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Integration of renewable energy in future sustainable energy systems and cross-cutting collaboration

Benefit of transboundary cooperation in water-energy nexus for renewable energy development

Note by the secretariat

Summary

The water-energy-food-ecosystems nexus approach comes in with the objective of promoting coordination and integrated planning and sustainable management of interlinked resources across sectors, which could speed up the achievement of the 2030 Agenda for Sustainable Development. The nexus approach could leverage deployment of renewable energy across the Goals. The meaning of "nexus", in the context of energy, water, and food refers to the inseparable linkage of these sectors, so that actions in one sector commonly have impacts on the others, as well as on ecosystems.

Renewable energy technologies could address several of the trade-offs between water, energy, food and ecosystems bringing substantial benefits to all sectors. The benefits of renewable energy include energy and emissions savings, reduced dependency on fossil fuels and increased energy security. The distributed nature of many renewable energy technologies could improve energy and water access especially in remote areas, which generates positive impacts on food security.

The present document highlights the potential of renewable energies to contribute to sustainable development in the energy sector and beyond, provided that intersectoral effects and possible synergies, as well as environmental impacts are taken into account.
The purpose of this policy brief is to encourage the consideration of good practices and policies for intersectoral synergies in the context of the nexus and for limiting negative impacts in deploying renewable energy in the ECE region and improving it sustainably.

I. Introduction

1. Member countries in the United Nations Economic Commission for Europe (ECE) have different levels of progress in developing their renewable energy potential. Their shares of renewable energy in total final energy consumption vary from more than 50% to less 3%. Higher shares of renewable energy are driven by hydropower developments, with consequences for management of water, food, energy sectors and ecosystems. Several countries in the region, including the riparian countries referred to this policy brief, continue to face strategic energy challenges such as ensuring energy security, seasonal power outages and insufficient energy, which could potentially become drivers for renewable energy development[1]. Renewable energy could play a central role in the countries' climate change mitigation efforts as they move to implement their obligation under the Paris Agreement.

2. The ECE, consisting of 56 member countries, contributes to the development of the region's vast renewable energy resources in synergy with the more sustainable use of other resources such as water, land and food. A holistic perspective, which allows the preservation of the integrity of ecosystems, is central to this approach. Therefore, the ECE has been using the nexus approach to assist Member States achieve a better understanding of the intersectoral synergies and leverage linkages between the energy, water and food sectors and the ecosystems.

3. The ECE Group of Experts on Renewable Energy (the Group of Experts) was created in 2014 with a mandate to carry out action-oriented, practical activities to greatly increase the uptake of renewable energy. The Group of Experts is encouraging the exchange of know-how and best practices between member states, relevant international organizations and other stakeholders. The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) fosters cooperation in the management of shared water resources. The Task Force on the Water-Food-Energy-Ecosystems Nexus provides a platform for exchange of experience on inter-sectoral (nexus) issues. The Group of Experts has cooperated with the Task Force on the Water-Food-Energy-Ecosystems under the ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, in some of the assessment work on the water-energy-food-ecosystem nexus presented in this document. The 2030 Agenda for Sustainable Development, which strives to fulfil its 17 Sustainable Development Goals (SDGs), provides the overall context.

4. The SDGs are closely interlinked and benefit from increased synergies in implementing measures towards their achievement. For example, the Sustainable Development Goal (SDG) 7, which advocates for access to affordable, reliable, sustainable, and modern energy for all, is interlinked both explicitly and implicitly with various other goals. Most obviously, most energy generation forms depend on water to variable degree and hence benefits from water management (part of SDG 6 on water sanitation). Energy access supports achievement of food security (SDG 2) but biofuel production may compete for the same limited land with food crops.

5. Access to energy is a precondition to economic growth driving improved health conditions and education. More sustainable energy is a basis for improved resilience. There are linkages between affordable and clean energy and other SDGs, namely those related to poverty elimination, decent work and economic growth, industry innovation and infrastructure, reduced inequalities and responsible consumption and production. Achieving

[1] REN21 (2015), United Nations Economic Commission for Europe Renewable Energy Status Report, http://www.unece.org/energywelcome/areas-of-work/renewable-energy/unece-renewable- energy-status-report.html

the Sustainable Development Goals will require coordination across sectors, coherent policies, and integrated planning.[2]

6. The water-energy-food-ecosystems nexus approach comes in with the objective of promoting coordination and integrated planning and sustainable management of interlinked resources across sectors, which could speed up the achievement of the 2030 Agenda for Sustainable Development. The nexus could leverage deployment of renewable energy across the Goals. The meaning of "nexus", in the context of energy, water and food refers to the inseparable linkage of these sectors, so that actions in one sector commonly have impacts on the others, as well as on ecosystems.

