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In recent years, GCC governments have put considerable emphasis on sustainable energy transition with the implementation of clean energy plans, actions towards reducing energy subsidies, adoption of targets – mainly based on diversification strategies and energy efficiency. The authors analyse key factors and propose areas of common interest, fostering EU-GCC cooperation in the field of clean energy and the linked sectors of climate and water. Emphasis on the specific features of the concerned regions (EU and GCC), the framework of the wider EU-GCC cooperation, the policies of the EU and the GCC members for renewables and desalination, energy efficiency and water conservation, and other parallel activities, will be discussed.

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Analysis of Key Areas for EU and GCC Cooperation in the Field of Clean Energy and the Linked Sectors of Climate and Water

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Introduction

The Kingdom of Saudi Arabia (KSA), Kuwait, the United Arab Emirates (UAE) and Qatar jointly hold 40% of world oil reserves and 20% of world gas reserves, and account for 23% of oil and 9% of gas world production [1]. Moreover, the KSA possesses 21% of the global oil reserves and 13% of world oil production, with a reserve to production ratio as high as 66 years. In other words, in case no new oil sources are found, KSA can keep the oil production levels for close to 70 years [2]. These facts place the Gulf Cooperation Council (GCC) countries among the world leaders in producing and exporting oil and gas.

Moreover, these countries are considered to have among the highest energy consumption globally, while the rise in their domestic energy consumption remains continuous. The average rate of growth in electricity demand is 7%, which will consequently double the required power generation capacity every decade. This strong electricity demand increase is driven on one hand by the increased population, housing stock and better living standards and on the other hand by artificially low prices. The existing electricity subsidies cause low rates of return for power utilities in some countries, which leads to inadequate capacity additions and dangerously decreased levels of reserve margins, in terms of generating outages and black-outs. Furthermore, the CO_2 footprint of GCC countries is among the highest in the world, since oil and gas largely dominate power generation [3].

Engaging with more sustainable development goals requires a reduction of domestic oil and natural gas demand, allowing conservation of fossil fuel reserves, while also enabling higher revenues through export. This will also free up hydrocarbons for alternative uses, such as the petrochemical industry. Although efforts in the GCC did not historically focus on rational energy use, energy efficiency, renewable energy sources (RES) and sustainable energy generally, attention is growing, as well as related policy initiatives across the GCC over the last few years.

Equally, the region will need to intensify its efforts to conserve its scarce water supply, as growing populations and wasteful use of water increasingly strain supply. This is particularly important since the GCC's water supply mostly comes from thermal desalination, which is carbon-intensive and inefficient during winter months. Thus, opportunities exist for the development of new water-producing technologies and industries, including new and more energy-efficient desalination technologies, such as reverse osmosis (RO).

As experienced and emphasized by the EU-GCC Clean Energy Technology Network [4, 5], past attitudes are changing rapidly, while recent developments and economic conditions have created an exciting momentum for fast development of markets for clean energy in the GCC. Interest in RES technologies, mainly solar, is rapidly increasing in many GCC countries [6]. Several projects are already implemented or underway, local and regional actors are developing impressive RES plans and local capacity is growing [7, 8]. In this framework, a number of technological, policy, as well as research challenges in developing and applying RES in the region will be analysed.

In the fields of demand-side management (DSM) and energy efficiency, limited progress has been made in the GCC. However, interest is growing fast since the emerging problems in electricity supply, intensified by the rapid increase in electricity demand, compel local stakeholders to take serious action on this issue. In the past, GCC countries have launched various DSM and energy efficiency initiatives. Therefore, there is a lot of potential on cooperation on energy efficiency. A potential starting point could be energy efficiency in the building sector, targeting GCC countries that appear more mature in the effort of adopting relevant policies [9]. The UAE, through organizations such as Estidama [10] and Dubai

Electricity & Water Authority (DEWA), Qatar with its Global Sustainability Assessment System (GSAS/QSAS) and KSA by its Saudi Energy Efficiency Building Code, pave the way for increased energy management in buildings [11, 12]. The remaining GCC countries lag in terms of developing fully-fledged Building Energy Efficiency systems. However, there is considerable recognition of the need to design and implement these systems [13, 14].

