UNECE

Deployment of Renewable Energy:

The Water-Energy-Food-Ecosystem Nexus Approach to Support the Sustainable Development Goals

Good practices and policies for intersectoral synergies to deploy renewable energy

UNITED NATIONS

Contents

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I. Introduction

Member countries in the United Nations Economic Commission for Europe (UNECE) 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 than 3%. Higher shares of renewable energy are driven by hydropower developments, with consequences for the management of water, food, energy sectors and other ecosystems. Several countries in the region, including some of the riparian countries covered by this policy brief, continue to face strategic energy challenges such as ensuring energy security, seasonal power outages and insufficient energy supply (See Figure 1 for details on the selected countries), which could potentially become drivers for renewable energy development[1]. Renewable energy could play a central role in these countries' climate change mitigation efforts as they move to implement their obligations under the Paris Climate Agreement.

Share of renewable energy

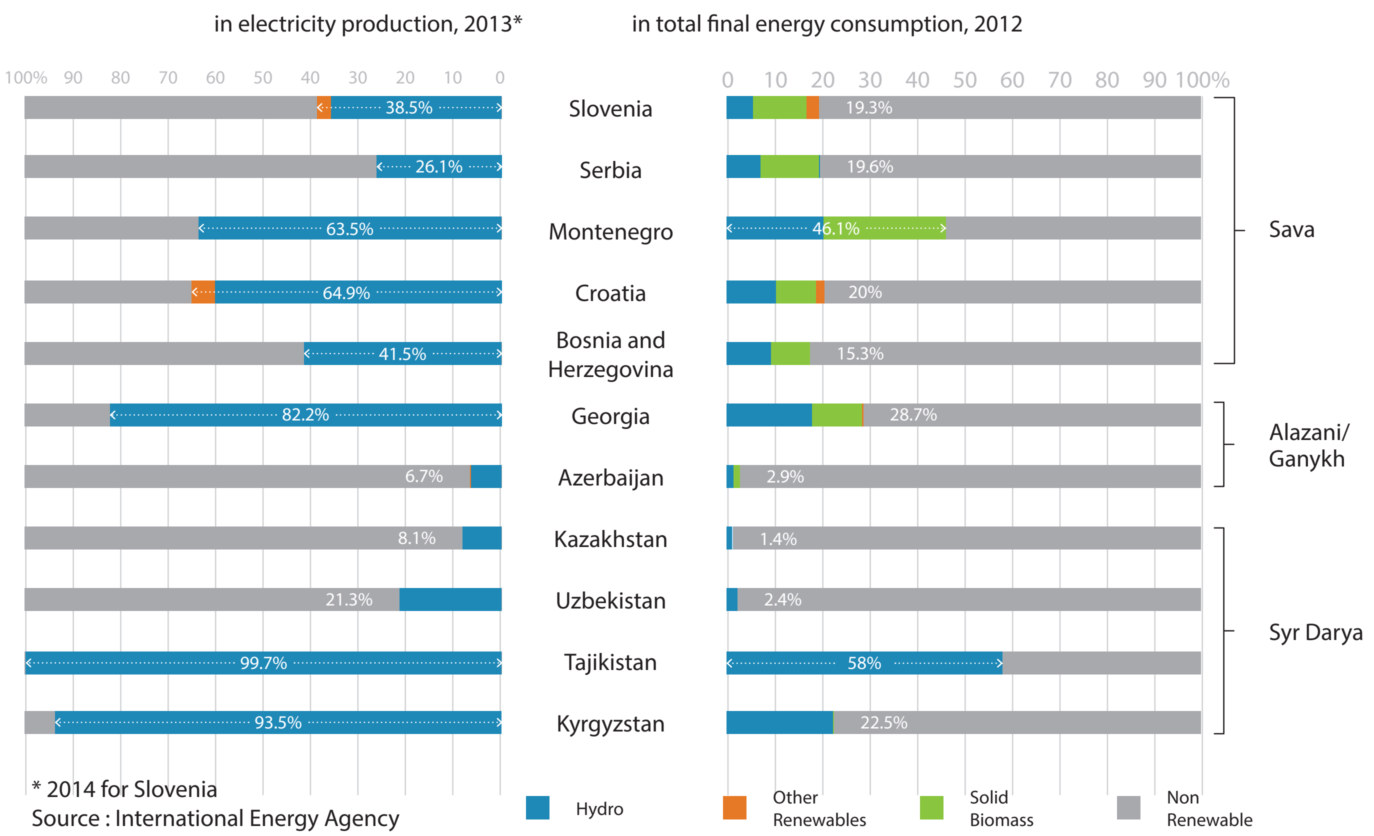


Figure 1: Renewable Energy in the Context of Energy Sector Challenges in Riparian Countries[2]

The UNECE, 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 UNECE has been using the nexus approach to assist the Member States achieve a better understanding of the intersectoral synergies and leverage linkages between the energy, water and food sectors and the ecosystems.

The UNECE 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 among 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 work includes considerations of water-energy-food-ecosystems nexus, in cooperation with the Task Force on the Water-Food-Energy-Ecosystems under the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, and is placed in the context of 2030 Agenda for Sustainable Development which strives to fulfil its 17 Sustainable Development Goals (SDGs).

The SDGs are closely interlinked and benefit from increased synergies in their deployment. 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. Clearly, most energy generation forms depend on water to a variable degree and thus benefit 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.

Access to energy is a precondition to economic growth driving improved health conditions and education. More sustainable energy is a basis for improved resilience. Figure 2 demonstrates the linkages between affordable and clean energy and other SDG's, namely those related to poverty elimination, decent work and economic growth, industry innovation and infrastructure, reduced inequalities and responsible consumption and production. Achieving the Sustainable Development Goals will require coordination across sectors, coherent policies, and integrated planning.3

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. 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 UNECE region and improving it sustainably.

