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VEF VIRTUAL SERIES

DISCUSSION PAPER

SUSTAINABLE ENERGY AND FOOD SYSTEMS

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Overview

The Vienna Energy Forum (VEF)—to be held in 6-7 July 2021—is designed to facilitate a multi-sectorial, multi-stakeholder and inter-disciplinary dialogue on sustainable energy[1] for inclusive development and productive capacities.

As preparations for the VEF 2021 progress, the VEF partners have assembled the VEF Virtual Series— a sequence of virtual consultations that will explore the pathways that stimulate demand and promote economic recovery in three end-use sectors: industry, food systems and products.

The Virtual Series have the overarching goal of progressing agreed recommendations and delivering policy briefs with action-oriented solutions in targeted locations. In this respect, it will launch three global programmes addressing the needs of developing countries and emerging economies, and unlocking opportunities to pursue the energy nexus within the three end-use sectors.

The outcomes of the consultations will feed key global events in 2021, including the Sustainable Energy Forum, the High-level Dialogue on Energy, the G20 Forum and the United Nations Climate Conference (COP26).

The sessions in the Food System Track will serve as a platform to discuss pathways to better align the energy transition with the food systems transformation, with a focus on opportunities in developing countries.

In order to incorporate issues of demand and efficiency improvements, the typical supply-driven approach to energy and agriculture must be shifted. Additionally, the achievement of the 2030 Sustainable Development Goals calls for a holistic approach that integrates factors such as poverty alleviation, job creation, gender equality, climate mitigation and energy-food-water nexus. The VEF Virtual Series will lead the identification of critical issues and offer action-oriented solutions, that will be further analysed at the VEF 2021.

A discussion paper on sustainable energy and food systems was developed to:

- Provide an overview of the status of food systems in terms of synergies with sustainable energy, prominent barriers and the impact of COVID-19
- Identify priority countries that present opportunities to achieve successful outcomes;
- Identify priority focus areas: the barriers, enablers, issues or themes emerging as most relevant to achieving the intended outcomes;
- Explore key questions: the “smart” questions that can help identify and unlock the most impactful interventions; and
- Start to explore the nature of recommendations: the multiple intervention pathways that are available to countries looking to achieve sustainable energy-food system integration, given different capabilities and contexts.

[1] Within the context of this paper, sustainable energy refers to the supply of renewable energy for electricity and thermal needs, as well as demand-side interventions through energy efficiency (e.g. efficient appliances and machinery).

This paper tackles issues related to **the integration of sustainable energy in industry**. It provides an introduction to the topic and highlights the key issues that will be addressed during eight virtual discussion sessions, to be held at monthly intervals starting from 14 October 2020, in anticipation of the Vienna Energy Forum in July 2021.

The paper is structured as follows:

- Section 1 gives an introduction to sustainable food-systems and opportunities to achieve the SDGs.
- Section 2 elaborates the context on the current status of food systems, its synergies with sustainable energy and the barriers of mainstreaming the use of sustainable energy to transform food systems, as well as the impact of COVID19 on food-systems
- Section 3 discusses the methodology on the categorisation of countries and the identification of intervention pathways for each category.

1. Introduction

Food systems[2] are fundamental to the achievement of many of the 2030 Sustainable Development Goals—in particular, SDGs 1, 2, 3, 5, 6, 7, 8, 9, 10, 12, 13 and 15. Yet, with only 10 years ahead, food systems are still failing to provide adequate food supply and proper nutrition in many places, while contributing to environmental degradation and greenhouse gas emissions.

There are many opportunities to improve food systems that provide secure food and economic benefits, as well as enhance natural environment and cultural systems. These will be characterized by a number of features and implemented structures, including:

- Improved and sustainable production that leads to the provision of healthy and affordable food
- Improved and resilient livelihoods for small scale farmers
- Wide-ranging job opportunities, integrating young people and women
- Mainstreamed circular economy principles, such as reduced waste, improved resource efficiency and closed nutrient cycles
- Energy-efficient land use, transport and technological practices that support climate change adaptation and mitigation

Through cost-effective renewable energy and energy efficiency solutions, the energy transition has the potential to accelerate the development and transformation of sustainable food systems, especially in areas with an energy access deficit, in the following areas:

Economic development and business opportunities

- Energy access can stimulate job creation in the food sector, reaching marginalised groups, such as women and youth
- The demand for energy-powered products (e.g. lighting, fridges, dryers) creates jobs, improves economic competitiveness and expands businesses
- Energy can support local value addition, encouraging more diversified rural economies and greater opportunities for women with limited access to farmland

[2] A food system includes all processes and infrastructure involved in feeding a population: growing, harvesting, processing, packaging, transporting, marketing, consumption, and disposal of food and food-related items. It also includes the needed inputs and generated outputs at each of these steps.

Contribution to key SDGs through social and environmental improvements

- Energy access can improve the cost-efficiency of food production and access to water
- The reduction of food waste through better storage (e.g. refrigerators) has the potential to reduce hunger and poverty
- Sustainable energy in agriculture can reduce local pollution and global CO2 emissions (e.g. from diesel generators)
- Sustainable energy can support labour saving technology, reducing women's workload

Access to global funding

- The effective use of funding for sustainable development, sustainable energy and climate change can be used to deliver multiple benefits for the food and energy sectors, helping to accelerate progress towards the related SDGs.

We currently face a unique opportunity to converge the achievement of the Sustainable Development Goals and promote the energy transition. The impact of the coronavirus pandemic has led to calls from all sectors of society to "build back better" and stimulate investment in the energy transition. This narrative has the support of many public, private and multilateral organizations[3]. The European Green Deal, for example, aims to boost the efficient use of resources, restore biodiversity and cut pollution across the EU[4]. Additionally, the COP 26—now scheduled in November 2021—will be an opportunity to galvanise new commitments and actions, in the context of the coronavirus-induced delays and urgency to achieve the climate goals.

These factors provide an opportunity over the next year to increase awareness of the linkages between energy and food systems, and encourage investment in combined sustainable energy, food and climate interventions. The COP26, for instance, can build upon related outcomes from international clean energy events, including the VEF, to ensure a low-carbon recovery that is inclusive and integrates food systems transformation.