Moreover, efforts to integrate the region's electricity system has already started with the first part of the GCC power grid, enabling the development of more renewable energy generation capacity and adding to its overall resilience. It should also be highlighted that on many recent occasions, including in various events/initiatives of the EU GCC Clean Energy Technology Network, as well as at the GCC-EU Joint Council and Ministerial Meeting (2015), the 21st session of the Conference of the Parties (COP21) of the UNFCCC in Paris in December 2015 and the GCC Nationally Determined Contributions (NDCs) [15, 16], GCC countries have declared climate change as a key strategic priority and seek to develop international cooperation on these grounds.

In contrast, Europe is the world's major importer of fossil fuels, while at the same time leading world climate change mitigation efforts. Thus, the European Union (EU) has a well-established interest to collaborate with the GCC countries in effectively tackling clean energy issues. The approach offers numerous benefits to both sides that include, among others, greenhouse effect mitigation, the conservation of fossil fuel reserves, the opportunity of natural gas supply diversification for Europe (e.g., natural gas or its derivatives from the GCC), the development of a market for the EU clean energy industry and, in the long run, even the potential for import of (solar) electricity from the GCC. Notably, the recent EU funded project initiative "EU-GCC Clean Energy Technology Network II" (2016-2018) is a mutual effort to catalyse developments between the EU and the GCC in the field of clean energy, through strengthening the collaboration (at the research, policy, technological and industrial level), sharing of knowledge and recommendations on clean energy principles, capacity building, expertise exchange and examination of opportunities for joint action (projects on technological research as well as pilot industrial scale).

This paper analyses key factors and propose areas of common interest, fostering effective EU-GCC cooperation in the field of clean energy and the linked sectors of climate and water. The analysis will emphasize the specific features of the concerned regions (EU & GCC), the framework of the wider EU-GCC cooperation, the policies of the EU and the GCC members for renewables and desalination, energy efficiency and water conservation, and other parallel activities.

Apart from this introductory section, the paper investigates the state of play in terms of energy policies, clean energy and research efforts in the EU and the GCC. Concrete ideas for potential clean energy cooperation in key areas, such as climate change, renewable energy sources, energy efficiency, desalination and water conservation are highlighted. The last section highlights the main conclusions.

Climate Change

EU state of play: The share of EU's GHGs emissions account for little more than 10% of global emissions, so the EU needs partners to confront the danger of global warming. It is evident that international effort is required, and the EU has a clear, declared and implemented strategy for the promotion of clean energy and is developing cooperation activities worldwide. In particular, the EU has made a commitment to global actions for tackling climate change. The European Commission (EC) has launched many mitigation and adaptation climate-related initiatives. Regarding the mitigation strategies, the first Community strategy to reduce CO_2 emissions and increase energy efficiency was issued in 1991. The UNFCCC's Kyoto Protocol, adopted in 1997, [17] was an important initial step towards a truly substantial global emission reduction regime. The European Commission, by launching the European Climate Change Programme (ECCP) [18] in June 2000, aimed to indicate, enhance and apply all the necessary elements of an EU strategy for the implementation of the Kyoto Protocol. Additional mitigation strategies concern the 20-20-20 target set for 2020, which placed very ambitious goals to limit the EU's GHG emissions and primary energy consumption by 20%, 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 GHG 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 end goal for 2050 [19] stands at reducing GHGs emissions to 80-95% below 1990 levels referring to necessary reductions by developed countries as a whole [20]. The Commission analyses the implications of this 2050 plan in its "Roadmap for moving to a competitive low-carbon economy in 2050" [21].

Regarding the adaptation strategies, the EC 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) (COM (2009) 147 final) [22]. Moreover, the Nationally-Determined Contributions (NDCs) are considered the key mechanism for governments in communicating internationally their strategies for cutting emissions for the post-2020 period. They also support countries to lead action and initiatives on tackling climate change. As each country faces unique circumstances, having diverse emissions profiles and emissions-reduction prospects, the NDCs enable tailored contributions to national priorities, capabilities and responsibilities. These individual measures can serve as a foundation for collective action, and, if they are ambitious enough, set a pathway towards a low-carbon, climate-resilient future, COP21 has concluded in a historic climate agreement [19, 22]. However, to put into effect the agreement and achieve its overall target to limit global temperature increase to well below 2ºC, momentous action is required at the international level and even greater at country level. In fact, the execution of the NDC framework will entail significant resources, public and private, domestic and international, to continue and scale up immediate mitigation action and to support the essential long-term decarbonisation. To support the range of activities related to NDC review and implementation and the associated processes, international bilateral and multilateral collaboration is of high importance. Beyond direct country support, knowledge sharing activities, peer to peer learning, as well as the enabling of dialogues and constructive expert reviews can also be useful.