7. The main document[3] has been developed building on what was presented to the Group of Experts in its Third Meeting in document ECE/ENERGY/GE.7/2016/6[4], notably on tools supporting identification of inter-sectoral synergies, case studies as well as general conclusions and recommendations. The further development of the previously mentioned document included collecting stakeholder/expert input using a questionnaire, identification of examples of good practices and illustration with infographics. Subsequently, a brochure titled 'Deployment of renewable energy: The water-energy-food-ecosystems nexus approach to support the Sustainable Development Goals' was prepared and launched at the Eighth International Forum on Energy for Sustainable Development (Astana, June 2017) where the nexus topic featured prominently.

II. Renewable energy and water-energy-food-ecosystems nexus

8. The Parties to the Water Convention decided on an assessment of the water-food-energy-ecosystems nexus to be carried out as a means of effectively addressing the aforementioned challenges. In the Water Convention's framework, a set of assessments were made in transboundary basins in South East Europe, the Caucasus and Central Asia[5]. Renewable energy could play a strong role in helping to achieve better management of resources (water, energy, land and ecosystem resources) within the water-energy-food-ecosystems nexus. The potential role of renewable energy in addressing the nexus could be specifically explored and the links to Agenda 2030 and climate change considerations could be further highlighted.

9. Renewable energy technologies could address several of the trade-offs between water, energy, food and ecosystems bringing substantial benefits to all sectors. The benefits of renewable energy include energy and emissions savings, reduced dependency on fossil fuels and increased energy security. The distributed nature of many renewable energy technologies could improve energy and water access especially in remote areas, which generates positive impacts on food security. The opportunities for renewable energy in the water-energy-food nexus were highlighted in a report[6] prepared by the International Renewable Energy Agency

[2] Adapted from the Ecosoc document , "A Nexus Approach For The SDGs ' https://www.un.org/ecosoc/sites/www.un.org.ecosoc/files/files/en/2016doc/interlinkages-sdgs.pdf

[3] ECE publication "Deployment of renewable energy: The water-energy-food-ecosystems nexus approach to support the Sustainable Development Goals, available at: http://www.unece.org/index.php?id=46026 .

[4] Good practices and policies for intersectoral synergies to deploy renewable energy: the water-energy-food-ecosystems nexus approach to support the Sustainable Development Goals. ECE/ENERGY/GE.7/2016/6

[5] UNECE (2015), 'Reconciling resource uses in transboundary basins: assessment of the water-food-energy-ecosystems', nexushttp://www.unece.org/index.php?id=41427

[6] International Renewable Energy Agency (2015), 'Renewable Energy in the Water, Energy & Food Nexus', 2015,

(IRENA). The energy-water food nexus was part of the World Energy Outlook by the International Energy Agency and gives insights into the role for renewable energy.[7]

10. Renewable energy, depending on the selected technology could reduce water requirements in energy production.[8] For example, electricity generation using solar photovoltaic (PV) and wind require limited amount of freshwater, e.g. for cleaning solar PV panels for improved efficiency of Concentrated solar power CSP, and geothermal uses heat in electricity production and have limited water requirements. Energy systems that include renewables have proved to be less water intensive compared to conventional energy in all countries analysed in the IRENA report. Many renewable energy resources, such as solar, wind and tidal, are freely available and require minimal water inputs to be developed and deployed, which benefits overall water efficiency.

11. Renewable energy technologies could boost water security by improving accessibility, affordability and safety. Renewable energy could fulfil energy requirements along the water supply chain. For example, solar-based pumping solutions could offer a cost-effective alternative to on-grid electricity supply or diesel generators. Large water utilities are deploying decentralised renewable energy options to offset both, electricity costs and their carbon footprint. Renewable energy offers solutions in wastewater treatment and wastewater treatment processes themselves can generate energy. Wastewater's energy potential could be utilised and the system's energy loop could be closed with local energy sources (e.g. biogas from waste).

12. Renewable energy could stimulate the food sector with new economic opportunities and bridge the modern energy deficit along the supply chain to reduce losses and enhance productivity. Renewable energy could provide energy on-site or could be integrated through large scale installations into the existing conventional energy supply chain. Waste from energy solutions could be used but other renewable energy sources could also be applied, for example, in food processing such as drying (e.g. solar and geothermal).

13. The production of bioenergy still raises concerns related to water consumption and land use. Bioenergy could play a positive role in addressing water-energy-food-ecosystems nexus linkages under specific parameters. For example, installation of anaerobic digesters in farms could provide locally available source of electricity or heat using a range of crop residues, animal and food waste. Forestry's by-products could also serve this purpose. Energy sector planning needs to use specific safeguard measures and regulations to exploit the bioenergy potential in a sustainable manner.

14. Other renewable energy technologies could complement hydropower generation. This may relieve the pressure on water resources use and trade-offs between power generation and irrigation or other water uses. The nexus approach helps to identify the stress points where hydropower development is creating concerns.