This paper proposes a framework to categorise countries with common needs, to systematically accelerate the development of sustainable food systems and achieve the Sustainable Development Goals.

[3] An example: "Climate change and COVID-19: UN urges nations to recover better" https://www.un.org/en/un-coronavirus-communications-team/un-urges-countries-%E2%80%98build-back-better%E2%80%99

[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

2. Context

2.1 Status of Food Systems

The Sustainable Development Goals (SDGs) call for the eradication of poverty and hunger, the advancement of sustainable agriculture and inclusive economic growth, and the provision of universal energy access by 2030. During this period, the global population will increase significantly, leading to a 50% growth in agriculture demand by 2030, compared to that of 2013[5]. If the SDGs are to be achieved, food systems must change in a sustainable way that responds to the reality of climate change and supports gender equity.

While food systems around the world are undergoing a transformation, the pace of change and implementation outcomes—challenges and opportunities—considerably vary across countries:

Expansion in productivity

Developed countries have seen a massive increase in agricultural productivity achieved through the expansion of the area under cultivation—often correlated with improved irrigation, the use of agro-chemicals (since the early 1960s, the use of nitrogen fertilizer has increased sevenfold[6]) and high yielding varieties.

Such an expansion has occurred with associated negative effects, including water scarcity and pollution within the water-agriculture nexus, loss of biodiversity and "environmental services" provided by biodiverse habitats, massive-scaled soil degradation, and emissions from soil and farm operations and input production that contribute to climate change.

Recent years, however, have seen a rejection towards intensive agriculture, arising from organic and regenerative agriculture. In the EU, for example, 7.5% of agricultural land is now organic and continues to expand[7].

[5] 2017, FAO, The future of food and agriculture – trends and challenges, Rome, http://www.fao.org/3/a-i6583e.pdf
[6] Pretty, J, Agricultural sustainability, concepts, principles and evidence, Phil. Trans. R. Soc. B, 363: 447-465
[7] EC, Eurostat, https://ec.europa.eu/eurostat/statistics-explained/index.php/Organic_farming_statistics#:~:text=The%20total%20area%20under%20organic,EU%20agricultural%20land%20in%202018

In contrast, many developing countries (especially in Sub-Saharan Africa, but also in South Asia and Latin America) are lagging behind. Productivity remains low and rural areas are associated with poverty and lacking job opportunities, especially for women and youth. In this respect, productivity must increase in a sustainable way, avoiding the "intensive" trajectory followed by most developed countries. Instead, improvements should ensure that agricultural production mitigates and adapts to climate change and other issues related to natural resource scarcity.

Changing consumption patterns

The growth in income associated to a country's development is generally correlated to an increased demand for fruits, vegetables, meats and processed foods. In developing countries, for example, the demand for meat is increasing at about 3% a year (in developed countries, demand has mostly levelled off[8]).

This change in consumption patterns has the potential to create job opportunities within an expanded food sector, processing, retail and sectors with established infrastructure—including energy access-related. However, it can also lead to increased emissions arising from intensive agriculture, land degradation and excessive/inefficient energy use in processing, storage and transportation. To this extent, the expansive use of land for livestock feed production, associated with a rising demand for meat, results in deforestation and increased water footprint.

Urbanisation

Cities in Africa, Asia and Latin America have witnessed an accelerated growth in the past 50 years. It is estimated that from 2018 to 2050, urban areas will experience an increase of 2.5 billion people—90% of which will take place in Africa and Asia[9]. This growth, accompanied by rising incomes, is expected to increase the value of urban food markets in Sub-Saharan Africa, from $150 billion in 2010 to $500 billion in 2030[10].

This presents an ideal opportunity for the development of localized food systems that support local value addition and job creation. Rather than following the path of developed countries—consolidating production, processing and retail at the expense of smallholder farmers and value addition opportunities for SMEs across the sector—sustainable energy must be at the core of the transformation.

[8] Paul Westcott & James Hansen, Agricultural projections to 2024, USDA, Feb 2015
[9] 2018 Revision of World Urbanization Prospects, Division of Population of UNDESA, available at https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
[10] FAO, The state of food and agriculture: Leveraging food systems for inclusive rural transformation, Rome, 2017

Longer supply chains

The typical food system trajectory[11] is associated with the lengthening of a number of food supply chains that seek to meet changing consumption patterns—including the diversification of diets and the use of economies of scale in particular areas—that requires enabling infrastructure and technology (e.g. cold chains).

This has contributed to higher carbon emissions within the sector, and increased food systems' vulnerabilities in face of the coronavirus pandemic (see section 2.4).

Food loss and waste

Globally, around 30% of food is lost or wasted. In developing countries, food loss is associated with limitations in harvesting, storage and cooling, and constraints in infrastructure, packing and marketing systems[12]. This results in delayed food transportation and a lack of adequate storage, leading, in turn, to higher wastage.

As economies develop, food waste increases, largely as a consequence of consumer behaviour.

There are cost-cutting opportunities within supply chains through circular economy practices (see bioenergy and digitalisation below) that could positively impact the income of small farmers.

2.2 Synergies: sustainable energy and food systems transformation

The Sustainable Development Goals can only be achieved by 2030 through the creation and maximization of synergies. SDG 7, related to energy access and sustainable energy, has beneficial correlations with the SDGs related to food systems transformation.

Through sustainable solutions—that integrate renewables and energy efficiency—energy has the potential to accelerate the achievement of SGDS and, in particular, improve accessibility within food systems (e.g. improving disposable income to pay for energy services or providing mini-grids). The points below highlight some of the opportunities:

[11] As economies develop, a number of factors lead to the lengthening of supply chains. There is a shift towards more intensive agriculture, where different areas specialize on specific products. As a result, food supplies need to come from an increased diversity of places. In addition, food preferences change while customers have increased purchasing abilities, that result in an growing demand for produce other than that locally available .