GCC state of play: Although the GCC accounts for less than 2.4 percent of global GHGs emissions [9, 23, 24], global climate change will have observable effects on the environmental conditions of the region, and as a consequence, economic implications.

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. In addition, countries like Bahrain, UAE and Qatar face the risk of losing a large part of their populated coastal area to the sea.

In the coming decade, the GCC countries will face pressure on their energy resources. To address the rapidly growing populations and free up resources for export, they will have to use them more efficiently. The GCC countries will seek to increase the proportion of downstream value-added product and to exploit renewables (with emphasis on solar). The emphasis on high value-added energy exports will also complement 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 an extensive potential for making energy use more efficient, by altering consumer behaviour, reforming subsidies, and/or by introducing new ideas in building and transport design. The region will also need to intensify its efforts 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 barriers. However, water shortages build opportunities to develop new water-producing technologies and industries, including new and more energy-efficient desalination technologies.

Considering the similar nature of the GCC's economies and climate and in view of the fact that in the GCC the clear majority of CO_2 emissions are related to energy, it makes sense for the GCC countries to coordinate mitigation and adaptation efforts. Regional cooperation, knowledge exchange and lessons learned are critical to enhance the dialogue on the ideal policy and

technology options in order to maximize clean energy deployment and climate change mitigation and adaptation.

Potential areas of cooperation [5]: Tackling climate change necessitates international cooperation. EU -GCC cooperation can significantly enhance the respective efforts, taking into consideration that the GCC countries' carbon footprint is among the highest in the world and the EU has long been committed to international efforts to tackle climate change. Moreover, GCC countries are severely affected by climate change impacts (rising sea levels, salinization of soil and coastal groundwater aquifers, scarce water supply). Cooperation efforts should focus on exchange of knowledge and lessons learned on technological needs assessments, priorities related to NDCs as well as on joint promotion of clean energy policies and technologies. Table 1 summarizes these points.

Table 1: Potential Areas of Cooperation in Climate Change

Status Highlights	Cooperation Areas of High Interest
• Need for adaptation strategies for coastal protection (Bahrain, UAE and Qatar may lose a large populated coastal area) • Need for adaptation strategies for rising sea levels on the Arabian Gulf, increased risks of salinization of soil and coastal groundwater aquifers. • Pressure to more rational use of energy resources. • Focus more intensively on conserving scarce water supply.	• Cooperation to achieve climate objectives and ensuring that climate actions are compatible with national energy policies' objectives. • Knowledge sharing on technological needs assessments and priorities related to NDCs' implementation and coordination among local and regional stakeholders. • Measures and practices to tackle increased CO_2 emissions through RES, EE and CCS. • Cooperation for new water-producing industries, including new and more energy-efficient desalination technologies.

Renewable Energy Sources and Desalination

EU state of play: Renewables will have a dominant position in the EU's efforts to meet its energy needs beyond 2020.

Among the purposes of the European Commission's 2020 Climate and Energy Package is to attain 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 for renewable energy. Individual Member States have targets set in EU legislation (Directive 2009/28/EC) [25] and some have set additional objectives nationally.

National RES action plans have been adopted by all EU countries indicating the exact actions they intend to undertake to achieve their renewables targets. These plans include sectoral 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.

In addition, in October 2014, EU leaders agreed to the 2030 policy framework for climate and energy [26, 27], which included the share of renewable energy generation to reach at least 27% in EU energy consumption.

An important instrument in achieving this goal are schemes for RES. These tools also attract high levels of interest regarding the differences between EU Member States and the overall costs to consumers. There is a wide variety of instruments used to promote RES including investment grants, tax-rebates, feed-in tariffs, feed-in premium, green certificates and auctions.

