS LEARNT

The similarities between the situation in the Gulf region nowadays and Europe at the beginning of the liberalisation process, allow drawing some useful lessons learnt.

It has to be reminded that energy reforms in Europe were part of a larger political integration process and were implemented in a top-down fashion by the European Commission. They had as starting point the vision to push for liberalization. Next steps were the need for more interconnections and the push for ambitious RES targets. The global electricity sector reform took the way of a legislative reform, implemented in phases. Each consecutive phase corrected side effects from previous ones or deepened positive elements. It appeared quite early in the process that independent 'technical' implementation bodies at national, regional and European level were key to support and develop the global initiatives, ensure security of supply and implement the needed changes for integrating RES.

Starting later this evolution and confronted with the same challenges, the Gulf region could avoid a trial and error approach, by taking into account key lessons learned from the implementation in Europe. In the following, such lessons learnt are presented as a checklist of potential actions in the coming years in the Gulf region.

Setting up of a Global Framework:

- Need of clear political commitment with long-term vision on the regional market development and roles/responsibilities of the market actors
- Alignment of global legal framework within states based on the subsidiary principle: common agreement on the key access and market rules, harmonisation of taxes and tariffs, etc. albeit leave freedom to the individual States on detailed implementation
- Bilateral and multilateral agreements could serve as a main building block for further development.
- Include TSOs in the process to guarantee technical security, allowing them a pivotal role for the well-functioning market and the RES integration.

Enhancing Regional Coordination:

- Need for coordinating bodies to ensure regional grid development and security of supply
- Coordinated development and management of interconnections is key to achieve a well-functioning market integration
- Harmonization of technical standards (e.g. common grid codes, accounting and settlement systems, operational information exchange, consistent technical constraints and reliability standards)

[5] The SOGL is part of the "network codes": it specifies TSOs actions on RES integration, increasing interconnection and cross-border competition and lays the ground for power system evolution, e.g. making regional coordination a legal obligation for grid operators.

[6] For details on the 5 RSCs currently active in Europe, see https://www.entsoe.eu/regions/#meet-rsc

Show the way for Market Reforms:

- Reinforce the freedom of TSOs from generation and supply to ensure an effective Third Party Access to all types of generation, with regulated grid access rules.
- Establishment of independent state NRAs with close cooperation with regional and international regulators
- Set up of common market rules (wholesale, balancing markets) and grid access rules, global harmonization of tariff structures and support mechanisms (like parallel phase-out of generation subsidies)
- Establishment of bidding zones and power exchanges for enabling market signals and giving more liquidity to the market
- Market-based deployment of RES, phasing out of subsidy schemes

Based on these lessons learnt and possible additional items, a detailed roadmap for the region should be developed to guide the process. The "no regret" policies should be identified and be prioritised.

The existing organisation of GCCIA might play an anchor role in this respect, by taking somehow the role of ENTSO-E and RSC in Europe. Some no regret actions that GCCIA could take can be the following:

- setting up a roadmap on how to guide the process towards a wholesale regional market between states with different levels of market maturity
- creation of detailed CBAs to assess the benefits and impacts from further interconnections in the region in short- to mid- term
- proposal of long-term strategic plans for development and/or reinforcement of interconnections in the region and for connecting the region to other neighbouring regions
- assessing the adequacy and security of supply impacts and benefits of enhanced regionalisation
- proposing common principles for grid codes and access to grid rules, or even draft common grid codes for technical issues, market and system operation.

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