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EU-GCC Clean Energy Network II

O.1.6 Report

Background Paper on Areas of Potential EU GCC Clean Energy Cooperation

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Note: This report is taking stock of best practices, obstacles or gaps that have emerged from the Network discussions during the previous phase (2010-2013) and reviews the EU GCC clean energy cooperation areas and potential in view of what is relevant to date. In addition the analysis takes into consideration the results of the e-Consultation process carried out in April and May 2016 as well as the recommendations that have emerged from the 1st Working Groups' Consultation Workshop (24 May 2016, Dubai) in the fields of Renewable Energy Sources, Electricity Interconnections and Market Integration.

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- a number of stakeholders and experts in the EU and in the GCC that were consulted during the first six months of 2016.

This report is intended to be a living document, subject to annual updating as appropriate in order to support the prioritisation and planning of the Network activities.

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ABBREVIATIONS

BAU	Business-as-usual
BEMS	Building Energy Management Systems
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Use
CEN	EU-GCC Clean Energy Network (Phase 1 Project: 2010-2013)
CENII	EU GCC Clean Energy Network II (Phase 2 Project: 2015 – 2018)
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CSP	Concentrated Solar Power
DEWA	Dubai Electricity and Water Authority
DHI	Diffuse horizontal irradiance
DIES	Dubai Integrated Energy Strategy
DNI	Direct normal irradiance
DSCE	Dubai Supreme Council of Energy
DSM	Demand Side Management
ECCP	European Climate Change Programme
EEOs	Energy efficiency obligation scheme
ESCO	Energy services companies
ESI	Emirates Steel Industries
FIT	Feed in Tariff
GCC	Gulf Cooperation Council
GCCIA	Gulf Cooperation Council Interconnection Authority
GHG	Greenhouse gases
GHI	Global horizontal irradiance
GTL	Gas-to-Liquids
INDC	Intended Nationally Determined Contributions
JICA	Japan International Cooperation Agency
KACARE	King Abdullah City for Atomic and Renewable Energy
KEEP	Kingdom of Bahrain Energy Efficiency Programme
KSA	Kingdom of Saudi Arabia

LCOE	Levelised costs of electricity
LNG	Liquefied Natural Gas
PPA	Power Purchase Agreement
PSI	Projects of Common Interest
PV	Photovoltaic
QGBC	Qatar Green Building Council
ReCREMA	Research Center for Renewable Energy Mapping and Assessment
RES	Renewable energy source
SEEC	Saudi Energy Efficiency Center
SEEP	Saudi Energy Efficiency Program
SET	Strategic Energy Technology
SOE's	State owned enterprises
UAE	United Arab Emirates
UPC	Urban Planning Council
ZEP	Zero Emission Fossil Fuel Power Plants

1 Introduction

The EU-GCC Clean Energy Network (CEN) was launched in 2010 with European Union funding, as a response to the common EU GCC interest for strategic clean energy cooperation. The Network is designed to catalyse and promote joint EU GCC clean energy initiatives, including policy and technology aspects involving a broad range of stakeholders in the EU and GCC countries. The Network aims to become permanent over the mid-term. With these objectives in mind, the European Union has recently launched the "EU GCC Clean Energy Network II" (CENII) project. Building on the achievements of the EU-GCC Clean Energy Network since 2010, the project aims to boost the Network and explore the opportunities for cooperation in the energy sector.

The new Project aims at widening the participation in the Network, ensuring its sustainability in the longer term and strengthening its capability to increase EU-GCC cooperation in the field of clean energy. The main instruments for the Network to promote cooperation activities such as policy discussions, joint research or technology implementation projects are a system of Working Groups and an advanced web based cooperation platform. Dissemination of information about the existing cooperation and relevant funding opportunities and the Network itself is a third pillar of the project content.

The Project covers all EU Member States and the countries of the Gulf Cooperation Council (GCC), namely: Bahrain, Kuwait, Oman, Qatar, Kingdom of Saudi Arabia (KSA) and United Arab Emirates (UAE). All GCC members are also members of the Arab League and Qatar, KSA, Kuwait and the UAE are prominent members of OPEC.

The targeted Network stakeholders include: industry, energy-related research entities, universities, government entities and policy makers, utilities, and others from the energy and climate change sectors. Of particular importance in the GCC Region are state owned enterprises (SOE's) who are often major consumers of power and in a number of cases owners of generation assets.

The Network can promote cooperation activities that are both regional and bilateral and will include the exchange of ideas, sharing best practices, development of common research co-operations etc. The Network aims to bring the stakeholders together, providing the means for the development of better and more efficient ways of cooperation and helping identify new fields and areas of cooperation among the Network's stakeholders. It provides a **platform** for debate and exchange of information, a **bridge** between the EU and GCC regions and a **source** of information on clean energy and climate change.

This background paper builds upon the discussions that took place in what were previously called Discussion Groups from 2010 to 2013. The analysis is taking stock of best practices, obstacles or gaps that have emerged from the existing Network and will review the Network cooperation areas and potential in view of what is relevant to date. It has greatly befitted from consultation with many stakeholders. In addition it takes into consideration the recommendations that have emerged from the 1st Working Groups' Consultation Workshop that has been held in Dubai on 24 May 2016. The workshop discussed among experts the two regions' cooperation potential in the fields of Renewable Energy Sources, Electricity Interconnections and Market Integration. The EU-funded workshop was organised with the support of the Dubai Supreme Council of Energy (DSCE) and in association with the Clean Energy Business Council.

A mapping of the current state of clean energy in each GCC country is also presented, identifying the countries' level of progress on policies, technologies, research, capacity and strategy. This is done based on previous work realised by the Network, as well as on papers, publications, industry and policy news and other reliable information released.

This background paper describes the current state of play in the GCC and EU regions and the desire for cooperation, with the ultimate goal to support discussion on updating areas for potential EU-GCC clean energy cooperation.

2 The Concerned Regions

The GCC countries are among the world leading oil and gas producing and exporting countries. This is in particular the case for the Kingdom of Saudi Arabia, Kuwait, the United Arab Emirates and Qatar, which jointly contain 40% of world oil reserves and 20% of world gas reserves, and account for production of 23% of world oil and 9% of gas. The KSA, on its own with 21% of world oil reserves and 13% of world oil production, has a reserve to production ratio of 66 years. This means that, assuming no new oil is found and that oil production levels remain at the present level, the KSA has oil for less than 70 years, i.e. three generations.

The GCC countries are also among the highest energy and water consumers worldwide and domestic energy consumption continues to increase fast. Electricity demand is increasing particularly fast, at average growth rates of 7%, which implies a doubling of the needed power generation capacity every 10 years. This strong electricity demand growth is also driven by low consumer energy prices. Low returns for the power utilities results in insufficient capacity additions and reserve margins falling to dangerously low levels, with increased risk of outages and black-outs. In the GCC all power generation is largely oil and gas based. The CO_2 footprint of GCC countries is among the highest in the world[1].

Engaging in a more sustainable development path and thus curbing domestic oil and gas demand will allow hydrocarbon reserves to last longer, enable higher revenues through export and make more hydrocarbons available for other use, such as the petrochemical industry. Although, efforts towards energy efficiency, renewable energy sources (RES) and sustainable energy in general had been limited in the past in the GCC, there is a new momentum in the area and all the countries in different way are now promoting energy efficiency and renewables policies.

Recent developments indicate that past attitudes have started to change rapidly. Interest in renewable energy source technologies (predominantly solar) is growing fast in various GCC countries, as a number of projects are already implemented or underway, local and regional actors are developing impressive RES plans and activities and local capacity is growing. In this framework, a number of technological, policy, as well as research challenges in developing and applying RES projects in the region are the basis for cooperation that the Network can build on. There is also intense interest in Carbon Capture and Storage (CCS) technologies, notably because CO_2 injection into oil reservoirs not only reduces atmospheric greenhouse gases (GHG), but can also enhance oil

[1] (Saab, 2012)AFED - Arab Forum for Environment and Development, 2012. Arab Environment 5, Survival Options, Ecological Footprint of Arab Countries. Edited by Najib Saab, Incorporating Arab Atlas of Footprint and Bio-capacity by Global Footprint Network, ISBN: 978-9953-437-43-9.

recovery. In addition, there is growing interest in technologies related to the transportation of gas into Liquefied Natural Gas (LNG) or Compressed Natural Gas (CNG) form, as well as in transformation of gas into clean liquid fuels and other petrochemical derivatives.

The interest in the GCC in the fields of Demand Side Management (DSM) and Energy Efficiency, through intervention processes and policies, is gaining ground as demand continues to put pressure on the provision of capacity in terms of primary fuel and generation. In addition, in recent years several GCC countries have been launching various DSM and Energy Efficiency initiatives. Consequently, there is large potential for cooperation on energy efficiency as well, starting potentially with energy efficiency in the building as well in the industry sectors, targeting GCC countries that appear more advanced and ready to consider adopting relevant policies.