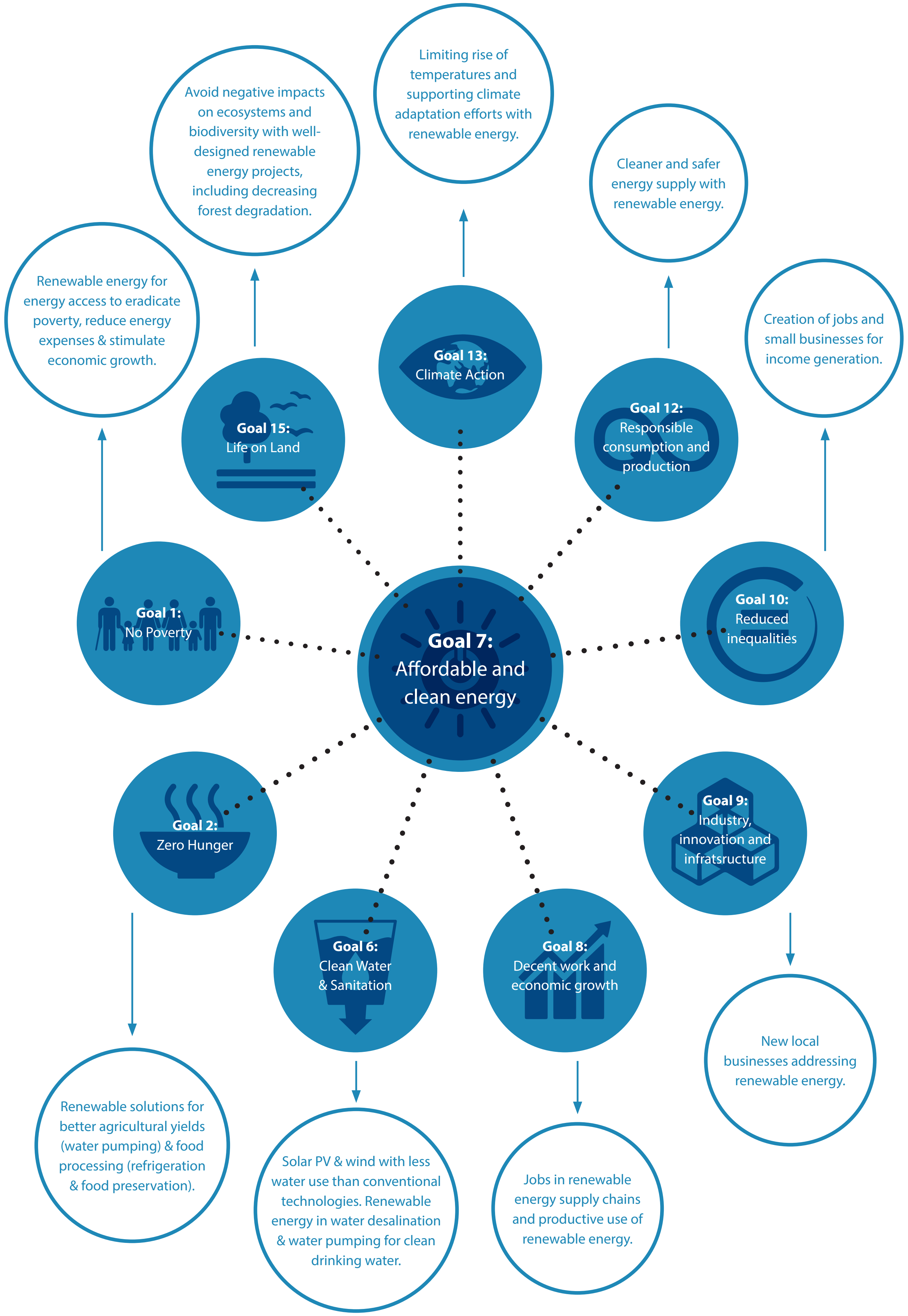


Figure 2: Nexus approach to Sustainable Development Goals: Affordable and clean energy[3]

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

Renewable energy could play a strong role in helping to achieve better management of 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.

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[4] prepared by the International Renewable Energy Agency (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.[5]

Renewable energy, depending on the selected technology could reduce water requirements in energy production.[6] For example, electricity generation using solar photovoltaic (PV) and the wind requires a limited amount of water, e.g. for cleaning solar PV panels for improved efficiency CSP and geothermal use heat in electricity production and have 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.

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).

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 energy could be utilized, but other renewable sources could also be adopted, for example, solar and geothermal heat can be used as dehydration energy sources in food processing.

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 a 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.