GCC state of play: All GCC countries now have clean energy project plans or targets and there are numerous initiatives that include RES targets in almost all GCC countries. 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 a capacity target of 7% renewable energy by 2020, which is equivalent to 1500 megawatt (MW) of solar energy, wind energy and waste to energy. Abu Dhabi's Masdar built the 100 MW Shams I concentrated solar power plant in Madinet Zayed, which was inaugurated in 2013 [4]. Dubai Electricity and Water Authority (DEWA) has signed a historical Power Purchase Agreement (PPA) and a Shareholder Agreement for the second phase of the Mohammed bin Rashid Al Maktoum Solar Park with ACWA Power for as little as US$0.054 per kWh in early 2015. Considered one of the largest of its kind in the world, producing 1,000 MW in a single location by 2020 and 5,000 MW by 2030, it will see total investments worth AED 50 billion until 2050 [28, 29]. 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 13 MW has been operational since 2013 [30, 31]. The 200 MW second phase was inaugurated in March 2017 producing energy with enough capacity to power 50,000 homes in Dubai, and at the world's cheapest rate for an operating solar plant at US$5.84 per kilowatt hour [32, 33]. A Masdar-led consortium is developing the third phase of Mohammed bin Rashid Al Maktoum Solar Park, which is an 800 MW solar photovoltaic (PV) plant. Starting January 2017, Phase 3 will be constructed in three stages: the first 200 MW is expected to be complete by April 2018; the second 300 MW by April 2019; and the final 300 MW planned for April 2020 [34, 35]. When complete, Phase 3 will displace 1.4 million tonnes of CO_2 emissions each year, which means that upon completion, the solar park will offset over 6.5 million tonnes of carbon emissions annually [36]. In March 2017, the JinkoSolar and Marubeni Corporation consortium have signed a PPA with Abu Dhabi Water and Electricity Company (ADWEC) to construct, own, operate and maintain a photovoltaic power plant with a power generation capacity of 1,177 MW (DC) near the town of Sweihan, in Abu Dhabi. Construction is expected to be completed in April 2019 and will sell power under a 25-year PPA at a record-setting low price [37].

Most of the GCC countries have initiated planning and executing RES projects. In the Kingdom of Bahrain, the ministry's energy plan sets the national target of renewable energy at 5% by 2025 which will be further boosted to become 10% by 2035 [38]. The Bahrain's BAPCO 5 MWp PV Grid–Connected Solar Project was the crucial first step towards achieving the goals of diversifying resources, [39] while more recently the Solar One Bahrain's first solar panel manufacturing facility was launched in January 2017 [40]. In Kuwait, the strategic target for renewable energy share of 15% by 2030 is set. Indicative facilities of the Kuwait Renewable Energy Technology Program include the Photovoltaic Test Platform of 100KWp which enables the assessment of panels and inverters from a variety of manufacturers and different technologies, the Salmi Mini-wind Farm, the first large- scale (70 megawatt) multi-technology Shagaya Renewable Energy Park and the Solar and Wind to Hydrogen Plant, which is a pilot-scale plant designed to use photovoltaic panels (10 kilowatts) and wind turbines (6 kilowatts) to produce and store hydrogen (H_2) as an energy carrier and use it in a fuel cell to provide electricity [41]. In Oman, a contract to build the Sultanate's first large-scale wind-based renewable power project, which will generate 50 megawatt electricity, was signed in 2016. The renewable energy project is being jointly developed by the state-owned Rural Areas Electricity Company (Raeco) and the UAE-based Masdar [42]. More recently, in May 2017, the country's Investment Fund (OIF) signed an agreement with Ningxia Zhongke Jiaye New Energy and Technology Management Co. to develop a 1,000 MW solar power plan [43]. Qatar's largest solar power project of 200 MW will begin construction in June 2017, and is scheduled to be completed and fully operational by 2020. The project will be developed by Siraj Power, a joint venture between QEWC and Qatar Petroleum and includes an expansion plan of up to 500 MW [44]. In Saudi Arabia, the National Renewable Energy Program aims to substantially increase the share of renewable energy in the total energy mix, targeting the generation of 3.45 gigawatts (GW) of renewable energy by 2020 under the National Transformation Program (NTP), and 9.5 GW by 2023, towards Vision 2030. In early 2017, Saudi Arabia initiated the first round of bidding for projects on the National Renewable Energy Program, which would create 10 GW of power, including a 300 MW solar PV project, and a 400 MW wind farm [45, 46]. Except for Dubai, the (conventional) energy system is highly subsidized; most of these projects require subsidies as well [6].