Integration of the region's electricity systems is a very important area since it brings a whole raft of benefits to participating countries including the promotion of capacity sharing. Towards this direction, stability and reliability to electricity supply has already begun with the operationalization of the first stage of the GCC power grid. It should also be noted that GCC countries on many occasions have declared climate change as key strategic priority and seek to develop international cooperation on these grounds.

On the other hand, the EU, as the world's major importer of hydrocarbons and the leading world proponent of climate change prevention has a well-founded interest to cooperate with the GCC countries in addressing and successfully tackling clean energy issues. The multiple benefits to this approach include reduction of the greenhouse effect, prolongation of the duration of the hydrocarbon fuel reserves, the potential for diversification of gas supply to Europe (through the supply of gas or gas derivatives from the region), the promotion of EU policies, the development of a market for the EU clean energy industry in the long run. The Project at hand is a manifestation of the European Commission's desire to catalyse developments in the field of clean energy, through the reinforcement of international cooperation (at the level of research, policy, technology and industry), dissemination of information and advice on clean energy policies, capacity building and exchange of know-how, and exploration of possibilities for joint projects (both technological research and pilot industrial scale projects).

3 Overview of EU-GCC Cooperation Initiatives

Energy has always been a central element of EU-GCC relations. Having the features presented before, the EU has a sound interest to cooperate with the GCC countries and partner with them in successfully addressing clean energy issues. Conversely, the GCC countries, as hydrocarbon exporters, have an interest in Europe, to strengthen international relations and in this context, the EU and the GCC countries have established and are further enhancing a long term regional strategic relationship in many sectors and policy areas including the energy sector. This development is fully reflected by the on-going contacts, underpinned by the growing interest of the GCC countries to work more closely with the EU on clean energy.

The EU imports approximately 2/3 of its requirements for natural gas, and this number is likely to increase due to further depletion of indigenous gas resources and the recently introduced cap on gas production in Netherlands. To diversify sources of natural gas there is an increasing focus on

importing LNG, which might be interesting to natural gas exporters such as Qatar, providing access to an integrated market with 500 million consumers.

In the political context, the EU has established bilateral relations with the GCC countries through the 1988 Cooperation Agreement, intended to strengthen stability in a region of strategic importance, facilitate political and economic relations, broaden economic and technical cooperation, broaden cooperation on energy, industry, trade and services, agriculture, fisheries, investment, science, technology and environment. The Agreement allowed for the development of closer cooperation on issues such as energy, transport, research and innovation, and the economy. Nowadays, the rationale for having close relations with the GCC countries is different and perhaps stronger, as trade and investment relations have grown.

Current EU-GCC relations are based on this Cooperation Agreement, putting into place a regular high level framework of dialogue. The Cooperation Agreement has established an annual Joint Council/ Ministerial Meeting between the EU and the GCC foreign ministers, as well as between senior officials at a Joint Cooperation Committee.

Furthermore, an Energy Experts Group was initiated, which started working at the beginning of the 1990s' and currently constitutes one of the longest standing cooperation mechanisms between the EU and the GCC partners. Exchanges within this group are being complemented by the activities of the EU-GCC Climate Change Experts' Group that has met on a regular basis since 2007.

At the 19th EU-GCC Joint Cooperation Committee meeting on the 18th March 2009 in Brussels, the EU and GCC partners agreed on extending energy cooperation and more specifically on establishing an EU-GCC clean energy network. The European Commission initially seeded the network with funding for three years, which ended in 2013. In December 2015, the EU initiated the second phase of the EU-GCC Clean Energy Network, with funding covering the period 2016-2018.

4 Potential Areas for cooperation

An essential element of the EU-GCC Clean Energy Network project are the five (5) Working Groups (previously called Discussion Groups) that focus on areas of common interest for the stakeholders of the two regions (EU, GCC):

- Renewable Energy Sources
- Energy Demand Side Management and Energy Efficiency
- Clean Natural Gas and Related Technologies
- Electricity Interconnections and Market Integration
- Carbon Capture and Storage.

The expanded Network will also address climate change.

The CEN supports EU GCC cooperation in clean energy fields through:

- Networking and Partnership development, with a wide range of stakeholders, including policy-making bodies, research institutes and industry players.
- Organisation of experts' events, thematic discussions, seminars, webinars, training sessions and high-level conferences.

- Operation of Working Groups to facilitate collaboration among EU and GCC experts.
- Dissemination of information on EU-GCC clean energy co-operation opportunities and policy frameworks:
    - Information on possibilities for cooperation and joint projects, including through Horizon 2020, the European Framework Programme for Research and Innovation.
    - Detailed information and better understanding of EU and GCC policies and frameworks related to clean energy and climate change.
    - Advanced Web-Area to facilitate discussion, dialogue and collaboration among EU and GCC stakeholders on technology, research and policy aspects of clean energy and climate change.
- Promotion and facilitation of a number of joint demonstration and pilot projects, as well as research activities, being implemented with participation of EU and GCC entities in the area of clean energy and climate change.
- Support for the publication of articles in scientific journals.
- Coordination with other networks/instruments, such as platforms for international scientific cooperation established under Horizon 2020.
- Closely liaising with initiatives in the region in related fields, e.g. waste, with a view to coordinating efforts and benefiting from synergies.

This section presents the highlights and the cooperation potential of the five thematic areas of cooperation of the current Network (as per the results/experience of the previous project and the analysis of the current state of clean energy in the GCC region). In addition, there is the thematic area of climate change, which is a cross cutting topic among the five thematic areas mentioned above.

4.1. Renewable Energy Sources

In the EU:

As a net importer of hydrocarbons, renewables will build on their key role in helping the EU meet its energy needs beyond 2020. EU countries have agreed on a renewable energy target of at least 27% of final energy consumption in the EU as a whole by 2030[2]. However, as the current legislation is not sufficient for this purpose[3], there is a need to modify the legislative framework to ensure a timely and cost effective achievement of the EU level binding target on renewables by 2030. Finalization of the new renewable energy directive (REDII) for the period 2020-2030 is foreseen before the end of 2016. The consultation period was concluded in February 2016[4].

One of the aims of the European Commission's 2020 Climate and Energy Package is to reach a 20% share of renewable energy generation in EU energy consumption by 2020 in a cost-effective and economically efficient manner. The Renewable Energy Directive adopted in 2009 sets binding targets

[2] European Council, October 2014

[3] As highlighted in the baseline scenario of the 2030 climate and energy framework (COM(2014) 15 final)

[4] https://ec.europa.eu/energy/en/consultations/preparation-new-renewable-energy-directive-period-after-2020

for renewable energy. Individual Member States have targets set in EU legislation[5] and some have set additional objectives nationally.

All EU countries have adopted national renewable energy action plans showing what actions they intend to take to meet their renewables targets. These plans include sectorial targets for electricity, heating and cooling, and transport; planned policy measures; the different mix of renewables technologies they expect to employ; and the planned use of cooperation mechanisms. Member states are free to select and implement mechanisms that are best suited to their national situation. Such mechanisms and instruments include investment grants, net-metering, feed-in tariffs, feed-in premiums, green certificates and auctions.

Every two years, EU countries report on their progress towards the EU's 2020 renewable energy goals. Based on the national reports, the European Commission produces an EU-wide report which gives an overview of renewable energy policy developments in EU countries. Based on the findings from the latest EU-wide report in 2015[6], in 2014, the projected share of renewable energy in the gross final energy consumption is 15.3%. The majority of the Member States are well on track to meeting the renewable energy targets laid down in the Renewable Energy Directive. For the EU as a whole, there are good prospects that the 2020 target will be reached.

With respect to the above, the EU has a significant and long standing experience in RES, technologies, policies and practices for enabling the technical, institutional and regulatory environment towards greater deployment of RES, which can be of significant value to the GCC countries. Apart from this policy-based know-how, the EU also possesses a wide range of experiences on technologies including:

- Wind energy, including constructing and maintenance of on and off shore parks,
- solar energy, including photovoltaic and concentrated solar power,
- geothermal energy sourcesand
- waste management and waste to energy technology.

<u>In the GCC:</u>

All countries now have clean energy project plans or targets in place and there are several conservation initiatives that include RES targets in almost all GCC countries. The main drivers are the increasing demand for energy, the desire to diversify the energy mix and reduce the impact on the climate. In this context, new technologies including for RES are also seen as solutions to increase competitiveness, as well as create employment opportunities in the region. RES manufacturing could help transforming the GCC economies, while ensuring their future sustainability.

The Dubai Integrated Energy Strategy 2030 aims to have a 15% share of renewable energy capacity in Dubai's energy mix by 2030. Abu Dhabi has published a capacity target of 7% renewable energy by 2020, which is equivalent to 1,500MW of solar energy, wind energy and waste to energy. Lastly, there is the contribution of nuclear power. Abu Dhabi's Masdar built the 100 MW Shams I concentrated solar power plant near Madinet Zayed, in the Emirate's Western Region, which was inaugurated in 2013. Recent bids for ADWEA's planned 350MW solar PV project in Sweihan (Abu

[5] DIRECTIVE 2009/28/EC

[6] COM (2015) 293 final, Brussels, 15.6.2015

Dhabi) showed world record low prices of 2.5$ct/kWh, putting the UAE at the forefront of global solar efforts in terms of pricing.