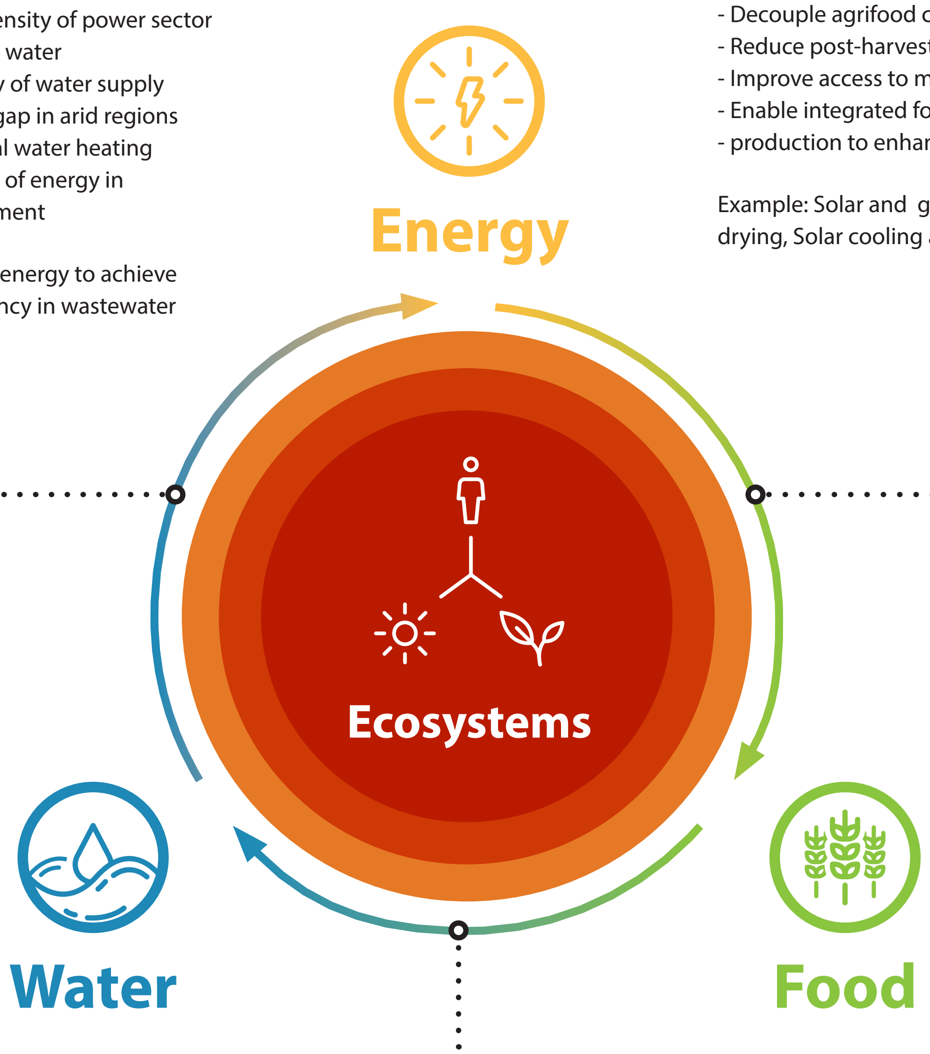
Other renewable energy technologies could complement hydropower generation. This may relieve the pressure on water resources use and trade-offs between power generation and irrigation or other water uses. The nexus approach helps to identify the stress points where hydropower development is creating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

Renewable energy contribution in energy/water nexus
- Reduce water-intensity of power sector
- Improve access to water
- Enhance reliability of water supply
- Bridge the water gap in arid regions
- Replace traditional water heating
- More efficient use of energy in wastewater treatment

Example: Using bioenergy to achieve energy self-sufficiency in wastewater treatment plants

Renewable energy contribution in energy/food nexus
- Decouple agrifood chain from fossil fuels
- Reduce post-harvest losses
- Improve access to modern cooking fuels
- Enable integrated food and energy
- production to enhance security

Example: Solar and geothermal food drying, Solar cooling and refrigeration



Renewable energy contribution in water/food nexus
- Improve access to and sustainability of water supply for agriculture use

Example: Solar in water pumping and conveyance, Solar irrigation

Figure 3: Renewable energy opportunities in the energy-water-food-ecosystems nexus

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 between 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, nexus could be used as a framework for solutions to emerge based on examination of plans of other entities or countries. In this context, 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).

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 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.

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 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 of unifying elements of such collaborations.

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 UNECE 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.

The UNECE Group of Experts has been actively supporting the identification of opportunities, benefits, and the tools for the application of the nexus to facilitate transboundary collaborations and increase understanding of water, energy, food sectors and ecosystems, including the 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-Eastern Europe and 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.

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[7]), 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[9] and Drina Basin assessment was being finalised at the time of writing this 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

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 into 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.

Nexus assessment methodology

The nexus assessments methodology was developed under the Water Convention. The assessment provides an overview of the interdependencies across water, energy, food, and the related ecosystems. Using a 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 UNECE Group of Experts on Renewable Energy contributes to the application of the nexus assessments methodology in relation to the increase of renewable energy uptake.[10]

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.

Analytical frameworks are used to assess the impacts of policies upon different sectors. They inform policy making 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 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[11].

The analytical framework[12] 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.

Several analytical tools[13] 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, the improvement of monitoring, data management, forecasting process, and their 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.

Strategic environmental assessment and environmental impact assessment in a transboundary context

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 preparation of policies, plans, programmes, and specific development projects 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 UNECE 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.

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 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 can streamline application of environmental impact assessments at project level. For example, focusing on energy, SEA could reveal significant cumulative environmental effects of planned hydropower plants early in the planning process. Such cumulative effects could be significant even if individual hydropower plants do not have a 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.

Sustainable hydropower guidelines

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[14], which were elaborated by the representatives from the 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.

National environmental standards

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, management of lake and river basins, water use and discharge, and more. They could also prescribe technical standards, methods or requirements for monitoring. A resource management act is one of the forms to bring consistency across sectors at national level to infrastructure planning requirements to avoid 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.

Policy guidelines for promotion of renewable energy

The nexus approach requires that a complex set of considerations is taken into account in developing renewable energy (See Figure 4). Comprehensive policy guidelines could facilitate this by helping policy makers to consider interlinkages among different areas of policy at the formulation stage, 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[15] 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.

Towards an energy-specific nexus assessment tool

The International Renewable Energy Agency proposes a conceptual framework for a tool which could conduct basic assessments of nexus impacts on energy policy, including renewables[16]. 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 analysed 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 the 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.