[12] FAO, Global food losses and food waste, Study conducted for the International Congress at Interpack, Düsseldorf, Germany, 2011

Food Production

Renewable energy can support irrigation in rural, off-grid areas, leading to productivity increases and consistent production throughout the year. Irrigation is perceived to be a critical factor in the future transformation of food systems in Africa, with some research suggesting that solar power could support the irrigation of 6–14 million new hectares of land[13]. Such development would require effective governance that ensures environmental sustainability, minimises land use conflict and ensures gender equity. Renewable energy can also support activities such as poultry incubation, greenhouse-heating and innovative regenerative agriculture approaches that combine these elements in a circular system (e.g. irrigated greenhouses, poultry, and horticulture).

Storage and Handling

Currently up to 30%[14] of food harvested in the developing world is lost post-harvest. For perishable goods like many fruit and vegetables, cold storage can reduce this waste and maintain quality, improving access to markets and increasing profitability as a result. In most developing countries there is a large deficit in cold storage capacity, closely linked to the energy access deficit. For example, in rural sub-Saharan Africa, only 27% of rural communities have access to electricity[15]. Even where there is access, many smallholder farmers are poor and unable to afford refrigeration. However, the growth in urban middle classes is increasing the demand for perishable goods and creating incentives for improvements in cold chains, including energy efficiency. Off-grid renewable technologies provide new opportunities, such as solar-powered container cold stores at markets.

Food processing and packaging

The provision of off-grid renewable energy can support basic food processing at village level, where it can help farmers add value to their produce and improve local nutrition. Larger-scale food processing and packaging, connected to electricity from the grid or larger scale off-grid renewables, can create jobs in peri-urban and urban areas. For instance, the food processing sector is yet to be developed in Africa and can be seen as a huge investment opportunity given its expanding urban markets[16]. Food processing can be energy-intensive, often requiring large amounts of heat. Energy efficiency is, thus. critical to improve both feasibility and economic viability while also reducing greenhouse gas emissions[17].

[13] Xie et al, 2018, Can Sub-Saharan Africa feed itself? The role of irrigation development in the regions drylands in food security, Water International, Volume 43, 2018, Issue 6: Virtual water: Its implications on agriculture and trade.
[14] http://www.fao.org/state-of-food-agriculture/2019/en/
[15] https://trackingsdg7.esmap.org/results
[16] An example of investment opportunities in to food processing in Africa: http://www.africa-do-business.com/food-processing.html
[17] Oyedepo, S. O. 2019, Energy use and energy saving potentials in food processing and packaging: case study of Nigerian industries, Bottled and packaged water, Vol 4, pp. 423-452. https://www.sciencedirect.com/science/article/pii/B9780128152720000155

Use of bioenergy across food systems

A significant contribution to the circular economy can be made by closing resource loops in the food system through bioenergy. For example, waste and residues can be used to produce renewable electricity or energy for cooking—such as biogas production from food or agricultural waste—thus helping to reduce energy access deficits. This also improves waste management (e.g. by replacing open burning and reducing land pollution) and has the additional benefit of producing organic fertilizer as a by-product. This in turn provides additional monetary value that can improve the economic feasibility of bioenergy projects, while reducing chemical use and greenhouse gas emissions.

Digitalisation

Recent advances in digital technology are helping to improve the safety, productivity, accessibility and sustainability of energy systems around the world. Digitalisation increases the efficiency of energy use, improves energy and food supply processes, and helps to create highly interconnected systems[18]. For food and energy systems, digitalisation can enable transformative change by providing remote farmers with a decision support system, based in real time, to cater effectively for variable energy consumption[19]. By using digital systems to match the energy demand of food systems with supply, the energy wastage from key processes (including e.g. crop drying and storage) can be reduced.

2.3 Barriers to the widespread use of sustainable energy to transform food systems

At present, large rural energy access deficits in most developing countries mean that opportunities such as those described above are difficult to realise. In recent years, sustainable energy solutions have improved accessibility—especially through the significant cost reductions of solar photovoltaics, both as stand-alone systems and through mini-grids, as well as the availability of efficient off-grid appliances. There are examples of how their applications in food systems has improved the viability of off-grid systems—especially mini-grids—by providing a constant demand.

However, there are still many obstacles hindering the scale-up of these solutions, including those indicated below.

[18] https://www.iea.org/reports/digitalisation-and-energy (2017)
[19] Powering a climate-neutral economy: An EU strategy for energy systems integration (2020)

Unsupportive policy environment

Renewable energy and energy efficiency need clear policy and legal structures that create a stable and predictable investment environment. Delays and uncertainties in renewable energy projects lead to declining confidence of the private sector. Energy efficiency requires clear standards and regulatory processes that are implemented effectively. In Africa particularly, renewable energy and energy efficiency policies are still relatively immature[20].

Technical capacity constraints

In many countries, renewable energy and energy efficient technologies are imported as many countries lack the innovation or manufacturing capacity to develop a home-grown sector. This adds to costs (see below) and also often results in poor servicing and maintenance, which itself contributes to unreliable technology and the gradual erosion of consumer confidence. Improvement in the use of energy within food systems requires local technical capacity (e.g. refrigeration, energy efficiency, circular energy solutions, solar PV) and capacity to develop or to adapt technologies and solutions that fit into the country context. A lack of such technical capacity often results in low interest or uptake of sustainable energy.

Financial barriers

At the farm level, affordability is a big concern. Especially for smallholder farmers, the initial capital costs can make sustainable energy solutions unaffordable. Business models such as Pay-as-you-go can help overcome this barrier but some sort of subsidy may also be needed, especially in the poorest communities. For larger-scale investors, the lack of familiarity with sustainable energy technologies, as well as high capital costs, create a substantial barrier. Such costs are increased when technology has to be imported (due to higher component costs, transport and import tariffs), which provides further motivation for building local production capacity. It is important to work with investors as partners and demonstrate that sustainable energy options can be an attractive investment proposition once lifetime costs are taken into account. However, some form of subsidy or guarantee to offset investment risk may be necessary, especially for new innovative applications, and in countries and settings that are less attractive to investors.