Dubai Electricity and Water Authority (DEWA), has signed a Power Purchase Agreement (PPA) and a Shareholder Agreement for the second phase of the Mohammed bin Rashid Al Maktoum Solar Park with ACWA Power to construct a 200MW photovoltaic power plant, while another 800MW plant is underway. It is worth noting that the Mohammed bin Rashid Al Maktoum Solar Park is the largest single-site strategic renewable energy project of its kind in the world, based on the IPP model. The first phase of 13MW has been operational since 2013. The 200MW second phase of the Solar Park will be operational by 2017, and the 800MW third phase is planned to be operational by 2020. Recently opened bids offered levelised costs of electricity (LCOE) at just under 3 $ct/kWh, which is substantially below the cost of electricity produced by gas, coal or nuclear.

In light of the UAE's ratification of the Paris Agreement, the Ministry of Climate Change and Environment announced a target to obtain 27% of its energy from nuclear and renewable energy by 2021, a rise from a commitment of 24% made prior to the agreement. GCC countries have established some type of policy support scheme to reach the established RES objectives (Table 1) and promote RES power generation. The KSA is discussing a proposed Feed in Tariff (FIT) for small-scale projects that would include a number of renewable technologies, as an important mechanism to meet the country's new targets, while the Emirate of Dubai has introduced a net metering scheme for roof-top PV. The UAE has so far adopted RES auctions in the region, followed by Kuwait, Saudi Arabia and Qatar, while Oman, which is planning to develop seven small scale solar and wind projects for rural areas, is considering auctions to attract developers for these projects[7].

Table 1: RES Policy Support Scheme in the GCC

Country	Renewable Energy Targets	Renewable Energy Strategy or Plan	Regulatory Policies			Fiscal Incentives			Public Financing	
			Feed-In-Tariffs/ Net metering	Electric Utility Quota Obligations	Heat obligation/ mandate	Capital subsidy, grant, or rebate	Investment/production tax credits	Energy production payment	Public investment, loans, or grants (incl. R&D)	Public competitive bidding
Bahrain	√	D	D							
Kuwait	√								√	√
Oman	√	D	Solar rooftop			√	√	√	√	√
Qatar	√								√	
KSA	√	D	D						√	√
UAE	√	√	Net Metering in Dubai	√	√	√		√	√	√

D: Under Discussion

[7] IRENA, 2016. "Renewable Energy Market Analysis: The GCC Region". IRENA, Abu Dhabi.

Source: Ferroukhi et al., 2013[8]; REN21, IRENA and UAE MoFA, 2013, Bahrain News Agency, 2016, Saudi-US Relation Service, 2015

The King Abdullah City for Atomic and Renewable Energy (KACARE) in the KSA, the governmental department so far responsible for the clean energy programme, published its vision for a long-term energy mix that relied on large contributions from solar and nuclear energy. By 2032, Saudi Arabia plans to add 41 GW of solar power, and 13 GW[9] from other renewable sources (geothermal, waste and wind) to expand electricity supply which would make Saudi Arabia one of the world's main producers of renewable electricity.

In the same direction, in 2013 K.A.CARE published a draft Renewable Energy Competitive Procurement paper (White Paper), which outlines the institutional structure for the promotion of RES in line with the national RES strategy. However, in 2014 Saudi Arabia delayed its target to complete this clean energy program by eight years. More recently as part of a wide-ranging economic and social policy vision for the Kingdom of Saudi Arabia, deputy crown prince Mohammed bin Salman, on April 25th, 2016 announced the first cornerstones for the deployment of renewable energy in the country.

The "Saudi Arabia Vision 2030" paper states an "initial" target of 9.5 gigawatts (GW) of renewable energy. The program will be implemented under the umbrella of a new "King Salman Renewable Energy Initiative". Legal and regulatory frameworks and the involvement of the private sector are expected to be set up to scale up the deployment of renewable energy. The paper also hints at encouraging distributed renewable energy deployment encouraged through "the gradual liberalization of the fuels market". A first step into this direction has already been taken with the steep increase in electricity tariffs at the beginning of 2016.

Overall the renewable energy targets in the GCC countries are constantly increasing and there is, hence, a growing interest in local production of renewable energy components and systems. The European renewable energy industry could definitely act as a valuable partner in such efforts.

While targets and national strategies constitute an important first step in national renewable energy planning, these elements need to be supported by an appropriate legal framework (such as a renewable energy law) in order to be effective. Without such framework, governments will find it difficult to translate their long-term visions into concrete, actionable plans.

In order to overcome existing barriers hindering their wider deployment, there is room for the establishment or the redesign of policies and regulations, a detailed resource assessment, awareness raising efforts, standards development and adequate technology adaptation. Several GCC countries have carried out a multi-annual detailed assessment of the renewable energy resources on their territory, most notably solar and wind. Furthermore, the harsh climate (high temperatures and humidity, dust and sand storms) may necessitate long term outdoor testing of equipment such as solar panels.

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8 Ferroukhi, R., Ghazal-Aswad, N., Androulaki, S., Hawila, D, Mezher, T. (2013), "Renewable energy in the GCC: Status and challenges", International Journal of Energy Sector Management, Vol. 7, Issue 1, pp. 84 - 112 *(paper development facilitated by the EU-GCC Clean Energy Network).*

9 https://www.kacare.gov.sa/K.A.CARE-Proposed-Competitive-Procurement-Process-for-the-Renewable-Energy-Program-2013.pdf

Some GCC countries have quality control systems for renewable energy technologies, involving testing and standards and related institutions, in place. There is generally great potential for testing and R&D activities.

SOLAR POTENTIAL ASSESSMENT[10]

Solar radiation and wind potential are variable in time and space, dependent on multiple factors, and due to these reasons they are difficult to predict.

In order to obtain relatively reliable information about wind and solar parameters, many years of observations are needed at specific spots, with good renewable energy resources. The existing methods of measuring solar and wind potential are basically using meteorological stations measurements, geographical and satellites observations, airplane observations and probes.

The data is gathered and compiled to develop solar and wind maps, estimate the market potential and determine projects' initial feasibility. Although these data have a certain level of reliability, they should be used tentatively and specific measurement campaigns in the project selected site should be undertaken to correlate the available data.

In the case of UAE, the Research Center for Renewable Energy Mapping and Assessment (ReCREMA) - Masdar Institute, in response to UAE's renewable energy drive, has developed a solar mapping tool to meet the country's prospecting and resource assessment needs.

The developed tool utilises a robust satellite-based model to map the solar potential across the country. Most of the existing models, developed elsewhere, typically overestimate solar irradiance in this region. The bias is primarily due to the models' inability to adequately account for the attenuation and scattering of solar irradiance by predominantly airborne dust.

The UAE solar mapping tool was specifically developed considering the local conditions and upon validation is revealed to be reasonably accurate for UAE climate and has the potential to be reliably used for similar arid environments.

The model produces direct normal irradiance (DNI), diffuse horizontal irradiance (DHI) and global horizontal irradiance (GHI) maps at a 3 km spatial resolution and in a near real-time manner, i.e., updated each 15 min. While DNI is used as a key input in all Concentrated Solar Power (CSP) applications, the latter two components are of immediate interest in PV simulations. Hourly, daily, monthly and yearly irradiation values for all three components can also be derived. One of the primary objectives of the solar atlas project is to bridge the gap between restricted number of existing ground measurement sites and regional demand for rapid solar technology deployment by providing reliable and readily available solar irradiance data.

The UAE Solar Atlas is accessible here: http://atlas.masdar.ac.ae

Furthermore, there is great interest and potential for capacity building towards enhancing technical knowledge in the region and strengthening industrial chains.

[10] M.Taoumi and all, Renewables Readiness Assessment, Sultanate of Oman, IRENA, 2014

A number of applications hold great promise for the cost-effective introduction of renewable energy And due to the ever growing population there are many opportunities in the cities and city areas for district cooling (in combination with e.g. geothermal heat sources) and for energy storage technologies. Lastly, the combination of desalination and renewable energies could greatly reduce the CO_2 footprint of water in the GCC, most of which comes from thermal desalination facilities powered by fossil fuels.

Table 2: Potential areas of Cooperation in RES

Status Highlights	Cooperation Areas of common Interest
Renewable Energy Sources	
RES can play an important role in addressing environmental, geopolitical and economic as well climate change issues in the GCC region. High potential for solar thermal and photovoltaic electricity generation in the GCC region. Wind and Geothermal as underutilised RE sources	• Institutional/regulatory environment for the greater deployment of RES. • Technology adaptation to GCC climate conditions (high moisture, dust, sand storms, high temperatures).RE resource assessment (solar, wind and geothermal), zoning and planning. • Quality control related to standards, testing and certification: development or harmonization of specific standards. • Distributed PV systems (i.e. PV Rooftop systems); policies, regulations and best practices. • Cooling applications; district cooling based on available renewable energy resources. • Energy Storage (Thermal and Electrical). • Expanding RES integration linked to water desalination; Reverse Osmosis. • Energy services companies using solar rooftop and energy storage systems. • Assessment of local manufacturing potential of renewable energy components and systems.