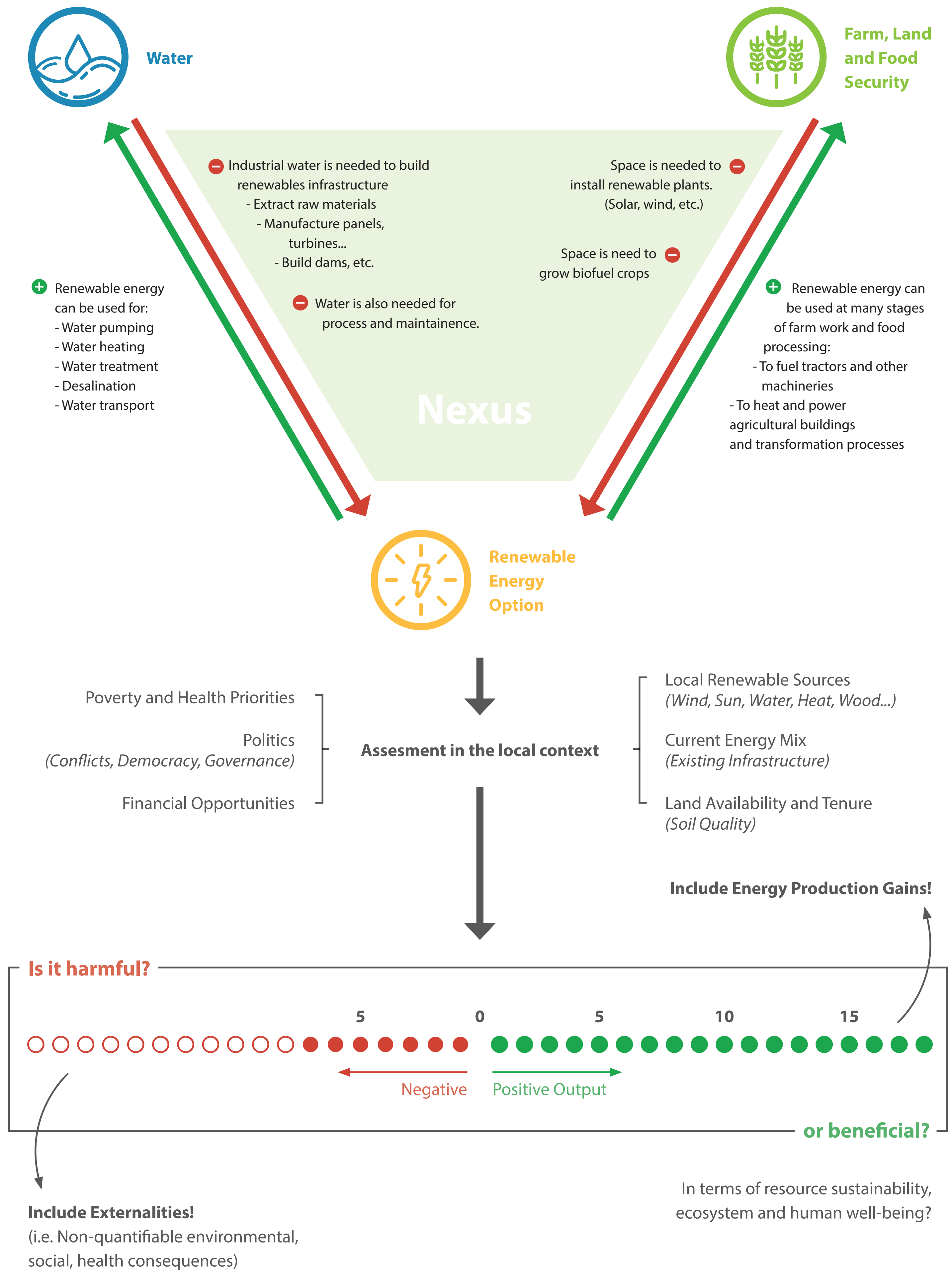


Figure 4: Water, land, renewable energy trade-offs in developing renewable energy sources

IV. Good practices: Innovating along the water-energy-food-ecosystems nexus

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 riparian 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. Figure 4 indicates some relevant considerations for assessing benefits and potential trade-offs for renewable energy to be beneficial in a local context from a nexus perspective. The 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 a utility as an operator of a hydropower plant in improving water allocation practices in the proximity of its assets. The second example demonstrates the decentralised 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.[17]

Example 1 - How utilities work with farmers to leverage nexus opportunities: Electricité de France[18]

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.[19] 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.

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.

At the beginning of 2000s, EDF realized that it needs to address the issue of water consumption directly with the irrigators to avoid over consumption 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 for valuing water is unique. 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.

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 the 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 built for its parties.

Example 2 - How renewable energy addresses nexus linkages at farm level[20]

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[21]. The average income from energy generation was 9% of the farms' total income[22] though an income of up to 52% has been reported[23]. 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.

A similar situation has 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[24] raising concerns of speculation and competition with farms' core agricultural activity[25]. This risk is expected to decrease with the feed-in-tariff scheme terminated and current regulation favouring self-consumption and small installations[26, 27]. 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[28]. This experience depicts the value of revising and adjusting the policies as the situation evolves.

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 microclimate. The risk to habitat, for example, the fish migration due to micro-hydro construction and bird collisions with wind turbines are the most common concerns.