Low consumer awareness

A lack of knowledge amongst target customer groups regarding potential sustainable energy applications under local conditions often prevents the growth of any market. The use of sustainable energy systems in developing countries is often supply-driven, with a resulting lack of choice or competition, due to the absence of customer demand. There is usually a great need to inform potential customers of the benefits from the range of renewable energy applications, and from energy efficiency. This can increase the market size, reducing the costs for suppliers and increasing the affordability for customers.

[20] Dorcus Kariuki, Barriers to renewable energy technologies, Energy Today, 2018: https://www.energytoday.net/economics-policy/barriers-renewable-energy-technologies-development/

2.4 Impact of COVID-19

The coronavirus pandemic has caused immediate and potentially long-term problems for food and energy supply chains around the world.

In the short term it has led to disruptions to supply chains. This makes it difficult to access input materials or labour to support production, and causes problems to transport produce to markets. There are reports from Africa and Asia of milk being thrown away and crops being burnt because they cannot be stored and preserved. Perishable products are most affected, resulting in potential nutrition problems for people in urban areas who are unable to obtain fresh fruit and vegetables, or meat and dairy products. The lack of access to energy and the related lack of cold chains is clearly a contributing factor. In Asia, millions are becoming unemployed due to the impact of COVID-19. As a result of large-scale urbanisation and the associated food systems transformation, they do not have agriculture production capacity to fall back upon.

The impacts of this have been felt across the different tiers of the food system. Farmers have experienced a significant drop in incomes and, in many places, there is a lack of confidence on whether or not to plant next year's crop. In areas where monocultures now dominate, or where food crops have been replaced by non-food crops, food security is an additional problem. Women have been particularly affected. For many, their only source of income, as agricultural day labourers, has dried up. Remittances sent by men to women headed rural households will have slowed down, making women more vulnerable[21].

Rural youth, predominantly employed in insecure jobs in the informal sector are likely to bear the brunt of under employment and unemployment[22].

SMEs have had mixed fortunes. Input suppliers (seeds, pesticides, fertilisers, etc.) have struggled to get access to supplies. Agribusinesses that rely on the direct training of farmers or agents in order to distribute their products have had to find alternative means to do this (e.g. via ICTs) or suffer significant loss of business [23].

[21] World Bank Blogs, COD-19, a pivotal moment for support to women farmers, Alison Decker et al, June 2020, https://blogs.worldbank.org/developmenttalk/covid-19-pivotal-moment-support-women-farmers

[22] FAO, COVID-19 response: Inclusion of youth in Sub-Saharan Africa: http://www.fao.org/support-to-investment/news/detail/en/c/1275405/

[23] Some useful examples of the impact of coronavirus on farmers and SMEs in agricultural value chains can be found in this Relief Web article: What African farmers and processors say about the COVID-19 pandemic and lockdowns. https://reliefweb.int/report/world/what-african-farmers-and-processors-say-about-covid-19-pandemic-and-lockdowns

Longer term, the deep economic shocks being felt everywhere will affect the cash flow of companies in the food system, and the financial institutions who support them. This has already happened to off-grid solar companies who have been struggling to maintain their operations, including those investing in off grid in the agriculture sector. The Endev survey in August 2020, indicated that 85% of companies are struggling for survival beyond the next five months[24]. Hardly any have been able to secure emergency funding. It is likely that the crisis will make new investments more challenging. This could represent a major threat to the development of integrated agriculture and energy solutions and highlights the need to firstly, make sound business cases that demonstrate the net economic, social and environmental benefits and secondly, highlight their contribution to a more resilient food system (linking back to the "building back better" narrative).

Not all the impacts of the coronavirus have been negative in the food and energy spectrum. Some of the responses to the pandemic may have long term positive impacts. These include:

- Increased use of digital applications in agriculture (e.g. production, marketing, retail) as a result of the need to find alternatives to face-to-face interactions[25]. Interest was already growing but the coronavirus pandemic has accelerated this.

- Increased interest in resilient food systems, including in shorter value chains[26].

Lastly, integrated energy/agriculture solutions, with their potential to generate economic opportunities and jobs, could become an important part of stimulus packages designed to support a post-COVID recovery.

[24] Endev, COVID-19, Energy Access Barometer, August 2020

[25] GSMA, Post COVID-19 Business un-usual in agricultural value chains https://www.gsma.com/mobilefordevelopment/uncategorized/post-covid-19-business-un-usual-in-the-agricultural-value-chains/

[26] "COVID-19 highlights supply chain vulnerability", Judith Evans, Financial Times, May 28, 2020: available on https://www.ft.com/content/d7a12d18-8313-11ea-b6e9-a94cffd1d9bf

3. Categorisation of Countries and Identification of Intervention Pathways

3.1 Overview of methodology

UNIDO aims to support all of its Member States to use sustainable energy effectively for enabling food systems transformation. The scale of the opportunity for this transformation—a function of a number of variables—will vary between countries. The proposed methodology for targeting such support is designed to allow UNIDO to work initially with those countries that have the greatest potential for early success, so that maximum impact is achieved with the resources available.

This methodology involves identifying common needs among countries with similar challenges and opportunities, and delivering action-oriented recommendations to pursue an integrated agenda. Having established the related benefits, these results can then provide the foundation for a global initiative that brings together various partners to engage with high impact countries.

To facilitate this process, country conditions have been reviewed to establish the likely level of impact from such intervention.

Three categories of countries can then be defined, as indicated below.

Category 1:

Priority Countries

Good enabling conditions in place for sustainable energy-focused interventions in food systems. Priority countries can also provide learning and evidence that can be used to influence progress in other countries. Participation from a critical mass of these countries would be required in the series of VEF virtual meetings.

Category 2:

Second Phase Countries

Some enabling conditions in place but require further support to improve them before energy-focused interventions in the food system can be most effective. Second phase countries can be recipients of learning and influence from Priority Countries. A selection of these countries should participate in the VEF Series of virtual meetings.

Category 3:

Currently Constrained Countries

Given the particular circumstances in these countries, they currently have very limited enabling conditions in place and little opportunity to improve these in the short-to-medium term. These are likely to be countries affected by a protracted crisis or conflict, so that the key variables are not under UNIDO's control. Intervention would be extremely difficult in these countries and not in line with the most urgent needs, although the situation can be monitored to see if there is movement to Category 2 over time.