15. The nexus approach presents an opportunity to strengthen the actions aimed at achieving the Sustainable Development Goals. First, nexus approach could contribute specifically by setting complementary goals and targets, which are jointly achievable. Nexus allows to identify interactions among goals and across sectors. It points at how individual targets might serve multiple goals. Second, nexus approach promotes collaboration and partnerships, which are essential to achieving the 2030 Agenda. Third, the nexus approach could be used as a framework for solutions to emerge based on examination of plans of other

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http://www.irena.org/DocumentDownloads/Publications/IRENA_Water_Energy_Food_Nexus_2015.pdf

[7] International Energy Agency (2016), 'World Energy Outlook, excerpt on Water-Energy Nexus, http://www.worldenergyoutlook.org/resources/water-energynexus/

[8] Ibid.

entities or countries. In this context, the nexus approach could contribute to mobilising renewable energy deployment beyond the SDG 7, ensuring access to affordable, reliable, sustainable and modern energy for all. For example, using nexus approach could identify opportunities for renewable energy powering interventions contributing to SDG 2, ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture, and SDG 6, ensuring availability and sustainable management of water and sanitation for all. Other SDGs could be brought in as well (12, 13 and 15).

16. The process initiated through the 2030 Agenda for Sustainable Development could in return contribute to achieving the principles of the nexus approach. Good governance and environmental protection, which are at the centre of the nexus approach run through the 2030 Agenda for Sustainable Development. Policy planning in relation to 2030 Agenda is now underway and could stimulate the riparian countries to adjust their national policies and institutions, which in return could facilitate application of the nexus approach. For example, Montenegro adopted a National Strategy for Sustainable Development, which drives achievement of the goals. Serbia on the other hand has created an Inter-Ministerial Working Group, which monitors implementation of SDGs.

17. Climate change has significant effects on energy, water and food sectors and ecosystem processes related to species and environment quality that are leading to a global loss of biodiversity. Climate change is behind water availability variations which affect the hydropower generation capacities. Several of the riparian countries of the basins assessed under the Water Convention are already experiencing impacts of climate change. For example, Drina basin is prone to episodes of flooding and droughts which cause significant damage to the economy. The concerns around climate change impacts emerged during the nexus assessments and could be used to leverage nexus approach as an additional tool for identifying ways to tackle climate change, combining mitigation and adaptation. Processes like developing national and transboundary strategies to adaptation to climate change could serve as an intersectoral coordination effort that nexus approach calls for. Development of renewable energy resources in a transboundary manner could be one the unifying elements of such collaborations.

18. Lack of intersectoral coordination is a major challenge in leveraging all the existing opportunities for renewable energy deployment in the riparian countries. The gap exists both on the national and transboundary levels throughout the ECE region in energy, land management and water resources planning. For example, when developing hydropower in transboundary settings, the trade-offs and externalities between water and energy management or the environment may cause friction between upstream and downstream countries and slow down or hamper project development.

19. The ECE Group of Experts has been actively supporting identification of opportunities, benefits and tools for application of the nexus to facilitate transboundary collaborations and increase understanding of water, energy, food sectors and ecosystems, including potential for improving renewable energy deployment. The collaboration with the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) forms an initial core for this work. Series of nexus assessments has been carried out in transboundary basins in South East Europe, the Caucasus and Central Asia in the framework of the Water Convention to demonstrate the need, value of working across sectors and some concrete opportunities in policies and measures for countries that want to utilise their renewable energy sources and yield benefits for the energy, water and food sectors.

20. The nexus assessments used a participatory process. First, related sectors and relevant stakeholders identified intersectoral challenges and opportunities for benefits from stronger integration across sectors. Second, the assessments presented practical solutions to trade-offs between the sectors. So far, four nexus assessments have been completed in the

Alazani/Ganikh (Azerbaijan, Georgia), Sava (Bosnia and Herzegovina, Croatia, Montenegro, Serbia, and Slovenia), Syr Darya (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan[9]), Isonzo/Soča[10] (Italy, Slovenia) and Drina Basins (Bosnia and Herzegovina, Montenegro and Serbia). The results of the first three nexus assessments, together with the methodology, were then published on November 2015 in a dedicated report[11] and the Drina River Basin assessment was being finalised at the time of writing the policy brief. An important conclusion from this work lies in policy recommendations that could facilitate renewable energy deployment, which is more sustainable and accounts for the nexus trade-offs between the energy, water and food sectors and the ecosystems.

III. Tools supporting identification of intersectoral synergies

21. The potential for improving renewable energy deployment through consideration of the water-energy-food-ecosystems-ecosystems nexus is clear. Yet, the challenge is in making sure that the nexus approach is fully integrated in the decision making and deployment of renewable energy potential and consequently projects. Several tools are in place and could be used by decision makers to identify renewable energy opportunities.