4.2. Energy Efficiency and Demand Side Management

In the EU:

The EU has adopted a series of targets to cope with climate change and secure the supply of energy, quantified as the 20-20-20 target set, with 20% improvement of energy efficiency by 2020 (EC 2008). Indeed, energy efficiency is at the heart of the EU's Europe 2020 Strategy and beyond.

The legal framework of the EU energy efficiency policy is based on the Energy Efficiency Directive – EED (2012/27/EU), the Ecodesign Directive - EDD (2009/125/EC), the Energy Performance of Buildings Directive – EPBD (2010/31/EU) and the Energy Labelling Directive - ELD (2010/30/EU). Moreover, in February 2016, the Commission proposed an EU heating and cooling strategy[11]. This strategy targets the reduction of the energy consumed by heating and cooling in buildings and industry.

To reach the EU's 20% energy efficiency target by 2020, individual EU countries have set their own indicative national energy efficiency targets. Depending on country preferences, these targets can be based on primary or final energy consumption, primary or final energy savings, or energy intensity12.

Especially as concerns the EED[13], it requires all new buildings to be nearly zero-energy by the end of 2020 and all new public buildings by 2018. Moreover, EU countries have to draw up national plans to increase the number of nearly zero-energy buildings, while the EC progress report from 2013 found

[11] https://ec.europa.eu/energy/en/topics/energy-efficiency/heating-and-cooling

[12] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive

[13] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency

that EU countries had to significantly step up their efforts to take advantage of the opportunities presented by nearly zero-energy buildings. The EED among others requires each member state to apply an energy efficiency obligation scheme (EEOs) or alternative policy measures that would deliver a certain amount of end-use energy savings over the 2014-2020 obligation period.

Moreover, the EU is designing and implementing training activities for the European workforce involved in the buildings, including engineers, architects and technicians, such as the BUILDUP Skills initiative[14].

The Energy Efficiency Plan[15], issued in 2011, proposed several directions for a transition towards a more efficient economy regarding the use of energy resources, covering targets, public sector measures, buildings, energy supply obligations, cogeneration and industry. The Plan also covered financing issues, promoting smart meters and smart grids, expanding the National Energy Efficiency Action Plans to cover the entire energy chain and not just energy demand.

The most recent policy document on energy efficiency was published in July 2014[16]. It was a Commission Communication on Energy Efficiency and its contribution to energy security strategy[17] and the 2030 Framework for climate and energy policy[18] calling for a 27% or greater energy efficiency target by 2030. Energy efficiency policy is also guided by an indicative target for 20% energy savings by 2020 and many policy reports and directives related to energy efficiency.

It should be noted that, taking into account that the EED is based on a 2020 timeframe and the EU has to respond to the Council and the European Parliament's call for a 2030 energy efficiency target, a revision of the EED is foreseen for October 2016 by the EC and this will be also the case for the EPBD afterwards.

In the field of Energy Efficient products, the EU has set regulations for Eco-Design and Eco-labelling of products. According to estimates of the EC[19], the effect of these regulations will bring 175 Mtoe primary energy savings per year by 2020 € and 102 billion net saving on consumer expenditure, equivalent to € 465 per household per year.

Under the EU's Ecodesign Directive manufacturers are required to lower the energy consumption of their products by setting minimum energy efficiency standards. Alternatively, in some sectors voluntary agreements may apply following formal recognition by the EC.

On the other hand the labelling requirements for numerous product groups are created under the EU's Energy Labelling Directive. The EU uses an alphabetical energy label scale from A+++ to D. Today, due to the great improvement in energy efficiency, the bottom classes of the scale are empty. As consumer studies show, the single A to G label would help consumers identify the most efficient products of today more easily. On 15 July 2015 the Commission proposed a review of the labeling scale accordingly. The Commission also proposed the creation of a new energy efficient product digital database to boost transparency and improve compliance with the rules.

[14] http://www.buildupskills.eu/

[15] COM(2011) 109 final

[16] COM(2014) 520 final

[17] https://ec.europa.eu/energy/en/topics/energy-strategy/energy-security-strategy

[18] COM(2014) 15 final

[19] https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficient-products

Demand Side Management (DSM) in electricity markets could improve energy efficiency and achieve environmental targets through controlled consumption. DSM would enable consumers to optimize consumption, while giving network operators greater flexibility in the management of the system. European agencies and companies have already studied and implemented DSM for many years and have achieved significant results, in particular through energy management, public and cooperative technology procurement, energy efficient buildings, energy efficient household appliances and other end-use equipment, smart energy metering, third party financing (among other things through the ESCO or Energy Services Company model), guarantee of results and other innovative financing schemes.

In the GCC:

Energy efficiency activities and policies are also gradually gaining traction in the region. The Dubai Integrated Energy Strategy 2030 (DIES) aims to reduce electricity demand by 30% compared to business as usual through the promotion of green buildings, building retrofitting, district cooling and other energy efficiency policies. Furthermore, as part of the Dubai Smart City program and DIES, Dubai's DEWA is introducing policies and measures that include the following[20]:

- The Distributed Renewable Resources Programme, containing the regulatory framework related to licensing, finance and technical standards.
- The introduction of smart meters, enabling demand side management.
- The introduction and promotion of the ESCO model.

In 2010, Abu Dhabi's Urban Planning Council (UPC) introduced the Estidama[21] rating system, requiring communities, buildings and villas to comply with energy performance standards. Under the leadership of Abu Dhabi's Executive Affairs Authority, a task force was set up to devise a Comprehensive Cooling Plan, tackling the energy consumption of Abu Dhabi's 200,000 buildings. Dubai's government has been working on a similar initiative as part of the DIES. Both Abu Dhabi and Dubai have recently introduced appliance standards covering AC units and light bulbs. Also, Dubai and Abu Dhabi have recently reduced energy subsidies, leading to higher prices for water and electricity, and similar announcements have been made in the KSA, Oman and Bahrain. The UAE furthermore initiated regulation on appliance efficiency standards; the UAE introduced the region's first efficiency standards for air-conditioning units, eliminating the lowest performing 20% of the units from the market, and is introducing efficiency standards for refrigeration and other appliances[22].

Kuwait's initiatives have mainly focused on the building sector, with a code of practice for energy conservation in buildings being developed and adopted. Moreover, Kuwait was the first country in the GCC to implement energy-conservation measures in air-conditioned buildings.

Saudi Arabia has implemented measures to conserve energy and to reduce peak load demand, while the Saudi Arabian Standards Organization has adopted several standards aiming to limit the

[20] Wouters F., 2015. Energy Cooperation between the United Arab Emirates and the Kingdom of the Netherlands under the Memorandum of Understanding (2013).

[21] http://estidama.upc.gov.ae/

[22] UNFCCC, UAE INDCs

penetration of inefficient electrical appliances into the KSA market. In this context, the Saudi Energy Efficiency Centre (SEEC) was established in 2010 and, since then, SEEC has been responsible for the demand-side energy efficiency effort in the KSA, with the mission to improve domestic energy consumption efficiency, and coordinate all related activities between governmental and non-governmental stakeholders. In 2012, SEEC launched the Saudi Energy Efficiency Program (SEEP) with the objectives of improving the KSA's energy efficiency by designing and implementing initiatives and their enablers. SEEP focuses on industry, buildings and transportation and has a total of 82 sub-programs as of September 2016. In the transportation sector a successful program was launched, consisting among other things of fuel efficiency labels and fuel economy standards for all incoming light duty vehicles. In the buildings sector the program focuses on standards for thermal insulation and various appliances such as air conditioners and lighting systems, with many other appliances under consideration. Green buildings and sustainable development are also a priority for Qatar. The related initiatives realised in the country include the National Vision 2030 on sustainable development, as well as the establishment of the Qatar Green Building Council (QGBC)[23].

In Oman, the first DSM study was conducted by JICA, the Japan International Cooperation Agency, which identified several strategies for potential load management and shifting load from peak time to off-peak time in the industrial and commercial sectors[24].

Bahrain promotes energy efficiency activities and programs, such as the Kingdom of Bahrain Energy Efficiency Programme (KEEP), which promotes energy efficiency by 2030 in the public, residential, commercial buildings and the industrial sector. Moreover, it has adopted the Motor Vehicles Standards and technical regulations to reduce energy consumption and emissions from gasoline and diesel engine vehicles, and it also supports the Energy Efficient Lighting Initiative[25].

Given the growth of the population and corresponding expanding cities, there are ample opportunities for smart energy city approaches, combining energy efficiency, DSM and renewable energy technologies, all linked with modern information and communication technology. The fact that electricity markets are not yet fully liberalised, makes the introduction of such smart energy cities somewhat less complicated.

Many industrial complexes, most notably in the oil and gas sector, have great potential for efficiency improvements, but could also serve as sources of waste heat, that could be used for local or district cooling.