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

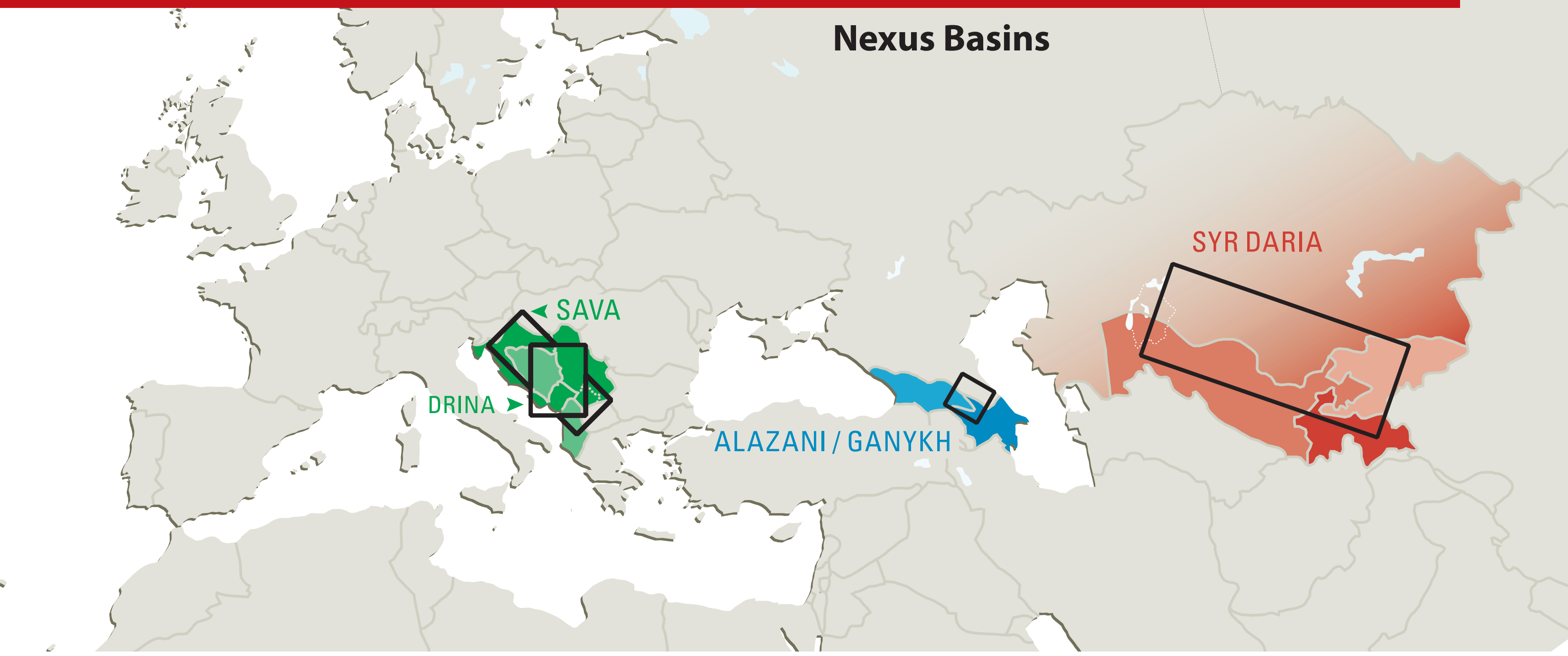
Example 3 – How energy potential of waste-water addresses urban nexus[29]

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 used 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 into the system for irrigation purposes.

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 Au neighbourhood.

The system has several benefits addressing water-energy nexus linkages. Biogas usage from wastewater reduces external energy requirements in wastewater treatment. The system is CO_2 emissions free. The separation of grey and black water and promotion of onsite green areas reduces the stress placed on stormwater 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.

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



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 more 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, cooling, and transportation.[30] 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. 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-energy-food trade-offs in hydropower between water for energy production and irrigation or environmental needs.

Alazani/Ganykh River Basin

The Alazani/Ganykh Basin is a sub-basin of the Kura Basin. The Alazani/Ganykh River, shared by Georgia and Azerbaijan, extends over an area of 11,717 km^2, with 59% of the basin being in the territory of Georgia and 41% in Azerbaijan. A bilateral agreement between Azerbaijan and Georgia on the shared water resources of the Kura River Basin is currently being negotiated. Renewable energy sources, namely hydropower, are being explored for export through international collaboration of the riparian countries. Hydropower potential is locally significant although its development in the upper tributaries is risky due to the geomorphology. Georgia has been successfully attracting investors into hydropower and is starting to consider wind and solar potential. Use of fuelwood is an issue. Georgia holds the potential for modern renewable technologies (bioenergy, geothermal, solar, wind) to reduce the impact of fuelwood exploitation on land erosion and the associated risk of aggravating vulnerability to effects of flooding. Azerbaijan, a large oil and gas producer, plans to exploit solar, wind, biomass and small hydropower (0.5 – 10 MW) and supports the deployment of the latter through power purchase guarantees.

Nexus overview:

• *Linkages*:
The basin has a number of nexus linkages which could be leveraged. Energy-land linkages are present through high level of fuelwood usage for heating and cooking in rural areas in Georgia. Land-water linkages exist given the negative impact of deforestation on hydrological flow and significant water losses due to degraded irrigation schemes. Issues of access and affordability of modern fuels in the upper basin, which leads to subsequent erosion of land through deforestation by the collection of fuelwood, affects water resources and population through higher flooding risks.

• *Trends*:
The basin has productive agricultural land, which relies on secure water and energy supply. Growth in agriculture and agro-industry will be driving water demand and water transfer, as well as the exploitation of hydropower potential. The need of water for energy purposes, either for electricity generation needs or cooling, is projected to rise significantly by 2030.

• *Opportunities*
Nexus could be leveraged by maximising the benefits of multiple uses of resources and the optimization of resources development at a basin scale. Ensuring that new hydropower plants are built in combination with irrigation systems, while minimising the impacts on the environment by preferring run-of-the-river type hydropower design would be beneficial. The preparation of the National Water Strategy and National Strategy on the Use of Alternative and Renewable Energy Sources in Azerbaijan, and the updating of the Georgian Water Law, along with the development of the new Energy Strategy for Georgia, provide an opportunity to improve consideration of intersectoral effects and to develop mechanisms to strengthen intersectoral coordination both at national and transboundary level.

• *Solutions*
Establishment and improvement of basin governance through integrated management of basin resources could be pursued. Georgia and Azerbaijan could collaborate on exploiting complementarities in their resource base (e.g. Georgian forests and Azerbaijani gas) and risk management (coordinated hydropower development and flood risk management). Concluding the bilateral agreement and establishing a multi-sectoral body for its implementation would improve collaboration. Introducing economic instruments[31], especially in agriculture, could set the scene for rational use of water and energy, while motivating investments in new technologies and infrastructure extension. Promoting the development of renewables (other than hydropower) – such as the currently planned production of electricity and heat from biomass, solar, wind etc. on the Azerbaijani side of the basin could contribute to relieving the pressure on energy infrastructure.