A. Nexus assessment methodology for transboundary basins

22. The nexus assessment methodology with a trasnsboundary focus was developed under the Water Convention. The assessment provides an overview of the interdependencies across water, energy, food and the related ecosystems. Using the specifically developed methodology, the assessment addressed uses, needs, economic and social benefits, potential synergies, impacts and trade-offs at both the national and transboundary levels. The process starts with the identification of interlinkages, then the possible policy, technical and cooperation responses between energy, water and food sectors, as well as environmental protection are determined. Renewable energy is integrated into the analysis through the lenses of the specific basin with hydropower in the main focus, given energy-water linkages and the prominence of hydropower in the basins assessed. Within this process, the ECE Group of Experts contributes to the application of the nexus assessments methodology in relation to the increase of renewable energy uptake.[12]

23. The process strongly emphasizes intersectoral dialogue in a transboundary context, which is informed by a joint assessment, with participation from the concerned countries. The dialogue focuses on uncovering the potential for improvement and possible benefits from cooperative and coordinated solutions. Assessments are made jointly with officials and experts from the countries sharing the basins.

24. Analytical frameworks are used to assess the impacts of policies upon different sectors. They inform policymaking by quantifying the trade-offs between resources and providing a sound framework through which potential, and sometimes unexpected, nexus-related risks are identified. The analytical approach also helps to identify context-specific

[9] Uzbekistan does not associate itself with the nexus assessment of the Syr Darya.

[10] A draft assessment of the Isonzo/Soča (shared by Italy and Slovenia) was not finalized

[11] UNECE (2015), 'Reconciling resource uses in transboundary basins: Assessment of the water-food-energy-ecosystems nexus'. The methodology and the general conclusions and recommendations contained in the publication were endorsed by the seventh session of the Meeting of the Parties to the Water Convention.

[12] For more information about the ECE work on renewable energy, please see at https://www.unece.org/energy/se/gere.html

integrated solutions that allow the three economic sectors of the nexus to develop without compromising long-term sustainability, including the integrity of ecosystems and the services they provide.[13]

25. The analytical framework[14] developed for the nexus assessment under the Water Convention is based upon a six-step process entailing: (1) Identification of basin conditions and the socioeconomic context, (2) Identification of key sectors and stakeholders to be included in the assessment, (3) Analysis of key sectors, (4) Identification of intersectoral issues, (5) Nexus dialogue, and (6) Identification of synergetic actions (across the sectors and countries) and related benefits.

26. Several analytical tools[15] could be applied, fit-for-purpose, for possible further studies of issues focusing on the water-food-energy-ecosystem nexus in order to inform policy development and decision making. These tools require better information to improve intersectoral coordination at national and transboundary level. Information-related solutions could include, for example, improving monitoring, data management, and forecasting, as well as extension programmes. Balanced decision making could be supported by jointly developed guidelines and strategic planning approaches that seek to define how, in practice, diverging interests could be weighed based upon agreed relevant criteria.

B. Strategic environmental assessment and environmental impact assessment in a transboundary context

27. Regulatory instruments are useful tools for further advancing the nexus analysis of the trade-offs and better alternatives but, moreover, for promoting intersectoral coordination. Transboundary Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are commonly used to take into account environmental (including health) considerations in planning projects and programmes in various sectors. They contribute to advancing the use of intersectoral coordination that is necessary for the nexus approach. In the pan-European region, EIA and SEA procedures are regulated by the ECE Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention) and its Protocol on Strategic Environmental Assessment, as well as the European Union (EU) and national legislation. At the global level, international financing institutions support the application of SEA, including the World Bank and the Asian Development Bank and other expert and advisory bodies, such as the Netherlands Commission for Environmental Assessment.

28. The SEA is a tool for integrating environment and health considerations into sectoral plans and programmes, helping to coordinate national development objectives and offering alternatives which could help to avoid costly mistakes and damages to the environment and health. The SEA works to resolve conflicting demands on water usage, and could be used for policy-level assessments of cumulative multi-sectoral impacts. A key feature of the SEA

[13] International Renewable Energy Agency (2015), 'Renewable Energy in the Water, Energy & Food Nexus', 2015, http://www.irena.org/DocumentDownloads/Publications/IRENA_Water_Energy_Food_Nexus_2015.pdf

[14] De Strasser and others (2015), A Methodology to Assess the Water Energy Food Ecosystems Nexus in Transboundary River Basins, Water 2016, 8(2), 59.

[15] For a brief overview of approaches and tools, the following source could be referred to: United Nations Economic Commission for Europe (2015), 'Reconciling resource uses in transboundary basins: Assessment of the water-food-energy-ecosystems nexus'; Mark Howells and others (2013). Integrated analysis of climate change, land-use, energy and water strategies. Nature Climate Change, vol. 3, pp. 621–626. IAEA, Annex VI: Seeking sustainable climate, land, energy and water (CLEW) strategies. In Nuclear Technology Review (Vienna, International Atomic Energy Agency, 2009).

procedure is that it facilitates communication and consultations among stakeholders (central and subnational governmental agencies, the business sector or the public) in streamlining policies – not only at the national level, but also at the international level in cases where transboundary impacts are expected – and by promoting transboundary cooperation. SEA is complementary to environmental impact assessment at project level. For example, focusing on energy, SEA could reveal significant cumulative environmental effects of planned hydropower plants early in the process. Such cumulative effects could be significant even if individual hydropower plants do not have significant impact, as identified and addressed through the environmental impact assessment (EIA) procedure. SEA could also bring its strategic and integrated approach to identifying geographical areas in which large scale wind and solar photovoltaic projects could be located, while reflecting on environmental, social and economic considerations.