GCC countries have established some type of policy support scheme to reach the defined RES objectives (Table 2) and promote RES power generation. Saudi Arabia is discussing a proposed Feed in Tariff (FIT) for small-scale projects that would include a number of RES 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 [47]. Auctions have taken place in the GCC to support the deployment of largescale renewable energy projects. The UAE has so far adapted auctions in the region, followed by Kuwait and Saudi Arabia, 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. In Saudi Arabia, the National Renewable Energy Program aims to substantially increase the share of renewable energy in the total energy mix, targeting the generation of 3.45 GW of renewable energy by 2020 under the National Transformation Program (NTP), and 9.5 GW by 2023, towards Vision 2030. In the beginning of 2017, Saudi Arabia initiated the first round of bidding for projects on the National Renewable Energy Program, which would create 10 GW of power, including a 300 MW solar PV project, and a 400 MW wind farm [48, 49].

Targets and national strategies can only be effective in national renewable energy planning if they are supported by an appropriate legal framework. Such framework will facilitate governments in translating their long-term visions into concrete, actionable plans [50, 51]. To facilitate this process, the Energy Department of the League of Arab States (LAS), in collaboration with the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) and the German International Cooperation Agency (GIZ), introduced the Arab Renewable Energy Framework (AREF). AREF provides Arab states with guidelines to develop their national renewable energy action plans (NREAPs) to 2030 [52].

Potential areas of cooperation [5]: The renewables targets in the GCC countries are constantly increasing and hence there is growing interest in local production of renewable energy components and systems. The European renewable energy industry could be a player and a strategic partner in such efforts. Apart from missing or inadequate policies and regulations, there are also other barriers hindering their wider deployment, such as inadequate resource assessment, lack of standards and inadequate technology adaptation. Not all GCC countries have carried out a multi-annual detailed assessment of the renewable energy resource 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. Not all GCC countries have quality control systems for renewable energy technologies, involving testing and standards and related institutions, in place. Furthermore, it is to be noted that technical knowledge in the region and industrial chains are non-integrated. Moreover, a number of applications hold great promise for the cost-effective introduction of renewable energy. Due to the growing population, there are many opportunities in the growing cities and city areas such as district cooling (in combination with geothermal heat sources for example) and energy storage.

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. For example, Reverse Osmosis (RO) is a technology that has come down in price tremendously and can decouple electricity from water production. Moreover, RO is one of the most suitable desalination processes to be coupled with RES. The combination of RO and renewable energies, such as CSP, wind and/or low-enthalpy geothermal resources, could greatly reduce the energy needed for these purposes and accordingly the respective CO_2 footprint. Wind power consumes no water, which is not the case for all the other renewable power generation technologies. The solar resource in the region is obvious. Regarding geothermal energy, the significant advantages over other renewable energy technologies is the constant availability, independent of time of day, season and weather.

Table 2 summarizes the analyses and highlights potential areas of cooperation.

Table 2: Potential Areas of Cooperation in RES

Status Highlights	Cooperation Areas of Common Interest
• RE critical role in addressing climate change, environmental, geopolitical and economic issues in the GCC region. • A lot of concrete projects are ongoing and more are to come. • Very good potential for solar thermal and photovoltaic electricity generation in the GCC region. • Wind and Geothermal could be further explored	• Policies and regulations: RES policy and institutional/regulatory environment for the larger RES deployment. • Integrated RES resource assessment (solar, wind and geothermal), zoning and planning. • Technology adaptation to GCC climate conditions (high moisture, dust, sand storms, high temperatures); Quality control infrastructure related to standards, testing and certification. • Distributed PV systems (i.e. PV Rooftop systems); policies, regulations and best practices. • Cooling applications; district cooling. • Expanding RES integration linked to water desalination. • Assessment of local manufacturing potential of renewable energy components and systems.