The categorization methodology uses two steps with the following outcomes:

- Step 1 results in countries being grouped into one of the categories above
- Step 2 provides a set of guiding questions designed to assist in the identification of intervention pathways.

3.2 Country categorisation

3.2.1 *Criteria for categorisation*

Three criteria are used in Step 1 "Categorisation," as explained below. (Note that data limitations mean these criteria can only provide an initial indication of country suitability. This would need to be followed-up by in-depth discussions with candidate countries).

Economic outlook: Food systems transform as the economy grows and incomes increase. A growing economy not only stimulates changes in the food system itself (e.g. expansion in the processing sector), but also increases demand for energy and the financial benefits from investments related to the energy application improvement. As a result, higher rates of real economic growth are treated as positive conditions for interventions.

State of food systems infrastructure: For the food system to transform, basic infrastructure is required. This includes transport networks—required to move produce from rural to urban areas and niche produce to ports—food storage facilities, processing infrastructure and irrigation schemes that support production. Hence, countries with high levels of infrastructure in place will provide the most significant opportunities to support sustainable food transformation. Those with lacking infrastructure need to address this as a priority.

Energy enabling environment: To facilitate the use of sustainable energy solutions in food systems, a number of enabling factors should be present. Ideally, there is already a high rate of electricity access in rural areas, combined with a significant percentage of electricity generated from renewables. Where electricity access is more limited, important indicators include the existence of an electrification plan that incorporates renewable off-grid solutions and a focus on productive uses. Specifically, an enabling framework for mini-grids is significant—including financial incentives)—as mini-grids can provide excellent opportunities for productive uses in off-grid areas.

Investment flows: The expansion of sustainable energy interventions in food systems will require considerable investment from governments, donors and the private sector. Current investment flows for sustainable energy can give an indication of a country's overall attractiveness for energy investment, although that does not necessarily reflect the conditions for energy/food system investments.

3.2.2 Process for categorising and data sources

Countries can be pre-assessed against criteria using the variables and datasets described in the table below. This will facilitate the identification of appropriate countries to participate in the VEF virtual series.

Criteria	Indicator used	Potential			Data source
		High	**Medium**	**Low**	
Economic outlook	Real GDP growth	>3%	>1-3%	<1%	International Monetary Fund World Economic Outlook Database[27]
Food systems infrastructure	GFSI agriculture infrastructure assessment	60-100%	40%-59%	0-39%	Global Food Security Index[28]
Energy enabling environment	Rural energy access combined & electricity generation from renewables	Rural electricity access ≥75 + ≥50 RE in electricity	Rural electricity access ≥50 + RE in electricity ≥50	Access, RE or RISE score <50	SDG7 tracking[29] International Renewable Energy Agency country data[30]
	Level of support for renewables, mini-grids and productive use (RISE indicators)	Or average RISE score ≥75	Or average RISE score ≥50		ESMAP RISE[31]
Clean energy investment	Climate scope cross-border clean energy investment	> USD 50 per million population	USD 10-50 per million population	<USD 10 per million population	Bloomberg NEF Climate scope[32]

Table 3.1 Proposed criteria and indicators

[27] Dataset is available on IMF website here: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD

[28] GFSI includes an Agriculture Infrastructure' category which is broken down into sub criteria including: Road network; Rail network; Ports; Food storage; Irrigation

[29] https://trackingsdg7.esmap.org/countries

[30] https://www.irena.org/Statistics/Download-Data

[31] https://rise.esmap.org/

[32] https://global-climatescope.org/clean-energy-investments

3.3 Identifying intervention pathways

It is assumed that UNIDO will engage in consultation with countries that express interest in collaborating. The following is intended to provide a guide to some of the issues that could be relevant in those discussions. It is not a prescriptive set of interventions.

Category 1 Countries

Category 1 countries provide opportunities for: practical initiatives that develop and demonstrate improved sustainable energy use that supports food system transformation; and expanding investment in sustainable food system transformation. Potential opportunities for development and support can then be explored using the guiding questions below.

Theme	Guiding Questions for Technical Support Area
Sustainable Energy	Are there good examples of sustainable energy technology demonstration? What technologies are covered by these (solar irrigation, refrigeration and improved insulation, heat recovery and cogeneration in pasteurisation and sterilisation processes, use of waste products from food processing for electricity generation, electric vehicles in transportation processes)? How do these examples ensure women's access to energy?
	What are the barriers to increased support for renewable energy? Are there fossil fuel subsidies which hinders the comparative economic viability of renewable energy investments? What form of promotion activities should be prioritised?
	Are there any initiatives/good examples which demonstrate the benefits of digitalisation to the integration of sustainable energy into food systems?
Production	Do existing policies support effective irrigation governance that ensures environmental sustainability and social equity (e.g. inclusion of women)? If not, what are the gaps and the opportunities for change?
	Is there information on the potential of sustainable irrigation and renewable energy to support it? If not, how can this information gap be filled?
	What are the strengths and weaknesses in relevant Government bodies with roles in irrigation management? What support do they need to be able to manage sustainable irrigation development?

Theme	Guiding Questions for Technical Support Area
	Are there initiatives that demonstrate good practise in the use of renewable energy to support irrigation including equitable and environmentally sustainable governance? What is the capacity of businesses that provide renewable energy irrigation services and inputs? What business development needs constrain their growth? What opportunities are there to provide business development support to address these?
Off-farm agricultural value addition	Are there policies that support productive energy use, including through the use of mini-grids? How effective are these and do relevant organisations have the capacity to implement these policies? Have opportunities for the integration of productive energy use to add value in rural communities been identified? How could this information be obtained? Are farmers and Government actors aware of the potential value addition options provided by productive energy use? Are women aware of the opportunities provided to them to reduce workloads and generate off farm income? Are there initiatives that demonstrate the use of productive energy use off farm within viable business models? Do farmers, women and other potential micro-entrepreneurs have access to training and support that encourages the diversification of income sources?
Value chain upgrading (beyond farm/community level along the value chain)	Have opportunities for the use of sustainable energy to upgrade value chains been identified? How could this information be obtained in a way that also increases awareness? Are there initiatives that demonstrate viable business models for the use of sustainable energy to upgrade value chains?
Investment	Is there sufficient evidence on the business case for renewable energy installations that support food system transformation, to attract investors? What are the gaps and how might these be addressed? Does the current policy environment create an enabling environment for renewable energy financing? If not, what are the critical blockages? What strategies exist for engaging with the investment community?