C. Sustainable hydropower guidelines

29. Another Sustainable hydropower guidelines constitute another example of a tool with application in a transboundary context of the water-food-energy-ecosystems nexus. The guidelines outline an approach for increasing hydropower potential, while at the same time meeting the obligations of water management and environmental legislation. They are based on the principle of sustainability, which discusses how resources should be managed in a holistic way, coordinating and integrating environmental, economic and social aspects. An often quoted example at the transboundary level so far is the Guiding Principles on Sustainable Hydropower Development in the Danube Basin[16], which were elaborated on by representatives from Danube countries and their relevant sectors, thus representing their shared understanding. The Principles are primarily addressed to public bodies and competent authorities responsible for the planning and authorization of hydropower at the national, regional and local level. The Principles provide relevant information for potential investors in the hydropower sector, NGOs and the interested public.

D. National environmental standards

30. National environmental standards provide the opportunity for central governments to promote the adoption of consistent standards at the regional and municipal levels. National environmental standards are regulations which prescribe technical standards, methods or requirements for land use, beds of lakes and rivers, water use and discharge, and more. They could also prescribe technical standards, methods or requirements for monitoring. If issued in the form of a Resource Management Act, these regulations ensure infrastructure planning requirements are nationally consistent across sectors without overexploiting resources and compromising the integrity of ecosystems. With regard to renewable energy development, these standards could promote the use of environmentally-friendly energy resources with a benefit of cutting CO_2 emissions.

E. Policy guidelines for promotion of renewable energy

31. The nexus approach requires that a complex set of policies is reviewed for their intersectoral effects. Comprehensive policy guidelines could facilitate this by helping policy makers to consider interlinkages among different areas of policy at the formulation stage,

[16] International Commission for the Protection of the Danube River. Sustainable Hydropower Development in the Danube Basin: Guiding Principles (Vienna, ICPDR, 2013). Available from: http://www.icpdr.org/main/activities-projects/hydropower

while offering prompt response to nexus considerations. For example, specific policy guidelines could support the formulation of short-, medium- and long-term policies and strategies targeting the promotion of renewable energy. Integration of policy guidelines implies that policymaking in any one area considers the effects of (and on) policies and outcomes in other sectors and areas. This helps to ensure that policy is mutually coherent across the full range of dimensions, and that the effects of policy in one area do not contradict or undermine desired outcomes in others. While setting a trajectory for meeting renewable energy targets, the policy guidelines should include recommendations based on best practices tested, open the space for public consultations with relevant stakeholders and ensure greater policy coherence and co-management across sectors. For example, the Energy Community Secretariat[17] published on Policy guidelines on reform of the support schemes for promotion of energy from renewable sources in December 2015. The guidelines include recommendations based on good practices tested in the implementation of the support schemes for renewable energy by EU member states. Obviously, what makes good policy or technical approaches, depends in many ways on the context.

F. Towards an energy-specific Nexus assessment tool

32. The International Renewable Energy Agency proposes a conceptual framework for a tool which could be used to conduct basic assessment of nexus impacts of energy policy, including renewables[18]. The proposed concept uses energy balances under baseline and alternative (desired) scenarios as an input. The proposed approach estimates the water, land, emissions and cost implications of the incremental energy balance. These provide insights about the basic resources, cost and emissions implications of the analyzed energy policy. The proposed concept provides information about the impacts of a specific policy choice but does not give indications how the policy should be developed. For example, policy incentivizing utility scale solar PV installations will have specific land use impacts (land surface used), which need to be examined by decision makers. Still, providing parameters of nexus implications offers an opportunity to review the planned renewable energy policy changes under the nexus lens. The last step in the assessment is evaluation by decision makers whether the nexus impacts are acceptable and adjusting proposed policy changes accordingly. The IRENA assessment tool is in a concept stage and needs to be translated into a practical instrument which could be leveraged for more sustainable deployment of renewable energy.