Energy Efficiency and Water Conservation

EU state of play: 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 [53]. The Directive on Energy Efficiency established in 2012 [54] requires each member state to apply an energy efficiency obligation scheme (EEOs) or alternative policy measures to reach a predefined level of end-use energy savings over the 2014-2020 obligation period.

The Energy Efficiency Plan [55], issued in 2011, sets several directions for a transition towards a more efficient economy with regards to the use of energy resources, covering targets, public sector measures, buildings, energy supply obligations, cogeneration and industry. The Plan also pursued 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 EU policy document of July 2014 on Energy Efficiency [56] communicated the contribution of energy efficiency to energy security and the 2030 Framework for climate and energy policy [56] calling for a 30% energy efficiency target by 2030. Energy efficiency policy is also guided by a binding indicative target for 20% energy savings by 2020, followed by many policy reports and directives related to energy efficiency. The Commission proposed an update to the Energy Efficiency Directive in November 2016, as well as measures to ensure that the new target for 30% energy efficiency by 2030 is met [57].

A technique for achieving large-scale energy efficiency improvements is demand-side management (DSM). DSM in electricity markets could increase the efficiency of energy consumption and reach environmental goals 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 dealt with DSM for many years, particularly in the fields of energy management and public and cooperative technology procurement, energy efficient buildings, energy efficient household appliances and other end-use equipment, smart energy metering, third party financing, guarantee of results and other innovative financing schemes and information dissemination. Moreover, the energy performance contracting approach is used for promoting energy efficiency investments, mainly in the public sector. In this approach, energy service companies (ESCOs) provide, as a service, guaranteed savings to end users and they are paid by a part of the respective achieved cost savings.

GCC state of play: Energy efficiency activities and policies are also gradually taking their place in the spotlight 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 [58]:

- 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 of electric vehicle charging stations

In 2010, Abu Dhabi's Urban Planning Council (UPC) introduced the Estidama 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 steps have been taken in Saudi Arabia, Oman and Bahrain. The UAE is also focusing its efforts on the appliance of efficiency standards; the UAE introduced the region's first efficiency standards for air-conditioning units, eliminating the lowest performing 20% of units on the market, and is introducing efficiency standards for refrigeration and other appliances [59, 60].

Kuwait's initiatives have been primarily 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 to introduce in the GCC energy conservation measures related to air-conditioned buildings.

Saudi Arabia has realized several related initiatives, such as steps for the implementation of energy conservation and reduction of peak load demand, while the Saudi Arabia Standards Organization has adopted several standards, aiming to limit the penetration of inefficient electrical appliances into the Saudi market, although they have not yet been put into effect. In this context, the Saudi Energy Efficiency Center (SEEC) was established in 2010 and since then, SEEC has been responsible for the demand-side energy efficiency effort in the KSA. In 2012, SEEC launched the Saudi Energy Efficiency Program (SEEP) having at its core to improve the KSA's energy efficiency by designing and implementing initiatives and their enablers. Currently, the program is launching initiatives for the three sectors representing more than 90% of the total local energy consumption, i.e., construction, land transportation, and industry sectors [61].

Green buildings and sustainable development are also a priority for Qatar. The related initiatives realized in the country include the National Vision 2030 on sustainable development, as well as the establishment of the Qatar Green Building Council (QGBC) [62, 63]. The Global Sustainability Assessment System (GSAS) deployed by the Qatar Gulf Organization for Research and Development, is the first performance-based system in the MENA region with the objective to rank the green buildings and infrastructures [64]. In Oman, the Japan International Cooperation Agency (JICA) led the first DSM study which identified several strategies for potential load management and shifting load from peak time to off-peak time in the industrial and commercial sectors [65].

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 and 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, while it supports the Energy Efficient Lighting Initiative [66].

Water management is an issue in the GCC region and efficiency can play a key role. GCC countries must increase the sustainability of their water sectors by focusing on three terms: excessive water demand, inadequate water supply, and ineffective institutional frameworks. Actions to manage the water sector must occur in an integrated manner due to the implications that water has on multiple

industries, including energy, agriculture, and recreation. Related EU-GCC research activities have to be further elaborated.