The potential for collaboration between Europe and GCC cities related to the exchange of information and best practices on energy efficiency policies and measures could lead to initiatives that are beneficial for both sides.[26, 27, 28]. The table below provides a non-exhaustive overview of such options, and also suggests some sectoral and technology options that could be useful.

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[23] Papadopoulou A.G., Hosany N.A., Karakosta C., Psarras J., 2013. Building Synergies between EU and GCC on Energy Efficiency, International Journal of Energy Sector Management, 7(1): 6-28. *(paper development facilitated by the EU-GCC Clean Energy Network).*

[24] Al-Badi A.H., Malik A., Gastli A., 2011. Sustainable energy usage in Oman-opportunities and barriers. Renewable and Sustainable Energy Reviews, 15(8): 3780-3788. *(authors include also members of the EU-GCC Clean Energy Network).*

[25] UNFCCC, Bahrain INDCs.

[26] KPMG (2015). Dubai – a new paradigm for smart cities.

[27] Monitor Deloitte, 2015. "Smart cities…Not just the sum of its parts".

Table 3: Potential Cooperation Areas in Energy Efficiency and DSM

Status Highlights	Potential Cooperation Areas
Energy Efficiency and Demand Side Management	
High potential for energy efficiency in both the built environment and the industrial sector. The GCC regions are actively involved in the pilot/demonstration or large scale implementation of emerging technological opportunities, such as smart energy meters. Low energy prices that don't give incentives for the consumers to save energy. Political will to introduce changes in the energy market and practices. Many options to increase industrial energy efficiency in the production and treatment of natural resources.	• Building retrofitting and building codes. • Passive building design, reduction of cooling and heating requirement by initial design, thermal mass, orientation, passive cooling techniques etc. • Use of "cool" materials in buildings, Building Energy Management Systems (BEMS), efficient lighting options. • Industrial heat management, including upgrading waste heat. • District cooling and options for coolth storage. • Advanced industrial processes to increase resource and energy efficiency. • Water desalination to improve energy efficiency. • Upgrading industrial auxiliary streams. • Labels and standards: AC, highly efficient appliances, building envelope materials, lighting. • Market based mechanisms to promote energy efficiency. • Smart grids, shifting peak cooling loads in metropolitan areas. • Energy services companies (ESCOs) using advanced, viable and affordable processes/ technologies to increase energy efficiency. • Establishment of institutional, legislative and governance frameworks enabling environment for clean energy investments and implementing innovative and flexible funding mechanisms.

Based on additional consultation and bilateral discussions with EU and GCC stakeholders during the Inception Meeting of the EU GCC Clean Energy Network (CENII phase) held in Brussels on 20 September 2016, some of the above areas were highlighted as a priority. Indicatively, these are district cooling, work on labels and standards, advanced industrial processes to increase resource and energy efficiency, water desalination and work related to energy services companies (ESCO's). These topics could be the basis for the respective Network's working group activities in the near future.

4.3. Clean Natural Gas and Related Technologies

In the EU:

Gas represents an important element of the EU energy mix covering approximately a quarter of the energy needs. The EU has taken significant steps towards reaching its energy and climate objectives for 2020 and integrating the fragmented electricity and natural gas markets into a single energy market[29].

[28] Tok E., McSparren J.J., Merekhi M.A., Elghaish H. and Ali F.M., 2015. Crafting Smart Cities in the Gulf Region: A Comparison of Masdar and Lusail. IGI Global.

[29] IEA-International Energy Agency, 2014. Energy Policies of IEA Countries - European Union – 2014 Review, OECD/IEA, France, available at: https://www.iea.org/Textbase/npsum/EU2014SUM.pdf

With indigenous natural gas production in the EU Member States dropping (around 40% decrease over the last 10 years, and a further 65% decrease expected until 2030[30]), reliance on gas imports is expected to grow, reaching 80% in 2030, from 69% in 2015 and 57% in 2005[30]. The EU is therefore seeking to diversify its gas supply sources and routes, and reduce its dependence in particular of Russian gas, the main external supplier. To this end, several gas infrastructure projects have been completed and are being developed in the EU, including a number of new LNG terminals and interconnections that allow gas flows from these terminals to the EU-wide gas system, thus facilitating access of Member States to global sources of LNG.

From a policy point of view, the 2010 Gas Security Directive[31] aimed to improve security of supply in the natural gas sector. Almost six years after the adoption of this Regulation, the security of the gas supply remains a major objective of the Energy Union and a highly topical issue. In February 2016, the Commission proposed an update[32] to its Security of Gas Supply Regulation. With this new Regulation the EU aims to improve regional coordination, to introduce and apply a new solidarity principle among Member states in cases of emergency and to introduce additional transparency measures in gas supply contracts in order to improve risk assessment and prevention.

Meanwhile, the Commission has also released a strategy for Liquefied Natural Gas (LNG) as well as gas storage in the EU. The EU wishes to benefit from the fast growing production of gas in various areas of the world (Australia, USA etc) in order to further enhance its security of supply.

Although reluctantly in many countries, Europe is also studying the feasibility of exploring shale gas. In January 2014, the Commission issued a recommendation aimed at ensuring that those EU countries undertaking fracking implement proper safety and environmental safeguards to improve transparency for citizens, establish a clearer framework for investors and a level playing field regarding the industry's regulation[33]. In the current phase, Member States inform the Commission about the measures they put in place in response to this Recommendation. Other relevant developments include a Eurobarometer survey[34] on attitudes of citizens towards shale gas and a European Science and Technology Network on unconventional hydrocarbon extraction[35], launched on July 2014. Still, even if concerns for shale gas production are eliminated, current forecasts of EU gas supply expect that unconventional gas production will be limited[36], and mostly directed to covering national demand of the producing countries.

In this framework, Qatar, currently the main LNG supplier of the EU, and the other GGC gas producing and exporting countries have an opportunity to increase their share in the supply mix of

[30] European Commission, EU Reference Scenario 2016, available at: https://ec.europa.eu/energy/en/data-analysis/energy-modelling

[31] Regulation (EU) No 994/2010

[32] https://ec.europa.eu/energy/en/news/new-rules-boost-gas-supply-security-and-solidarity

[33] EC - European Commission, 2014. Recommendation on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing, 2014/70/EU, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV:1801_4

[34] Eurobarometer survey

[35] European Science and Technology Network on unconventional hydrocarbon extraction

[36] ENTSOG, Ten Year Development Plan 2015, available at: http://www.entsog.eu/public/uploads/files/publications/TYNDP/2015/entsog_TYNDP2015_main_report_lowres.pdf

the EU markets. This would allow gas sales to a significantly interconnected region, with access to a population of over 500 million people and over 118 million gas consumers[37].

New developments are emerging in the EU with the increasing use of CNG and LNG in transport, and the development of 'virtual pipelines' to supply off grid customers with CNG and LNG. European countries such as Italy and Spain are leading such efforts, and such expertise and technology could also find useful applications in GCC countries[38].

Within the EU, extensive experience is available at natural gas sweetening and purification as well as at the production of substitute natural gas. Especially the first topic may be of interest to the GCC countries, due to large volumes of sour gas in the region. A broad combination of knowledge on proven technologies is available that can be applied today for existing economically viable wells, as well as on breakthrough technologies for future fields, which can currently not be operated in a profitable fashion. Examples of these breakthrough processes include membrane and solid sorbent based separation processes. Substitutes for natural gas are often based on biomass and on hydrogen that has been produced in a renewable way (power-to-gas).. With the GCC presently exhibiting the lowest cost of solar power in the world, producing hydrogen using renewable energy could be an interesting option for the future.

Europe has been leading the global development of concentrated solar power, a technology that can be used to hybridize fossil fuel power plants. Gas is furthermore considered as the main back-up fuel for renewables, ensuring a stable and dispatchable supply of energy.

In the GCC:

The six countries are among the world leading oil and NG producing and exporting countries. Fundamental changes in the global gas market have created a significant global supply overhang and provide GCC countries with a unique opportunity to address their gas shortage in the short term. At the same time, the European experience in its pursuit of a single, transparent and competitive gas market, combined with a drive to diversify sources and suppliers of natural gas, may be of interest to the GCC countries.

Natural gas related policy measures differ, depending on the supply/demand situation of a particular country in the GCC region. Moreover, there is an opportunity for national oil companies, regulators, and utilities in the region to develop an integrated, GCC-wide approach.

The following table highlights key issues concerning natural gas in the GCC countries.