IV. Examples of emerging approaches: innovating along the water-energy-food-ecosystems nexus

33. The water-energy-food-ecosystems nexus provides tangible value when it moves from the conceptual stage toward practical implementation. The nexus is already being used by both public and private sectors alike to create innovative solutions, which enable economic development and business growth in the countries. The scarcity of water is the choke point for both agriculture and energy and it is the most common focus of addressing the nexus stress. Better and more sustainable use of renewable energy is an integral part of the innovation. There are relevant considerations for assessing benefits and potential trade-offs for renewable energy to be beneficial in a local context from a nexus perspective. The

[17] Energy Community Secretariat (2015), Policy guidelines on reform of the support schemes for promotion of energy, https://www.energy-

[18] International Renewable Energy Agency (2015), 'Renewable Energy in the Water, Energy & Food Nexus', 2015, http://www.irena.org/DocumentDownloads/Publications/IRENA_Water_Energy_Food_Nexus_2015.pdf

following examples have been selected to demonstrate different concepts of applying the nexus in the context of renewable energy deployment. The first example shows the role to be played by utility as an operator of hydropower plant in improving water allocation practices in the proximity of its assets. The second example demonstrates decentralized use of renewable energy on farms. The last example pertains to leveraging bioenergy in the context of wastewater treatment facilities, which enables operators to close their energy loop in Germany. It is worth noting that for best sustainability effect, such measures can be complemented in other parts of the energy system, such as improving energy efficiency.[19]

A. Example 1 - How utilities work with farmers to leverage nexus opportunities: Electricité de France[20]

34. Utilities could play a powerful role in leveraging the nexus opportunities. Electricité de France (EDF) achieved important synergies across water-energy-food-nexus when working with major irrigators in proximity of its Serre-Ponçon hydropower plant.[21] The result is an agreement on allocation of water resources between power generation and irrigation, which makes renewable energy use more sustainable while securing buy-in from all the concerned stakeholders.

35. The Serre-Ponçon dam and reservoir is located in the Durance and Verdon River system in southeast France. The system is composed of 21 hydropower plants generating 6,500 GWh per year of renewable electricity. The system supplies drinking water and water for industrial purposes to an entire region. It also supplies water for irrigation to over 150,000 hectares of farmland. The reservoir has guaranteed storage of 450 million cubic meters of water in the summer, allowing a total annual withdrawal of about 1,800 million cubic meters.

36. At the beginning of 2000s EDF realized that it needs to address the issue of water consumption directly with the irrigators to avoid overconsumption and hence limits on power generation during peak demand. Therefore, EDF developed and signed a Water Saving Convention, an agreement with two main irrigators in proximity of the dam. The agreement sets out irrigators' commitment to reduce their water consumption and EDF's commitment to remunerating them for their savings. The agreement allows the irrigators to revise their commitment on an annual basis. EDF's approach is unique in its approach for valuing water. EDF decided to link water price to the value of energy it could produce per cubic meter, reflecting current and future energy prices in France.

37. The irrigators received an incentive to reduce their water consumption, which led them to innovate in the technology and processes for better water efficiently. The savings resulted in reduction of annual water consumption from 325 million cubic meters over 2000-2006 to 235 million cubic meters in 2015. On EDF's side, the benefits were translated into the company's capacities to generate more electricity during peak demand periods. A new agreement, following up on the original Water Saving Convention was signed in 2014 confirming the value build for its parties.

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[19] Joint Statement of the Executive Secretaries of the United Nations Regional Commissions for the 5th International Forum on Energy for Sustainable Development (4 - 7 November 2014), available at http://www.unece.org/index.php?id=37243

[20] Sarni, Will; Deflecting the scarcity trajectory Innovation at the water, energy, and food nexus, Deloitte Review, Issue 17, 2015, https://dupress.deloitte.com/content/dam/dup-us-en/articles/water-energy-food-nexus/DUP1205_DR17_DeflectingtheScarcityTrajectory.pdf

[21] The plant is designed, commissioned, and operated by EDF.

B. Example 2 – How renewable energy addresses nexus linkages at farm level[22]

38. On-farm renewable energy technology applications diversify farm income sources or reduce energy costs. Therefore they are used as a common strategy to increase resilience. The energy produced from renewable energy sources can be consumed on the farm or sold to the main grid, provided the regulatory regime allows for it. Farms in England provide an interesting example. 23% of English farms generated renewable energy in 2015[23]. The average income from energy generation was 9% of the farms' total income[24] though income of up to 52% has been reported[25]. Changes in feed in tariffs create uncertainties, which are hampering further installation of power generation capacities on farms in England. However, advances in energy storage could change prospects for on-farm renewable energy use.

39. Similar situation developed in Italy. Due to a successful feed-in tariff scheme, 13% of the total installed solar PV capacity was installed in the agricultural sector[26] raising concerns of speculation and competition with farms' core agricultural activity[27]. This risk is expected to decrease with the feed-in-tariff scheme terminated and current regulation favouring self-consumption and small installations[28][29]. Meanwhile, the attention to of energy production and consumption in agriculture stays high, with the Ministry of Energy and Forestry joining forces with the Italian National Agency for New Technologies, Energy and Sustainable Economic Development for developing innovative solutions for energy efficiency and production from renewables[30]. This experience show the value of revising and adjusting the policies as the situation evolves.

40. Whilst renewable energy clearly contributes to renewable energy production targets at national level, they could affect several parts of the nexus positively or negatively. Renewable energy affects water quality in a positive manner, for example by using farmyard manure for anaerobic digestion. Negative impacts during construction and when more crops are grown for digestion include erosion. Impacts for food and ecosystems also need to be considered. On the food side, this may include land lost for food production and potential changes in micro-climate. Risk to habitat, for example fish migration due to micro-hydro construction and bird collisions with wind turbines are the most common concerns.