Category 2 Countries

Category 2 countries are likely to need many of the intervention pathways revealed through the guiding questions identified for Category 1 countries. However, they may also required the development of specific enabling conditions for food systems transformation and renewable energy development. Guiding questions to assist in the identification of these additional issues are indicated below.

Theme	Guiding Questions for Technical Support Area
Learning/ Awareness	Is there information available that demonstrates the potential and the cost-effectiveness of renewable energy integration to support the transformation of the national food system? How might research be organised to gather this information in a persuasive way? Are there gaps in food system infrastructure* that will constrain food systems transformation? What is the level of awareness of policy makers on energy needs of the food system and the role and potential of energy improvements?
Coalition development	Are there any civil society, academia or private sector groups actively working to generate support for sustainable energy development? How might the effectiveness of such organisations be improved?
Policy Support	How does the current policy environment influence incentives for investment in sustainable energy? What are the opportunities to improve this? Are there policies that support the development of mini grids and productive energy use interventions?
Basic infrastructure support	What is the status of investment within gaps in the food system infrastructure (e.g. transport networks, food storage and processing capacity, irrigation capacity, etc.)? Is there potential to align with sustainable energy development?

* Likely to be a priority in many Sub-Saharan African countries where undeveloped infrastructure is one of the biggest constraints to transformation.

4. Appendix: Virtual Series

4.1 Outline of the Virtual Series

Eight virtual meetings will be held at monthly intervals in anticipation of the Vienna Energy Forum 2021. The aim of these sessions is to consider why, when, and how efforts should be made to support greater clean energy access and efficiency in the food systems of developing countries. The virtual series will bring together selected representatives from governments, donors, the private sector, academia, think tanks, NGOs, and CSOs.

The virtual sessions will take account of the following factors:

- Ensure the focus is on the sustainable food systems/energy transition nexus
- Representatives invited from the full range of stakeholder groups to each session
- Each session to address one specific issue through a set of questions for discussion
- Each session will start by presenting the objective, i.e. to agree potential actions to address the issue under consideration
- The aim of each session will be to identify pathways towards modern, sustainable food systems through the enhanced use of clean energy
- Each session will produce a set of recommendations, commitments and actions to be presented at the VEF.

4.2 Proposed Sessions

Possible topics and questions for the virtual sessions are outlined below. There are two key issues that should be taken into account during the discussions in each of the 8 sessions. The impact of these issues should be considered in all discussions so that any recommended consider their practical implications.

COVID-19, in particular:

- How to ensure that COVID-19 stimulus packages achieve a resilient, inclusive and sustainable recovery of food systems
- How to adapt farming processes to cope with COVID-19 impacts and likely localisation
- Investment risks/opportunities due to COVID-19
- COVID-19 implications for the achievement of the 2030 SDGs

Job creation, specifically:

- Opportunities for addressing current (COVID-19) job losses linked to supply chain and localisation issues
- How can local demand be stimulated to support new job opportunities?
- How to create training and employment opportunities for youth?

Session 1: Opportunities for energy / agriculture nexus interventions

Main question: What evidence and dissemination strategies are needed to demonstrate that the integration of sustainable energy in food systems can ensure transformational development outcomes?

Sub-questions:

- What data is available to identify which countries offer most potential for sustainable energy in agriculture?
- Which are the most important enabling conditions to allow effective interventions on sustainable energy in food systems?
- How can positive outcomes related to the integration of sustainable energy into agriculture be best demonstrated and disseminated, both in and between countries?

Outputs:

- Small group of countries identified as a priority list to engage with in the global initiative

Discussion Points

Sustainable energy offers many opportunities for the transformation of food systems in developing countries. Yet, its take-up has been slow. There are numerous examples of positive case studies, but there is probably no country that can claim real leadership. However, some countries have better enabling environments than others to drive forward this pathway. This session will present a proposed methodology for categorising countries into those with high, medium or low potential for energy/agriculture nexus interventions. Participants are invited to contribute their inputs to this categorisation.

Since most developing countries have major infrastructure challenges affecting both energy and agriculture (e.g. lack of grid access, poor road transport), it is important to consider how these can be overcome through specific interventions, for example through the creation of a functioning market for off-grid renewables and the establishment of cold chains and/or local food processing to overcome lengthy transport times.

In principle, there is high potential of replicability and scalability for sustainable energy interventions in food systems, as farmers and other agricultural enterprises are generally well connected through associations; and many have similar needs and operations. A system of technology demonstration and dissemination is therefore essential. There is also a need for technological innovation and adaptation for novel applications. The potential for demonstration and dissemination strategies through international processes should be explored.

Session 2: Priorities at the farm level

Main question: How can support to energy interventions at farm level be designed to maximise the impact on small-scale farmers?

Sub-questions:

- What is the potential of different technologies?
- How can environmental sustainability be ensured?
- How can women's decent employment economic empowerment be supported?
- What are the characteristics of successful business models? What supportive market systems need to be in place?

Outputs:

- Identification of most significant opportunities for energy interventions at farm level
- Design principles for a set of priority energy interventions at farm level

Discussion Points

Approximately 6% of arable land in Africa is irrigated, compared to 37% in Asia[38]. Some research suggests solar power could support the irrigation of 6 – 14 million new Hectares of land in Africa[39]. However, good governance is needed to avoid water scarcity, water-based conflict and salinization.