Syr Darya River Basin

The Syr Darya is the longest river in Central Asia (3,019 km from the headwaters of the Naryn) and the second largest in terms of water quantity (annual average runoff of 36.57 km^3). The basin is shared by Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. Despite the Interstate Commission for Water Coordination (ICWC) and the International Fund for Saving the Aral Sea (IFAS) providing frameworks, basin level cooperation has degraded and energy authorities are not involved in the organizations of interstate water cooperation. Some of the world's largest oil, coal and natural gas reserves are found in Kazakhstan and Uzbekistan. The basin is home to both existing and planned oil and gas pipelines from Turkmenistan, Uzbekistan, and Kazakhstan to the Russian Federation and China. Policies in Kazakhstan and Uzbekistan target the optimization of supply and the modernization of power. Kyrgyzstan and Tajikistan display a very high dependency on hydropower to meet electricity and heating demand and the policy focus is on the expansion of hydropower generation capacity. From an energy production perspective, the Syr Darya Basin is vital for Kyrgyzstan, which is also planning to expand its hydropower capacity. There is both the potential for and interest in developing hydropower, especially upstream. Significant potential for developing other renewables, e.g. wind and solar, is currently unexploited at the basin, despite hydropower allowing for extension of power generation through the integration of other renewable energy sources. Kazakhstan has a well-articulated framework for renewable energy, including feed-in tariffs, while Uzbekistan is building 300 MW of solar PV through public tendering.

Nexus overview:

• *Linkages:*
The main linkages are water-energy (hydropower and irrigation) and water-land (large and complex irrigation schemes, soil salinization and water quality degradation).

• *Trends:*
The evolution of the links between land, water and energy resources in the Syr Darya River Basin are facing high uncertainties. Forecasts show, however, that the demand for water resources for electricity generation and cooling (Tajikistan and Uzbekistan), as well as the demand for energy resources for food production and distribution (Kyrgyzstan and Tajikistan) will rise significantly by 2030. To supply larger amounts of energy, Kyrgyzstan, which is already heavily dependent on hydropower and is experiencing substantial grid losses, plans the building of two dams: Kambarata 1 and Upper Naryn. Although addressing a pressing challenge, the construction of these dams may further diminish access to irrigation water downstream but may also allow for using the existing flow regulation (and storage) capacity to better serve also irrigation needs. Current dynamics towards expansion of coal-based generation capacities in the upstream countries improves their energy security and production on the one hand, but may increase negative environmental impacts on the other.

• *Opportunities*
Cooperation involving all the countries and sectors has a great potential in optimising the use of available resources. Major opportunities are found in vitalising the regional energy market and exploring opportunities for energy-water exchanges, investing in expanding electricity networks and re-establishing grid interconnections, diversifying energy sources to reduce dependency on hydropower, implementing policy mixes to support energy and water efficiency and the upgrade of the related infrastructure to minimise system losses especially in agriculture, and boosting the trade in agricultural products.

• *Solutions:*
Transboundary cooperation between riparian countries is essential given that the Syr Darya Basin demonstrates a considerable number of trade-offs across sectors, resulting in an inefficient use of resources, environmental degradation, and tension between riparian countries. Investing in the diversification of energy sources, particularly in upstream countries – as the use of renewable energy sources such as wind (in Tajikistan) and small hydro (in Kyrgyzstan) would reduce the peak demand for large hydropower. National reforms to water and energy pricing could also support a more rational use of water and energy resources. For example, Kyrgyzstan increased electricity tariffs for 2014-2015 and there are indications that the electricity consumption by up to 20%. These initiatives could generate financial resources to pay for infrastructure modernisation and capacity expansion, including the integration of more renewable energy sources other than hydropower.


Photo by: Eduard Kim
Web: www.savacommission.org

Sava River Basin

The Sava Basin covers territory in Bosnia and Herzegovina, Croatia, Montenegro, Serbia, Slovenia, and Albania. The basin is home to a significant share of hydropower, water and land areas and economic activity of its riparian countries – for example, 53% of the electricity generation capacity within the riparian countries is located within the basin. Water governance is well developed, where the Framework Agreement on the Sava River Basin (FASRB) is used to provide the legal framework for cooperation.[32] The International Sava River Basin Commission (ISRBC) operates as the implementing body of the FASRB. Relevant EU policies are expected to push for closer coordination of Sava countries in the energy sector through the Energy Community when those riparians that are currently not EU member States increasingly transpose the EU acquis communautaire. It is expected that by 2030 around 30 % of new thermal power plants and 19 % of new hydropower plants of all riparian countries will be dependent on Sava Basin's water resources for electricity generation and cooling. Each country in the Sava Basin has set specific targets for renewable energy and mitigation of greenhouse gases. The Royal Institute of Technology (KTH) anticipated that renewable energy targets in Sara River Basin countries could reach 55% by 2020, with hydropower contributing 33%. Due to its low cost, hydropower is under pressure to be exploited at a larger scale. However, future changes in the availability of water for hydropower and the need to reconcile with environmental objectives call for more flexibility in the energy system. The integration of other renewables, e.g. wind, solar and biofuels, is being pursued.

Nexus overview:

• *Linkages:*

The main linkages are energy-water (hydropower generation, cooling thermal power plants, and development of wastewater treatment) and water-land (increase in irrigation, control of erosion and sedimentation, flood protection). The trade-off between hydropower development and agricultural expansion is presently not prominent but needs to be carefully managed as irrigation needs are expected to increase.

• *Trends:*

The basin has the largest proportion of hydropower generation in the region – in numbers, 15% in Slovenia, 5% in Croatia, 24% in Bosnia and Herzegovina, 31% in Serbia and 45% in Montenegro, of national hydropower generation[33]. The cumulative effect of agricultural expansion and its associated increase in water demand and the substantial increase in low flow conditions (dry spells) and flooding instances, makes the energy system vulnerable to the status of water resources, which is expected to be further reflected in the energy trade (net electricity imports).

• *Opportunities:*

The nexus assessment identified several opportunities: Promotion of multi-functional infrastructure to balance electricity generation, flood control and irrigation, energy-efficient wastewater treatment and alignment of energy and water planning to reflect water constraints and the increased use of energy for pumping. ISRBC could be better used as a platform to discuss all the relevant basin resources and for a consultation process to review the basin-level impact of national and sectoral development strategies.