41. The nexus approach should be leveraged to achieve more sustainable development of renewable energy sources. Evaluating in advance how changes in energy supply might affect

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22 Todman, L., 'On-farm renewables and resilience: a water-energy-food nexus case study', Geophysical Research Abstracts, Vol. 19, EGU2017-8070, 2017.

23 DEFRA (2016), Farm Accounts in England – Results from the Farm Business Survey 2015/16

24 Ibid.

25 Farm Power (2014) Eploring the size of the prize

26 Filippo Sgroi *, Salvatore Tudisca, Anna Maria Di Trapani, Riccardo Testa and Riccardo Squatrito, Efficacy and Efficiency of Italian Energy Policy: The Case of PV Systems in Greenhouse Farms, Energies 2014, 7(6), 3985-4001, http://www.mdpi.com/1996-1073/7/6/3985/htm#B14-energies-07-03985

27 Produzione energetica e sistema rurale: monitoraggio delle tendenze in atto. Presentation at the Sustainable Energy Week 24-28 June 2013. GSE – Roma.

28 Qual Energia, April 2014, http://m.qualenergia.it/content/italian-pv-beyond-incentives-and-through-regulatory-changes-toward-self-consumption

29 Protecta Web , Fotovoltaico senza incentivi: quali modelli di business nel nuovo mercato, http://www.protectaweb.it/energia/rinnovabili/2614-fotovoltaico-senza-incentivi-quali-modelli-di-business-nel-nuovo-mercato

30 http://www.enea.it/it/Stampa/comunicati/agricoltura-accordo-enea-mipaaf-per-efficienza-e-risparmio-energetico

the water, food sectors or ecosystems as a whole may avoid unintended consequences and capitalise on win-wins between the sectors.

C. Example 3 – How energy potential of waste-water could be leveraged[31]

42. The Jenfelder Au eco-district addresses water-energy linkages leveraging bioenergy opportunities in the content of urban nexus linkages. The district is part of the Hamburg Water Cycle, which is a closed-loop system which optimizes the use of resources by integrating two systems, the energy production system and the waste water treatment system. The district collects wastewater from toilets and diverts it into a biogas plant. The biogas is sued to produce heat and electricity for the neighbourhood of 770 accommodation units and 2,000 residents. Grey water from residential units is recycled separately to be used for irrigation and flushing. Rainwater is also integrated in the system for irrigation purposes.

43. The project has been championed by the Hamburg municipality water company, Hamburg Wasser. The company first demonstrated the system's feasibility in the environmental theme park, Gut Karlshöhe where it was operationalized for educational purposes. The system was then adopted by the Wandsbek District Authority followed by the Jenfelder's Au neighborhood.

44. The system has several benefits addressing water-energy nexus linkages. Biogas usage from waste-water reduces external energy requirements in waste-water treatment. The system is CO2 emissions free. The separation of grey and black water and promotion of onsite green areas reduces the stress placed on storm water infrastructure. This reduces the risk of flooding while increasing the neighbourhood's resilience to climate change. The benefits of the system could also be extended to agriculture. The biogas plant's fermentation residues could be re-used in farming.

D. Basin case studies: Opportunities for renewable energy and nexus synergies

45. The water-food-energy-ecosystems nexus assessment has been completed in four transboundary river basins under the Water Convention: The Alazani/Ganykh, Syr Darya as well as the Sava River Basin and its tributary the Drina. The results of these assessments are summarised in this section with focus on renewable energy and nexus opportunities. All of the riparian countries have active hydropower development and the potential to exploit other renewable sources. Applicable uses include power generation, heating and cooling and transport.[32] The basins covered by this assessment have so far developed the potential for large scale (Syr Darya), and small to medium scale (Sava, Alazani/Ganykh) hydropower. All the basins have potential to develop other renewable technologies such as solar, wind, bioenergy and geothermal (Alazani/Ganykh). The large hydropower capacity could facilitate greater penetration of solar and wind by providing balancing services, i.e. storing energy from intermittent renewable sources and then providing energy supply when demand peaks. Modern renewable energy technologies on the other hand could reduce pressure on water-

[31] GIZ (2014), Hamburg, Germany, Achieving energy-efficiency through the Hamburg Water Cycle in the Jenfelder Au eco-neighborhood, Urban NEXUS Case Story 2014 – 24, http://www2.giz.de/wbf/4tDx9kw63gma/24_UrbanNEXUS_CaseStory_Hamburg.pdf

[32] REN21 (2015), United Nations Economic Commission for Europe Renewable Energy Status Report, http://www.unece.org/energywelcome/areas-of-work/renewable-energy/unece-renewable- energy-status-report.html

energy-food trade-offs in hydropower between water for energy production and irrigation or environmental needs.