Energy can also support activities such as poultry incubation and greenhouse-heating, which open up opportunities for value-addition in rural areas. Innovative regenerative agriculture approaches that combine these elements in a circular system (e.g. irrigated greenhouses, poultry, and horticulture) allow high productivity from small areas of land[40]. This can be important where land is becoming scarce and for young people and women for whom land access is often difficult.

Small solar powered refrigeration units can reduce spoilage of horticultural products, milk and fish, helping farmers maintain quality and access better markets. The generation of energy from crop and livestock residues presents an opportunity not only to provide domestic energy but also to support value addition. For instance, biogas from manure presents a means to support milk chilling, reducing post-harvest losses and increasing incomes for millions of small-scale dairy farmers[41].

[38] You et al, What is the irrigation potential for Africa, IFPRI Discussion Paper, 2010
[39] Xie et al, 2018, Can Sub Saharan Africa feed itself? The role of irrigation development in the regions drylands in food security, Water International, Volume 43, 2018, Issue 6: Virtual water: Its implications on agriculture and trade
[40] For a typical example: https://www.youtube.com/watch?v=RS06kUNsLM4
[41] An example is provided by Sim Gas, a Kenyan company providing bio digesters and chilling units to small scale farmers https://simgas.org/projects/biogas-milk-chilling/

Session 3: Value chain upgrading

Main question: What are cost effective ways in which energy improvements can support the up-grading of agricultural value chains?

Sub-questions:

- How can you identify where energy improvements in a value chain present the most significant upgrading opportunities?
- What are the most cost-effective opportunities to support up-grading?
- How can agricultural development programmes integrate energy needs in the planning stage? What economic and social dimensions need to be considered when upgrading value chains? How can the upgrading can create jobs and enhance inclusiveness?

Outputs: Guidelines on a process for identifying energy focused value chain upgrading opportunities

Discussion Points

Value chain upgrading strategies, involving the use of improved energy, could include the development of cold chains, improvements in processing infrastructure and the adoption of circular economy approaches using organic residues.

In 2009 cold storage capacity in developed countries in urban areas was 200 litres per capita. In developing countries, it was only 19 litres per capita[34]. In Africa, it is particularly low, with figures for Ethiopia and Tanzania of only 2 litres per capita[35]. Incentives to improve this are provided by growth in demand for perishable goods. In hotter countries, energy efficiency is a critical issue and recent advances in insulation technology can play an important role in making cold chains economically viable.

Although undeveloped in Africa, food processing presents a huge investment opportunity because of expanding urban markets[36]. This can be a source of jobs in urban and peri urban areas. Energy efficiency is an issue, with many food-processing plants, utilising 50% more energy than they need[37].

Significant research and development is taking place on the use of crop or animal residues to generate power, particularly in Africa. This also results in the creation of organic fertiliser – which itself can provide a source of income and can contribute to sustainable agriculture and reductions in greenhouse emissions. If built into the planning stage, these strategies could demonstrate a better return on investment for agriculture interventions.

Value chain upgrading solutions require infrastructure to be in place (e.g. transport networks), agricultural productivity to be able to meet increased demand and other enabling business conditions. Joined up planning involving agricultural, energy and other sectors is thus, important.

[34] Quoted in FAO, Agroindustry Policy Brief 2, Developing the cold chain in the agrifood sector in Sub Saharan Africa, 2016
[35] FAO, Agroindustry Policy Brief 2, Developing the cold chain in the agrifood sector in Sub Saharan Africa, 2016
[36] An example of investment opportunities in to food processing in Africa: http://www.africa-do-business.com/food-processing.html
[37] R. Sims et al, Opportunities for agri good chains to become energy smart, FAO (PAEGC), Nov 2015

Session 4: Equity - gender and youth

Main question: How can interventions be designed so that women and youth can equally lead, participate in and benefit? How can the engagement of youth be maximised?

Sub-questions:

- What are the gender and youth dimensions in the energy-food nexus? E.g. What particular needs do women and youth have? What parts of the food systems present the most significant opportunities for women and youth?
- What constrains women and youth from benefitting from sustainable energy interventions in the food system?
- Where is the data on gender/youth and the food system? Who do you need to collaborate with to obtain this information?
- What are the lessons learned of interventions with the involvement of women and youth?

Outputs: Identify priority actions for ensuring inclusive sustainable energy/food system interventions. Identify possible partners and entry points for developing interventions that promote gender equality, the empowerment of women and inclusion of youth.

Discussion Points

Women are typically found in the less lucrative parts of agricultural value chains (e.g. production, basic processing, unskilled labour). Their movement to more rewarding opportunities is hindered by a combination of social norms and market constraints that manifest in different ways. Examples include limited access to finance, lack of secure land title and time poverty, caused by unbalanced distribution of care work.

Energy related interventions can help address some of these constraints. "Rent to own" models can help women gain access to valuable energy and agriculture assets (e.g. solar irrigation, greenhouses). Small scale sustainable agriculture that allows intensive production from a small area of land (e.g. solar irrigated greenhouses and integrated poultry, fish, vegetable systems[42]) have much reduced labour requirements than traditional farming and can be situated close to homes. Solar powered threshers and huskers can reduce workloads for women.

The application of renewable energy has the potential of driving young people back in agriculture, by facilitating a form of agriculture that is more "modern," less arduous and that presents off farm income opportunities.

The transformation of the food sector could lead to the expansion of jobs in processing and food distribution and sale. It is important that this does not lead to the creation of poorly paid jobs that perpetuate existing gender and youth inequalities. The expansion of jobs is an opportunity to change the labour market so it presents new types of opportunities for women and youth.

[42] For a typical example: https://www.youtube.com/watch?v=RS06kUNsLM4

Session 5: Agro-Industry

Main question: How do we increase the effectiveness of overall energy management in the agro-industry to reduce costs and increase resilience—considering appropriate renewable energy interventions, but also ensuring that energy efficiency and the demand-side are given adequate consideration?

Sub-questions:

- What interventions are needed from governments to create an enabling environment for renewable energy applications, energy efficient appliances and circular economy practices?
- How to determine when investment in renewable energy technologies and/or energy efficient appliances is worthwhile?
- What are the opportunities for developing bioenergy pathways (e.g. process residues for bioenergy)?