• *Solutions*

The basin countries need to coordinate hydropower with other infrastructure investments, such as those for other renewable energy sources. The Guiding Principles on Sustainable Hydropower (ICPDR, 2013) need to be applied. Preparation of River Basin Management Plans at the transboundary level helps ensure efficient and coordinated uses of water in the energy sector and agriculture. The demand for hydropower provides the opportunity to invest in multi-functional infrastructure or to adopt designs that minimise the impact on the environment.

Drina River Basin

The Drina River Basin has a total surface area of 19,570 km^2 and covers territory in Bosnia and Herzegovina, Montenegro, Serbia and a very small share of Albania. The basin is characterised by untouched basins and high biodiversity which are currently under threat from pollution. The River forms an international boundary along some of its reaches between Serbia and Bosnia and Herzegovina. While there is no specific basin-level cooperation mechanism for the Drina Basin, it benefits from well-developed water governance mechanism. Robust governance mechanisms are in place at the regional level of the Sava River Basin, of which the Drina is a sub-basin. The Framework Agreement on the Sava River Basin ("FASRB") establishes a legal framework for basin cooperation. There are strong water governance mechanisms in place at the regional level of the Danube River Basin, which affects its sub-basin; the Sava, and in turn the Sava's sub- basin, Drina. The Drina Basin holds important hydropower potential, which is still largely unexploited. All the riparian countries plan to develop new hydropower in the basin. Building new infrastructure will make coordination on dams operation more urgent. There is potential to develop other renewable energy technologies in the basin (bioenergy and solar mostly, with more limited geothermal resources).

The UNECE Group of Experts on Renewable Energy participated in various phases of the assessment of the Drina River Basin contributing with specific expertise to consider how to include the renewable energy deployment in these countries within a more integrated approach.

Information box:
Status of renewable energy in the riparian countries of Drina Basin

In Montenegro and Serbia, hydropower represents almost half of the renewable energy share (19.7% of Total Final Energy Consumption (TFEC) in Montenegro and 9.7% of TFEC in Serbia). All countries have a high share of traditional solid biofuels in their share (See Figure 5). Modern solid biofuels represent only a small share of their renewable energy share in TFEC.

All countries share the interest to keep on deploying hydropower and the basin itself is potentially central for this development, with eight hydropower plants (and many smaller ones) accounting for 1,772 MW of power installed, and an estimated 60% of hydro potential in the basin is still unexploited[34]. At the basin level, hydropower is most developed in the Serbian part with 1,028 MW installed constituting around 40% of the total hydropower capacity of the country. Montenegro follows with 360 MW of hydropower installed (52% of the total hydropower installed in the country) Finally, Bosnia and Herzegovina has 333 MW of hydropower (15% of total hydropower).

The basin also hosts coal power generation capacities in all three countries. In Serbia, there is 54 MW of installed coal capacity, representing 1% of the total coal power installed capacity in Serbia. There is 225 MW in Montenegro. The Pljevlja coal power plant is the only one in Montenegro. Bosnia and Herzegovina has 325 MW of coal power installed in the basin, representing 16% of total coal power installed capacity at country level.

All three countries have committed to renewable energy targets as part of their obligations under the Energy Community membership. Bosnia and Herzegovina committed to a binding target of 40% renewable energy in gross final energy consumption in 2020 and overachieved this target in 2014. Montenegro committed to a binding 33% target in 2020 and overachieved this target in 2014. The overachieving of the targets was based on the revision of the countries' biomass data reported to Eurostat. Serbia committed to a binding 27% target in 2020 and as of 2014 reported renewable energy shares below the target.[35]

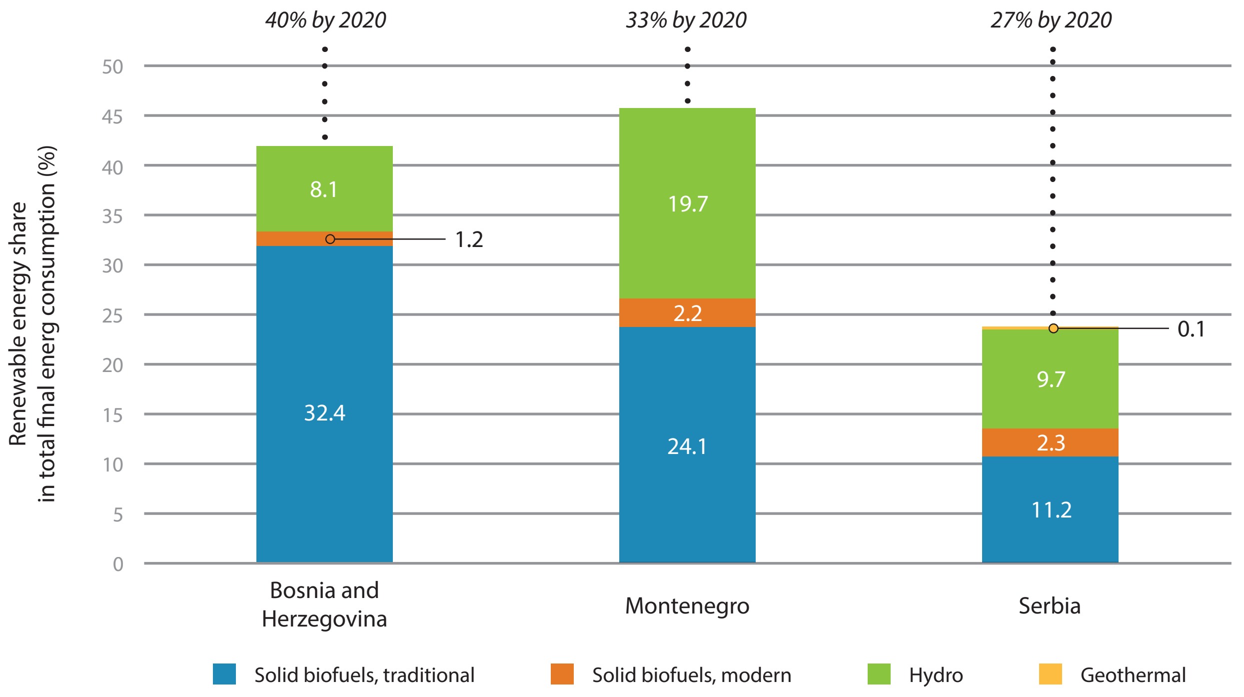


Figure 5: Current share of renewable energy in total final eergy cosumption & renewable energy targets
Source: *Share in total final energy consumption - IEA, Targets – Energy Community*