Table 4: GCC National Context for Collaboration

Country	Key Issues
Bahrain	- Newly formed Natural Oil and Gas Authority aiming to restructure the country's offshore. - Current growing demand for electric power forces Bahrain to become a net NG importer in the coming years. - Difficulty for large scale investment projects due to fiscal constraints.
Kuwait	- A number of collaborative agreements with other countries from the region and

[37] Eurogas, Activity Report 2015-2016, available at: http://www.eurogas.org/uploads/2016/eurogas_flipbook_AR_2015/index.html#p=14

[38] ACER, Gas Target Model Review and Update, available at: http://www.acer.europa.eu/events/presentation-of-acer-gas-target-model-/documents/european%20gas%20target%20model%20review%20and%20update.pdf

	internationally (e.g. with Esso, GE and Pertamina).
Oman	- The government is following an aggressive exploration campaign for NG leading to a recent significant increase in reserves. - The government enlists foreign companies in new exploration and production projects, requiring the sophisticated technology and expertise of the private sector.
Qatar	- In the field of NG, the country follows an aggressive exploration tactic. - Important cooperation agreements have already taken place with EU countries. - Moratorium imposed on new gas development projects in the North Field (decision on lifting the moratorium would likely be made in 2016-17) constrains production capability.
Saudi Arabia	- The government is investing heavily in research to improve production in order to meet soaring demand. - Extended existing gas transmission system with planned additional large NG gas pipeline capacity to meet domestic demand. - Pricing regime for Natural Gas, which are not cost-reflective.
UAE	- 95% of the fossil fuel reserves in the UAE are inside the emirate of Abu Dhabi. - Most important domestic issues are mainly dealt with on an emirate level. - Although ADNOC is committed to reducing the flaring of natural gas, more can be done, e.g. by joining the Global Gas Flaring Reduction Partnership of the World Bank. The country is facing shortage problems which is mainly due to slow growth in gas infrastructure and increasing demand for gas. - Abu Dhabi has started the production of sour gas, requiring the removal of large amounts of sulphur with a net output around 500 MMBTU/day - Any gas that is produced is prioritized for re-injection to maximize oil production →associated gas production growth is limited by legislation such as the OPEC quotas on oil production. - Due to the heavy subsidization of domestic energy prices within the region, upstream gas players have received around US$2-2.5/mmbtu → currently insufficient to stimulate exploration and development of more challenging gas reserves, given the associated costs and rate of return on investment that investors would receive.

Source: Doukas et al., 2013[39], Fuel gauge report, 2016, Gulf Times, 2014,

Table 5: Potential areas of Cooperation in Clean Natural Gas

Status Highlights	Cooperation Areas of High Interest
Clean Natural Gas and Related Technologies	
Many aspects of clean natural gas technologies have been the subject of close cooperation between Gulf entities and specialized companies. The whole value chain is important, i.e. natural gas production, processing, transportation and end use.	• Norms and standards: o Advanced processes to remove and treat contaminants from natural gas fields. • Transport sector: o Compressed natural gas (CNG) o Liquefied natural gas (LNG) o Gas-to-Liquids (GTL) o Production of oxygenated fuel additives, etc. • Power sector: o Ways to further improve the efficiency of gas turbines. • Hybrid solar- gas combined cycle and gas combined cycle. • Unconventional natural gas in GCC countries. • Management of national and regional gas networks. Learning from the EU experience.

[39] Doukas H., Flamos A., Marinakis V., Assadi M., 2013. EU-GCC cooperation for natural gas: prospects and challenges. International Journal of Energy Sector Management, 7(2): 194 - 222. *(paper development facilitated by the EU-GCC Clean Energy Network)*

	• Novel technologies to enable profitable operation of natural gas fields that are not within reach. Consideration of high energy utilisation costs due to the required purification process.

4.4. Electricity interconnections & market integration

In the EU:

The European Council of October 2014 called for all Member States to achieve interconnection of at least 10% of their installed electricity production capacity by 2020. This means that each Member State should have in place electricity connections that allow at least 10% of the electricity that is produced by their power plants to be transported across its borders to its neighbouring countries[40]. The necessary measures to achieve this 10% target are set out in the Commission Communication presented with the Energy Union Strategic Framework[41].

As underlined by the European Council, the interconnection target should mainly be reached through implementation of the Projects of Common Interest (PCI). The EC has today adopted a list of 195 key energy infrastructure projects, which will help deliver Europe's energy and climate objectives and form key building blocks of the EU's Energy Union. The list is updated every two years to integrate newly needed projects and remove obsolete ones. The first list of PCIs was published in 2013 while the second was approved at the end of 2015[42], and it consists of 108 electricity, 77 gas, 7 oil and 3 smart grids projects. A good balance between electricity and gas projects was achieved also thanks to the identification of clear priority projects in the regional context. Interconnections between Member States and neighbouring countries are also foreseen through the EU RES Directive[43], since a prerequisite for the implementation of Joint projects between Member States and third countries is that the electricity should be exported to the EU.

Increase the Resilience, Security and Smartness of the Energy System

The core objectives of the EU Energy Union Framework Strategy[44] are to develop a long-term, secure, sustainable and competitive energy system in the EU.

With the next generation of smart energy-system solutions, the EU needs to develop and demonstrate innovative power electronics, flexible thermal generation, demand response and storage, as well as efficient heating and cooling technologies (such as heat pumps and combined heat

[40] EC - European Commission, 2015. Connecting power markets to deliver security of supply, market integration and the large-scale uptake of renewables", Factsheet: MEMO/15/4486, Brussels, available at: http://europa.eu/rapid/press-release_MEMO-15-4486_en.htm

[41] COM(2015) 80 final

[42] EC - European Commission, 2016. Commission Delegated Regulation (EU) 2016/89 of 18 November 2015, amending Regulation (EU) No 347/2013 of the European Parliament and of the Council as regards the Union list of projects of common interest, C(2015) 8052 final, Brussels, available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:JOL_2016_019_R_0001&from=EN.

[43] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009.

[44] Commission Communication: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy (COM/2015/080 final) of 25 February 2015.

and power) to use synergies between energy vectors, new transmission technologies, new techniques for physical and cyber security of networks, and demand analysis including exploitation of Big Data[45].

Connecting the different networks in an integrated energy system, will be particularly important for ensuring the stability and security of the electricity system, as well as the protection and privacy of consumer data. This requires the development of new methodologies for optimisation across networks and for protocols of data exchange, including testing and demonstration. This will require a collaborative effort between the Commission and Member States, as well as the energy, transport, and information and communication technology sectors and regulators.

In the GCC:

Electricity remains to a large extent national business in the GCC. However, in 2011, the GCC countries have moved a step closer towards linking their electricity sectors with the formal completion of a regional GCC grid interconnection system (GCCIA - Gulf Cooperation Council Interconnection Authority). With a total installed size of two times 1,200MW on average, the interconnector currently maintains a relatively small capacity, primarily as a result of the grid's design reaching back to the 1990s when demand volumes differed significantly from today's consumption patterns and demand growth across the GCC. For current purposes the capacity appears to be sufficient, as the grid's primary function to date is to act as an emergency backup system that allows flexible ad hoc transfers of electricity between GCC members at time of need[46]. However, it is proposed to construct a 400 kV double circuit corridor to increase the sustainability of the import/export of electricity between GCC countries.

The GCC countries, while actively participating in the GCC Interconnection project, have been equally active on the national level; each GCC country has its own strategy when it comes to national interconnection, organisational model, private sector's involvement and the pace of evolution[47].

GCCIA is progressing a feasibility study to assess the option of the interconnector expansion options within GCCIA and other countries outside the GCC, with the aim to enhance supply reliability and security in the GCC countries in sharing their generation spinning reserve, reduce maintenance cost and defer investment in new added generation capacities.

While the GCC region has strengths and attractive conditions to achieve a high rate of integration and a wide deployment of renewable energy, the adoption of a regional approach and strategy is essential to support and coordinate the efforts of the six countries in achieving their stated objectives. Indeed, the existing electricity interconnections between the GCC countries currently built for back-up support in spinning reserve and limited load transfer, could be used for larger trades between countries and expanded to link it to the other Arab countries and later on to the Mediterranean networks through the existing frameworks, e.g. MEDRING, MED REG and the

[45] COMMUNICATION FROM THE COMMISSION, Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation, Brussels, 15.9.2015; C(2015) 6317 final.

[46] Laura El-Katiri, Interlinking the Arab Gulf: Opportunities and Challenges of GCC Electricity Market Cooperation, Oxford Institute for Energy Studies, July 2011

[47] EU-GCC Clean Energy Network, 2011. Background Paper on Electricity Interconnections and Market Integration. Report of the EU-GCC Clean Energy Network.

European Network of Transmission System Operators for electricity (ENTSO-E). It should also promote economies of scale and reduced production costs.

In addition, as the national markets are being developed, a regional strategy is necessary to avoid imbalances between countries and distortion of energy markets. However, regional energy integration requires a clearly articulated common policy that promotes the harmonisation of policies, regulatory frameworks, norms/standards and procedures and the establishment of fair trading conditions, addressing both private and public interests and rallying more funds for investment.

A larger-scale application of the grid, by extending its capacity and creating a wholesale market similar to those of several European neighbourhood systems and Latin America, is technically possible, though competitive markets for electricity and price controls in each of the GCC countries are essential. There are also technical caveats to consider: The KSA operates on a different frequency than the rest of the GCC, requiring a separate back-to-back HVDC interconnector.