Outputs:

- Identification of priorities for clean energy interventions in the agro-industry

Discussion Points

Energy interventions related to industrial processes traditionally focus on the supply side, e.g. on providing electricity supply for irrigation or food processing. Considering that larger-scale renewable energy technologies are a focus with significant capital outlay, a clear match to market needs is essential. The cost savings and positive environmental impact associated with energy efficiency are often overlooked but play an equally important role in designing these interventions. The use of efficient appliances and machinery can enhance the feasibility and cost-effectiveness of renewable energy applications in agriculture, while enhancing women's empowerment through time freeing. In thermal energy operations (e.g. greenhouse heating, drying, refrigeration), these are low-cost energy-efficient procedures which do not require expensive technologies but can be supported with training and capacity building.

Agricultural production and food processing also provide opportunities for developing bioenergy applications through the re-use of harvest or processing residues. Potentially, this is a large resource that is rarely considered in developing countries—with the exception of sugar cane bagasse which is typically used for electricity generation and/or bioethanol; there is also small-scale biogas use in some countries. Bioenergy could be more widely used for both electricity generation and thermal applications (including in food processing) and help improve resource efficiency in food systems.

Session 6: Digitalisation

Main question: How can digitalisation be applied best to ensure effective sustainable energy use for food system development?

Sub-questions:

- Should digitalisation be a priority for energy use in food systems development?
- What related issues need to be given more focus to facilitate increased digitalisation of energy-related activities?
- What are the design factors—such as pricing, customer service level, product performance, availability, economies of scale, partnerships, social dimensions—that make digitalisation a success or not?

Outputs:

- Recommendations for the application of digitalisation to energy use in food systems
- Identification of issues that should be prioritised to enable increased digitalisation

Discussion Points

The digital revolution presents the prospect of a new range of energy-related operators, one where small-scale, flexible systems flourish and have the capability to respond quickly to changing operating environments at the local level (World Economic Forum). It has been estimated that the share of GHG emissions caused by digital technologies will rise from 4% in 2020 to 8% in 2025, primarily due to increases in energy consumption (The Shift Project, 2018). However, the digital use of efficient energy technologies can provide significant energy, carbon and cost savings (Grubler et al., 2018). An effective balance between increasing digitalisation and environmental sustainability must be carefully managed (TWI2050) - what factors should be prioritised to enable this?

The introduction of digital technologies is already evident in the agriculture sector (there are signs that COVID-19 has further encouraged their use[33]). Digitalisation linked to renewable energy systems—especially solar—has been an important driver of energy access in many countries. To date, digital energy systems have mainly been used at the household level—e.g. pay-as-you go (PAYG) solar systems that allow remote payment and has transformed people's lives. Is there potential for other digital energy applications in food systems? Is there potential for other digital energy applications in food systems?

For food systems, digitalisation can offer a multitude of opportunities, including remote performance monitoring of energy applications—such as refrigeration units, remote communications, marketing platforms, weather details, real-time market information (e.g. the price of products), logistics traceability and financial support data. For example, direct sales (farmer to consumer) through online platforms make food accessible in remote areas and reduce food waste. This can shorten the food supply chains and transport distance, thus saving GHG emissions.

[33] For example, the UK Government is considering incentivising the development of integrated digital platforms and smart food systems for retailers, processors and producers, and government agencies to inform real-time planning and ordering (https://post.parliament.uk/analysis/food-security/effects-of-covid-19-on-the-food-supply-system/).

Session 7: Investment and partnership needs

Main question: What form of investment is required to enable the positive transformation of food systems using access to sustainable and clean energy sources (particularly in developing countries)?

Sub-questions:

- What aspects of food system transformation will require external investment?
- How can such investment be sourced and repaid?
- What partnerships are required to source and manage appropriate investment?
- What is the ideal balance of public and private sector finance?
- What scale-up plans/activities are required to attract investors?

Outputs:

- Identification of investment options—including public and private sector finance—for clean energy access related to food system transformation
- Propose target partnerships to source and manage appropriate investments

Discussion Points

To ensure transformational change, decision-makers in government, the financial sector—especially local banks—and the private sector need to understand that sustainable energy investments can significantly improve the economic competitiveness of food systems. In this respect, to delineate the best way to work together to meet each other's needs.

The positive impact of appropriate energy investment for food systems can include lower O&M costs, and increased resilience against fluctuating fossil fuel costs and disruptions in energy supply in developing countries. The monetary value of such benefits must be determined in order to motivate potential investors.

The risk of investment in sustainable energy for food system transformation is based on the limited awareness of potential financiers and uncertainty over the potential outcomes. For this reason, public funding is required to offset upfront capital costs that are often associated with clean energy applications. Linking public and private sector finance from the outset, particularly in developing countries, presents a significant challenge that must be overcome.

Session 8: Galvanising political action

Main question: How can decision-makers at national and international levels be motivated to place greater focus on sustainable and inclusive energy/food system policies and interventions?

Sub-questions:

- How to best highlight the urgent need for food system transformation, and the potential opportunities driven by sustainable energy at a political level
- Which decision-makers—and at what levels—need to be influenced most?
- What opportunities are there to put the issue on the agenda of forthcoming large international events?

Outputs: Identification of possible interventions at key international fora over the next 12-24 months

Discussion Points

The year 2021 will witness a series of high-level international events relevant to the sustainable energy/food systems nexus. In addition to the VEF, these include the SEforALL Forum (February, Kigali), the UN High-Level Political Forum (July, New York), the G20 (tbc, Italy), the UN High-Level Dialogue on Energy (September, New York), and COP26 (November, Glasgow). In view of the economic crisis resulting from the coronavirus pandemic, it is likely that recovery will be a major theme at these events.

While sustainable energy and food systems transformation clearly provide excellent opportunities for driving an inclusive recovery, key decision-makers are not always aware of the possibilities. Major global event present opportunities for stimulating political will and engagement. The aim is to use the VEF and the VEF Virtual Series as platforms that support the delivery of recommendations, commitments and actions to drive low carbon economic development and recovery.

The other events provide further occasions for galvanising action.