Potential areas of cooperation [5]: 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 liberalized, 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, which could be used for (district) cooling. The expansive experience with energy efficiency policies and measures in Europe offers lessons that can potentially be considered in the GCC cities [67-69]. Moreover, energy efficiency concepts, such as the "energy performance contracting approach" could be also tailored for the water sector. Table 3 provides an overview (not exhaustive) of those options, and suggests some sectoral and technology options that could be useful.

Table 3: Potential Cooperation Areas in Energy Efficiency and DSM

Status Highlights	Potential Cooperation Areas
• Very big potential for energy efficiency in both the building environment and the industrial sector • Strong manufacturing capabilities and industry capacities: 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 for energy saving. • 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. • Use of "cool" materials in buildings, Building Energy Management Systems (BEMS), efficient lighting options. • Industrial heat management, including upgrading waste heat; district cooling. • Labels and standards: AC highly efficient appliances, building envelop material. • Market-based mechanisms to promote energy efficiency. • Energy efficiency concepts, such as the "energy performance contracting approach" could also be customized for the water sector. • Smart grids.

Conclusions

During the last few years, GCC countries have acknowledged that current energy consumption trends are not sustainable from either an environmental or economic perspective. Combined with the growing necessity to diversify away from economies largely based on oil and gas, in recent years a gradual evolution in the legislative framework for clean energy is observed – though to a different degree and maturity in each GCC country.

Considering the differences in the development and the specifications of each country from the Gulf region, energy policies are the first step into overcoming the future energy sector challenges in the Gulf [9]. Regional cooperation, know-how exchange and lessons learned are essential to upgrade the discussion on the best policy and technology options that will at most exploit clean energy deployment [10]. These new policies must balance energy, water and climate and target an electricity system more water and climate-resilient.

This article investigated EU-GCC clean energy cooperation opportunities, as the EU and the GCC are seeking to establish a long term strategic relationship. Both regions can benefit from these cooperation opportunities, especially when considering that Europe is working hard to:

- Cut its GHGs emissions (20% till 2020 and 40% till 2030 compared to 1990 levels).
- Encourage other nations and regions to do likewise (as done in COP21).

On the other hand, there are the GCC countries that show their commitment through a number of initiatives, such as:

- Setting quantitative targets for the decarbonisation of the energy mix and the promotion of sustainable development policies and initiatives.
- Fostering the development of clean cities and several demonstration/pilot and industrial scale clean energy projects.

It is evident that the promotion, planning and implementation of regional and bilateral cooperation activities in order to increase the partnership opportunities and to produce concrete results in both EU and GCC is particularly challenging, especially within this multicultural and complex environment. The key areas and means of cooperation that arose from this study, address research collaboration, collaboration on policy issues, as well as technology and industry collaboration. The analysis highlights EU-GCC clean energy cooperation opportunities, with links to the water sector:

- Renewable Energy Source and Desalination: Significant prospects exist for the usage of renewable energy technologies for desalination, e.g., solar, wind and geothermal.
- Energy Efficiency and Water Conservation: There are considerable similarities between the energy efficiency and water conservation problems. Energy efficiency concepts, such as the "energy performance contracting approach" could also be customized for the water sector.

Some concrete actions that would further promote cooperation among the two regions are the following:

- Assessing the viability of exploiting geothermal energy for water production (e.g., low-enthalpy geothermal energy via MED) and if viable extension of the study to geothermal resource assessment.
- Knowledge exchange for the minimization of water losses through the whole cycle of water production and distribution.
- Wind resource assessment and potential application in GCC countries.
- Resource assessment and potential application of Concentrated Solar Plants for power and water production.
- Development of effective ways for deploying rational uses of energy and water.

Maintaining and strengthening the cooperation between the EU and the GCC around sustainable clean energy and water sectors is crucial and a win-win bet for both regions, bound to trigger mutual benefits at an industry, policy, market development and research levels. Furthermore, this cooperation should directly benefit from the implementation of the Paris Agreement on climate change concluded in December 2015, through the economic diversification strategies in the Gulf region that form the basis for their GHG emissions reduction.

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