The physical infrastructure is not the only work progressing. The GCC Interconnection Authority (GCCIA) is gradually putting together the regulatory framework that will facilitate region-wide electricity trading. Key to this is the formation of an Advisory and Regulatory Committee consisting of two representatives from each member state. The GCCIA, through the Regulatory & Advisory Committee in which all States are represented, will act as the regulator who set-up the rules and monitors the market of electricity through the network once two states negotiate a deal. Member states have to ensure they manage their networks so that trading can happen. The Regulatory Committee has convened for the first time in April 2014 and started working on a trading agreement framework. GCCIA has an ambitious plan within GCCIA to go for effective power trading between GCC member states.

The Regulatory Committee will have to regulate the use of the Interconnection and the behaviour of the players during steady state and commercial trading times. The Regulatory Committee must ensure that the GCC Interconnection is available for all countries for immediate response and mutual support. Besides its regulatory role, this Committee has an advisory role on improvement of the 'system' and strategic directions to be endorsed appropriately for further development. Pricing is an inevitable part of the set up and the GCCIA is also working, with the Member States, on a tariff study.

GCCIA would require more resources to perform the following task: Work with GCC countries to make sure they exert full determination in transferring RES plans into a time-stage projects. The implementation shall consider high quality and efficient RES adapting to the GCC climatic conditions (heat, humidity, dust, storms).The long term benefits of such implementation will overlay the invested CAPEX considering the NPV over 25 years.

Table 7: Potential areas of cooperation in Electricity Interconnections and Market Integration

Status Highlights	Cooperation Areas of High Interest
Electricity Interconnections and Market Integration	
Rapidly growing energy and peak power demand. Currently in nearly all the GCC systems the supply-demand balance is tight, especially during summer peaks.	• Electricity markets and interconnections. o Technical Aspects of RE integration. o Establishment /enhancement of national electricity markets. o Establishment of a regional electricity market o Market oriented management of interconnections (access, operation, capacity allocation / congestion management, etc.).

Strong link between electricity and water production (desalination in integrated water and power plants, IWPPs) in the GCC electricity system.	○ Interconnection expandability – High Voltage. Interconnection vision for use and expansion. ○ Intra-country connection. Initial Focus on Oman and UAE. • Transmission System Operators (TSO) role in cross border electricity trade. • Electricity from Renewable Energy Sources ○ Integration of (mainly non-dispatchable forms of RES –PV & wind) into electricity markets. ○ Forecasting as an important tool for improving operational integration of varying RES. ○ Grid connection issues (RES are often distributed and located away from load centres or grid infrastructure). ○ Reinforce the interconnections among GCC countries and with neighbouring countries. • Quantifying the impact on CO_2 emissions by the introduction of integrated markets.

4.5. Carbon Capture, Storage and Usage

In the EU:

Carbon Capture and geological Storage (CCS) technology has significant potential to help mitigate climate change both in Europe and internationally, particularly in countries with large reserves of fossil fuels and a fast increasing energy consumption and generating CO_2 emissions. More specifically, in the EU, CCS technologies are considered an important tool to decrease CO_2 emissions in countries such as Germany, Greece, Poland, Czech Republic which rely on coal to generate electricity as well as countries such as Norway, France, Spain and the Netherlands. There are existing mature CCS projects elaborated in the EU such as Sleipner and Mongstad, in Norway, where over 1 Million tonnes of CO_2 per year are injected in saline aquifers in the North Sea and two different CO_2 capture technologies are applied. CCS technology is has developed in the EU by carrying out intensive research over the last decades. However, even though technology is well addressed, through the involvement of power and oil companies as well as academia and research institutes, further financial support for commercial application of CCS is required.

The European Commission's proposal for a "2030 climate and energy policy framework" acknowledges the role of CCS in reaching the EU's long-term emissions reduction goal. However, to ensure that CCS can be deployed in the 2030 timeframe, increased R&D efforts and commercial demonstration are essential over the next decade, while a supportive EU framework will be necessary through continued and strengthened use of auctioning revenues.

Research and innovation should support carbon and energy intensive industries to explore the feasibility of CCS, focusing primarily on sectors with high-purity sources of CO_2 to minimise capture costs. Carbon Capture and Usage (CCU) options, such as transforming CO_2 into fuels, chemicals and material, could further improve the economic case for CCS[48].

[48] COMMUNICATION FROM THE COMMISSION, Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation, Brussels, 15.9.2015; C(2015) 6317 final.

The environmental integrity of CCS is the Commission's overriding concern. Although the components of CCS are all known and deployed at commercial scale, integrated systems and the applications are creating new challenges beyond the current state of the art. Different boundary conditions are also likely to result in different optimal operation conditions and in turn completely different preferred technological solution. A clear regulatory framework is required, and the EU's Directive on the geological storage of CO_2 (so-called "CCS Directive") provides this[49]. It establishes a legal framework for the environmentally safe geological storage of CO_2 to contribute to the fight against climate change (ZEP, 2011). This CCS Directive has been approved by the EU Member States.

According to the European Technology Platform for Zero Emission Fossil Fuel Power Plants (Platform ZEP, created out of the EU's recognition of CCS as a key component of any future sustainable energy system), without CCS, the cost of decarbonising European power is 20-50% higher by 2050[50].

In addition, enhanced efforts by Member States, in the implementation of large-scale integrated chain CCS demonstration projects in both power and industrial sectors, are necessary to gain experience, bring down costs and demonstrate safe and reliable underground storage of CO_2. At the EU level, apart from the support planned under Horizon 2020, future CCS projects may be able to benefit from the proposed Innovation Fund to support highly innovative, low-carbon first-of-a-kind projects; and the Modernisation Fund, to support modernisation of energy systems in 10 lower-income Member States. Moreover, some European Member states (including Germany, UK, Spain, the Netherlands, Greece and others) are working together in a transnational initiative ACT (Accelerating CCS Technologies) with the ambition to fund world class RD&D Innovation that can lead to safe and cost effective CCS technology. ACT is a so-called ERA NET Cofund, which is a new tool established by the European Commission under the Horizon 2020 Programme for research and innovation. ACT is the only ERA NET Cofund addressing CCS and comes with a total budget of over 40 million euros for the next 5 years.

Despite major setbacks in especially the UK in setting up a large demonstration project purely for sequestration purposes, interest in CCS is on the increase again. Especially, the ROAD project[51] (Rotterdam capture and Storage Demonstration) looks promising in this respect. Here CO_2 from a coal fired power plant is planned to be stored in a depleted gas reservoir under the North Sea.

In addition, major steps are being taken to maximise CO_2 utilization. In this vision, CO_2 is seen as a low cost carbon source that can be used to produce fuels, chemicals and as to store electricity in the form of chemical energy. The presence of affordable renewably produced hydrogen is essential for these concepts. The Phoenix initiative is one of the more prominent examples in this field.

Public acceptance of CCS in Europe is a drawback to promote these technologies. However specific EU-funded projects, such as R&Dialogue[52], were launched to support public awareness with positive results.

In the GCC:

[49] DIRECTIVE 2009/31/EC.

[50] ZEP - European Technology Platform for Zero Emission Fossil Fuel Power Plants, 2011. CCS plays key role in EU Energy Roadmap 2050, Statement by the Zero Emissions Platform, available at: http://www.zeroemissionsplatform.eu/extranet-library/publication/185-zep-statement-on-eu-energy-roadmap-2050.html

[51] http://road2020.nl/en/

[52] http://www.rndialogue.eu/

Levels of public awareness and positivity towards key CCS processes, such as pipeline transportation of high pressure CO_2 and CO_2 injection and storage, may be assumed to be more favourable than those in the European countries. This is mainly attributable to public confidence in the safety and robustness of existing similar practices in the oil and gas industry, such as high pressure natural gas transportation and gas injection.

Masdar and ADNOC are presently constructing a carbon capture, utilization and storage project using an off stream from the Emirates Steel Industries (ESI) iron making process from their plant in Musaffah, Abu Dhabi. The current project is the first in a planned series of CCS projects in the Emirate of Abu Dhabi, potentially involving the power sector. The captured and pressurized CO_2 is transported by pipeline to ADNOC reservoirs, approximately 45 km southwest of Abu Dhabi City[53].

The use of CO_2 as a chemical feedstock is also studied with the GCC countries, such as at the Qatar University.

Recently KSA Aramco's commissioned the first successful use of CO_2 to replace hydraulic fracturing to enhance oil recovery[54]. The project aims to enhance oil recovery beyond the more common method of water flooding, and is the largest of its kind in the Middle East.

In this pilot project, 40 million standard cubic feet per day of CO_2 will be captured at Hawiyah NGL plant and then piped 85 kilometres to the 'Uthmaniyah field. At 'Uthmaniyah, it will be injected — and sequestered, or stored — into flooded oil reservoirs under high pressure to enhance oil recovery, making it a win-win solution.

The pilot project is the latest in the company's list of efforts, injecting 800,000 tons of CO_2 every year into flooded oil reservoirs. The project includes an elaborate monitoring and surveillance program that will collect data to evaluate its performance and build public confidence in the Kingdom's — and the GCC's — first CO_2 sequestration project.