46. Depending on the context, diverse solutions to externalities from hydropower development and making renewable energy more sustainable can be identified, ranging from technical measures to information and governance. Some selected examples (with a focus on energy sector measures):

(a) The Sava and Drina River Basins - Develop hydropower sustainably and integrate other renewable energies; coordinate operation of hydropower plants (for flood control, for energy system benefits, ensuring environmental flow) and development of new capacities ideally with a basin-wide strategy, taking into account the trade-offs with other water uses and the enviornment;

(b) The Alazani/Ganykh River Basin - Facilitate access to modern energy sources and energy trade; minimize impacts from new hydropower development; apply catchment management to control erosion to limit impacts on infrastructure;

(c) The Syr Darya River Basin - Promote restoring the regional grid and vitalizing energy market; improve efficiency in energy generation, transmission and use; improve efficiency in water use (especially in agriculture)

47. Detailed examples of these basin case studies are included in the ECE brochure “Deployment of renewable energy: The water-energy-food-ecosystems nexus approach to support the Sustainable Development Goals”[33].

V. Conclusions

48. Renewable energy could play a strong role in helping to achieve better management of resources and synergies within the water-energy-food-ecosystems nexus. The Agenda 2030 on Sustainable Development could benefit from the nexus approach to speed up collaboration across sectors and between countries and to promote informed discussion about the trade-offs. The renewed process for achieving the Sustainable Development Goals is an opportunity to make the nexus approach a common tool supporting decision makers and industry alike to develop renewable energy potential in a sustainable manner.

49. Renewable energy could have multiple contributions to address the nexus challenges in the context of transboundary collaboration. The following are the main potential benefits to be considered by stakeholders at basin level:

(a) Well selected renewable energy technologies could contribute to reducing and optimising water needs in energy production (Example 3 – How energy potential of waste-water could be leveraged);

(b) Renewable energy could provide a more sustainable energy source in water supply chain (Example 1- How utilities work with farmers to leverage nexus opportunities - EDF);

(c) Off-grid renewable solutions could supply energy to agricultural and food processing activities (Example 2 - How renewable energy addresses nexus linkages at farm level);

(d) The nexus assessment could help in making bioenergy and hydropower developments more sustainable by providing insights into their impacts on water, land and ecosystems;

33 The report is available at: http://www.unece.org/index.php?id=46026

(e) Taking the synergies and impacts into account in planning and developing strategies can bring about wider application and acceptance to renewable energy, also hydropower where the trade-offs may be more prominent.

50. Climate change is a reinforcing factor for the nexus approach, which seeks to take both mitigation and adaptation into account. Climate change threatens water, energy and land resources availability. The nexus approach highlights opportunities, which could mitigate climate change: Reduced conventional energy use, reduced CO2 emissions, resource efficiency and preservation of ecosystems. Renewable energy is central to all of these climate change mitigation measures.

51. Decision makers have a number of tools at their disposal to examine the water-energy-food-ecosystems nexus and identify opportunities for renewable energy. The nexus assessment methodology applied in the basin case studies in collaboration with the Water Convention provides a holistic approach which could unveil full spectrum of solutions including renewable energy. Strategic environmental assessment and environmental impact assessment could be explored in a transboundary context along with sustainable hydropower guidelines. National environmental standards and policy guidelines for renewable energy development could offer an additional opportunity to identify nexus opportunities. The IRENA's concept for an energy-specific nexus tool could be the way forward to build an assessment tool which is adapted to renewable energy.

52. The nexus approach can be very practical if adopted by the industry, with resource efficiency and improved risk management benefits. Utilities, producing electricity, managing waste water or farmers could build value through integration of renewable energy through the nexus approach. Cases in France (EDF) and Germany (Jenfelder Au eco-district) provide examples to follow. The Drina Basin case study offers insights into possible nexus interlinkages and solutions using renewable energy. For example, potential for non-hydro renewable energy (solar, biomass but also perhaps wind) could be identified bearing in mind the nexus considerations. Implementing land consolidation policies and developing practice in using the strategic environmental assessment could offer a solution to this specific food - land-energy nexus situation.

53. Commitment and implementation of better policies and showcasing of successful projects is necessary for attracting financing into renewable energy projects in conjunction with the nexus approach. While changing the macro environment may be challenging, facilitating administrative processes at local level may be helpful for moving forward.

54. Whatever the solution, developing transboundary collaborations is critical for achieving practical results from the nexus approach, including renewable energy development in a sustainable manner. Where cooperation is limited, riparian countries are more exposed to external shocks. The economic cost of non-coordination can be significant. For example, when multiple uses of infrastructure cannot be agreed upon, costly investments might be made in response to duplicate or extend infrastructure. Complementarities in different sectors and countries (e.g. in the energy mix as a greater diversity across well-connected countries with flexible markets is more energy secure) can create a broader package of benefits (e.g. renewable energy technologies deployment) that are attainable through cooperation.