Nexus overview:

• *Linkages:*
There are a number of strong linkages across three clusters of Drina Basin: water flow regulation, rural development and water quality and solid waste. Use of water is important for both hydropower and thermal power generation. Hydropower dams have negative impacts on the river ecosystems and the ability of the river to clean itself and maintain high water quality. Water flow regulation for hydropower has an impact on water availability for other uses including irrigation. Hydropower reservoirs could help mitigating the impact of floods on land-based assets. Pollution from land-based activities has a negative impact on water quality and ecosystems. Environment and ecosystems have a central role in the development of the rural economy through sustainable agriculture and ecotourism.

• *Trends:*

The operation of thermal power plants causes thermal pollution in the river, consequently damaging ecosystems. Ash deposits are a problem and tailings dams/ash ponds could affect the water bodies and the surroundings. Flow regulation comprising the operation of hydropower plants and large reservoirs could better serve as well, for example, flood response. On the other hand, water availability and the different uses of water could likewise affect hydropower generation.

• *Opportunities:*
Water flow impacts of power generation are at the heart of the nexus in Drina Basin. River flow regulation needs to be improved. At the same time, the energy mix and trading are expected to evolve, where renewable energy technologies could come in. Development of modern, organic agricultural and ecotourism activities while leveraging locally available renewable energy resources could drive economic growth in the basin. Improving wastewater treatment and management of solid waste need to be pursued, the latter also having co-benefits for the operation of hydropower infrastructure which is affected by floating trash. Potential of biomass as a feedstock for power generation would need to be evaluated.

• *Solutions:*
Improved management of the basin's resources is critical for its socio-economic development. Strengthening of the current collaboration efforts around nexus issues would generate more and larger benefits. Strengthening and formalising coordination of hydropower operation (for responding to high flows but also for optimized electricity generation), developing a basin-wide approach to the development of new hydropower plants and assessing the technical potential for solar and wind power generation and biomass is needed. Investments, including renewable energy-related ones, require further development of markets as well as transparency, predictability as well as accountability, and adequate checks and balances in the regulatory system. The development of a basin investment strategy may help to prioritise investments (analysing trade-offs) and attract funding. Other possible areas for collaboration include flood management, common environmental flow standards, and water quality protection.

Sectors involved	Interlinkages	Solutions
Water-Energy (means impact of event/ action in energy sector on water)	• Pumped storage playing a key role in integrating renewable energy in the grid	• Harmonize legislation related to water resources use for energy generation (i.e. regulate the practice of hydropeaking, pumped storage, implementation of feed-in tariffs for the promotion of non-hydro renewables, legislation on concessions in order to overcome investments barriers) and to permitting of hydropower projects and utilities. • Utilize the potential of non-hydro renewable energy to reduce dependence on coal and on water resources from the basin.
Energy-Food/Land (means impact of event/ action in food/land sector on energy)	• Potential for installation of small scale renewables in the agricultural and eco-touristic sectors • Potential for biomass production associated to the wood industry	• Facilitate access to modern technologies, high-efficiency irrigation in particular • Promote the use of renewable energies in eco-tourism (for instance, solar on rooftop of buildings), especially in remote areas
Food/Land-Energy (means impact of event/ action in energy sector on food/land)	• Potential new land use for non-hydro renewable energy (solar and wind) • Potential for biofuels in the region	• Implement/continue implementing land consolidation policies (making larger clusters, swapping, farm cooperatives), restoring unutilised land) • Develop practice in SEA or sustainability impact assessmentin land use planning • Using landscape based and ecosystem approaches as means for agriculture to reduce risks related to hydrological extremes and to preserve important ecosystem services.
Ecosystems-Energy (means impact of event/ action in energy sector on environment)	• Ecosystems compromised by expansion of small hydropower (also in protected areas)	• Transboundary collaboration on gathering and sharing information on the status of biodiversity, development and enforcement of common regulations (including those related to the siting of small hydropower facilities), and the establishment of transboundary protected areas (notably the Tara-Drina)

Figure 6: Drina basin & renewable energy deployment in the context of water-energy-food-ecosystems nexus

VI. Conclusion

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 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.

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:

- Well selected renewable energy technologies could contribute to reducing and optimising water needs in energy production (Example 3 – How energy potential of wastewater could be leveraged).
- 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).
- Off-grid renewable solutions could supply energy to agricultural and food processing activities (Example 2 - How renewable energy addresses nexus linkages at farm level).
- The nexus assessment could help in making bioenergy and hydropower developments more sustainable by providing insights into their impacts on water, land and ecosystems.
- 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.

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 CO_2 emissions, resource efficiency and preservation of ecosystems. Renewable energy is central to all of these climate change mitigation measures.

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 a 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.

The nexus approach can be very practical if adopted by the industry, with resource efficiency and improved risk management benefits. Utilities producing electricity, and farmers managing waste water, could build value through the integration of renewable energy through the nexus approach. Examples from 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, the 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.

Commitment and implementation of better policies and showcasing of successful projects are 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 the local level may be helpful for moving forward.

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 a particular infrastructure cannot be agreed upon, costly investments might be made in response to duplicate or extend the 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.

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Deployment of Renewable Energy:
The Water-Energy-Food-Ecosystems Nexus Approach to Support the Sustainable Development Goals

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