CCS technologies, such as storage of CO_2 in saline aquifers and enhanced oil recovery, monitoring of CO_2, capture techniques are of interest and potential benefit for the GCC region as they are for the EU region as well.

Table 6: Potential areas of Cooperation in Carbon Capture, Storage and Usage

Status Highlights	Cooperation Areas of High Interest
Carbon Capture, Storage and Usage	

Lift from individual projects to knowledge or action networks
 	
Legislation may be an issue.
	• CO_2 storage for enhanced oil and gas recovery
	• Integrated approaches in natural gas treatment and hydrogen production facilities.
	• Other CO uses:
	  • CO_2 storage in deep saline aquifers;
	  • Mineral carbonation of CO_2 in basalts;
	  • CO_2 monitoring
	  • Production of solar fuels and chemical energy storage; Pilot permanent storage.

[53] Theeyattuparampil V., Zarzour O., Koukouzas N., Vidican G., Al-Saleh Y., Katsimpardi I., 2013. Carbon capture and storage: State of play, challenges and opportunities for the GCC countries. International Journal of Energy Sector Management, 7(2): 223-42 *(paper development facilitated by the EU-GCC Clean Energy Network).*

[54] www.saudiaramco.com/en/home/news-media/news/capturing-carbon.html

	• Existing and new - pilot and test plants and laboratory scale test equipment. • Advanced and integrated capture technologies • Identification of potential CO_2 storage sites • Step up research and innovation activities on the application of CCS and the commercial viability of carbon capture usage (CCU)Legislation

5 Current State of GCC- EU Policies on Climate Change

In the EU:

The EU has long been committed to international efforts to tackle climate change. The European Commission has taken many climate-related initiatives since 1991, when it issued the first Community strategy to limit carbon dioxide (CO_2) emissions and improve energy efficiency. Agreed in 1997, the UNFCCC's Kyoto Protocol[55] was a first step towards achieving more substantial global emission reductions. The goal of the European Climate Change Programme (ECCP)[56], launched in June 2000 by EC is to identify, develop and implement all the necessary elements of an EU strategy to implement the Kyoto Protocol avoiding dangerous climate change.

Towards this direction, European Commission published a green paper in 2007 (Adapting to climate change in Europe - options for EU action) and a white paper in 2009 (Adapting to climate change: Towards a European framework for action)[57]. Consequently, the 20-20-20 target set for 2020 placed very ambitious goals for the reduction by 20% of EU's GHG emissions and primary energy consumption, only to be surpassed by the agreement of the 2030 Framework for climate and energy for the period between 2020 and 2030. The 2030 goals include a 40% cut in EU's greenhouse gas emissions compared to 1990 levels and at least a 27% share of renewable energy consumption and an additional 27% energy savings compared with the business-as-usual (BAU) scenario.

The goal for 2050[58] stands for reducing greenhouse gas emissions to 80-95% below 1990 in the context of necessary reductions by developed countries as a group[59]. The Commission analysed the implications of this in its "Roadmap for moving to a competitive low-carbon economy in 2050[60].

In the GCC:

[55] COM (1999) 230
[56] COM (2001) 580 final
[57] COM (2009) 147 final
[58] COM (2011) 885 final
[59] European Council, October 2009
[60] COM(2011) 112 of 8 March 2011

Although the region accounts for less than 2.4 percent of global greenhouse gas emissions[61], global climate change will have a severe negative environmental impact on the region, which in turn will have implications for the economic and other development gains achieved by the region.

Rising sea levels on the Red Sea, the Arabian Gulf, and the Indian Ocean and the associated risk of salinization of soil and coastal groundwater aquifers pose a growing threat; besides, countries like Bahrain, Qatar and the UAE may lose a large part of their populated coastal area to the sea should sea levels rise substantially.

In the coming decade, the GCC countries will face pressure to use their energy resources more efficiently, in order to supply their rapidly growing populations, free up resources for export, and address concerns about climate change and pollution. The countries of the region will seek to manage energy in new ways, focusing not just on the export of oil and gas, but on increasing the proportion of downstream value-added products and the utilization of renewable energy. The focus on high-value-added energy exports will also add to the opportunity cost of wasting energy through inefficient domestic uses. Although the GCC economies will remain energy-intensive because of the harsh climate, they have a broad scope for making energy use more efficient, whether by changing consumer behaviour, reforming subsidies, and/or by introducing new ideas in building and transport design. The region will also need to focus more intensively on conserving its scarce water supply, as growing populations and wasteful use of water increasingly strain supply. As with electricity, reforms of the tariff subsidy system present political obstacles. However, water shortages create opportunities to develop new water-producing technologies and industries, including new and more energy-efficient desalination technologies.

INDCs: From Intentions to Implementation

Intended Nationally Determined Contributions (INDCs) are the key vehicle for governments to communicate internationally how they will cut emissions for the post-2020 period. They also help countries demonstrate leadership on addressing climate change. While climate change is a global challenge, each country faces unique circumstances, with a different emissions profile and emissions-reduction opportunities. INDCs allow contributions to be tailored to national priorities, capabilities and responsibilities. These individual measures can be the basis for collective action, and, if they are ambitious enough, set a path toward a low-carbon, climate-resilient future.

COP21 has concluded in an historic climate agreement. However, in order to implement the Agreement and reach its overall objective to limit global temperature increase to well below 2°C significant effort is needed at the international level and more so at country level.

In fact, the implementation of the INDC framework will require significant resources, public and private, domestic and international, to continue and scale up immediate mitigation action and to support the necessary long term decarbonisation.

Beyond the provision of financial resources, capacities will need to continue to be built at the country level to enable Parties to carry out the range of activities needed to reach the INDCs targets.

[61] http://trendsinstitution.org/?p=1590

Although, over the INDC preparation process it has been highlighted that many capacity and knowledge gaps exist. These relate in particular to the identification of technical options for increased mitigation effort, the understanding finance and investment needs as well as more generally to the need to build institutional capacities[62]. International bilateral and multilateral cooperation can play a key role in supporting the different activities related to INDC review and implementation and the associated processes. Beyond direct country support, knowledge sharing activities, peer to peer learning as well as the facilitation of dialogues and constructive expert reviews can also be helpful. These can build on the existing EU GCC cooperation frameworks to mobilize all relevant stakeholders and ensure effective transfer of knowledge and experience.

Taking into account the similar nature of the GCC's economies and climate and considering the fact that in the GCC the vast majority of CO_2 emissions are related to energy, it makes sense for the GCC countries to coordinate mitigation and adaptation efforts. Regional cooperation and exchange of knowledge and lessons learned are essential to enrich the discussion on the best policy and technology options that will maximize clean energy deployment and climate change mitigation and adaptation.

Table 8: Potential areas of cooperation in Climate Change

Status Highlights	Cooperation Areas of High Interest
Climate Change	
New area of cooperation –activities of the network are expected to be enhanced to this specific area of interest.	• Building capacity – in order to achieve climate objectives and ensuring that climate actions are entirely compatible with national energy policies' objectives. • Knowledge sharing on technological needs assessments and priorities related to INDCs' implementation and coordination among local and regional stakeholders • Measures and practices to tackle increased CO_2 emissions through RES, EE and CCS/U.

[62] Frauke Röser, Thomas Day, Marie Kurdziel, March 2016; http://newclimate.org

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ANNEX: EU Strategic Energy Technology (SET) Plan

In the autumn of 2015 the European Commission has communicated an updated and targeted version of the Strategic Energy Technology (SET) Plan. Ten actions, listed beneath, have been designed to accelerate the energy system transformation and to create jobs and stimulate growth. The EU-GCC Clean Energy Network underlines these actions as starting points.

- Core priority 1: Number 1 in renewable energy:
  - Action 1: Sustain technological leadership by developing highly performant renewable technologies and their integration in the EU's energy system;
  - Action 2: Reduce the cost of key technologies.
- Core priority 2: The future smart EU energy system, with the consumer at the centre:
  - Action 3: Create technologies and services for smart homes that provide smart solutions to energy consumers;
  - Action 4: Increase the resilience, security and smartness of the energy system.
- Core priority 3: Develop and strengthen energy-efficient systems:
  - Action 5: Develop new materials and technologies for, and the market uptake of energy efficiency solutions for buildings;
  - Action 6: Continue efforts to make EU industry less energy intensive and more competitive.
- Core priority 4: Diversify and strengthen energy options for sustainable transport:
  - Action 7: Become competitive in the global battery sector to drive e-mobility forward;
  - Action 8: Strengthen market take-up of renewable fuels needed for sustainable transport solutions.
- Additional priority 1: Driving ambition in carbon capture storage and use deployment:
  - Action 9: Step up research and innovation activities on the application of carbon capture and storage (CCS) and the commercial viability of carbon capture and use (CCU).
- Additional priority 2: Increase safety in the use of nuclear energy:
  - Action 10: Maintaining a high level of safety of nuclear reactors and associated fuel cycles during operation and decommissioning, while improving their efficiency.