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Agenda 4

INTEGRATION OF RENEWABLE ENERGY INTO POWER SYSTEMS PROGRAM

1. Overview of the sector

1. **To achieve global climate goals, the global energy sector needs to shift from fossil-based to zero-carbon by the second half of this century.** At its heart is the need to reduce energy-related CO_2 emissions to limit climate change. Decarbonization of the energy sector and corresponding sectors requires urgent action on a global scale, while ensuring energy security and affordable access to those living in areas where large shares of population lack reliable supply of electricity and affordable modern cooking fuels.

2. **Global energy consumption grew by 2.3 percent in 2018, nearly twice the average rate of growth since 2010, driven by a robust global economy as well as higher heating and cooling needs in some parts of the world.**[1] Weather conditions were responsible for almost a fifth of the increase in global energy demand as average winter and summer temperatures in some regions approached or exceeded historical records. Hotter summer temperatures pushed up demand for cooling and cold snaps drove demand for heating.[2] Higher electricity demand was responsible for over half of the growth in energy needs.

3. Demand for all fuels rose, with fossil fuels meeting nearly 70 percent of the growth for the second year running. Natural gas accounted for nearly 45% of the increase in total energy demand, thereby emerging as the fuel of choice. Oil and coal together accounted for a quarter of global demand growth.

4. Renewables met around one-quarter of the growth in total primary energy demand and, despite growing at double-digit pace largely thanks to the expansion in electricity generation, growth is still not fast enough to meet the increase in demand for electricity around the world. [3] To meet internationally climate goals and provide access to modern energy sources, the share of renewables in the power mix needs to rise to two-thirds in 2040 and to over two-thirds by 2050.[4] For this to happen, and to reducing the need for keeping fossil fuel capacity as a backup, several flexibility sources[5] need to be harnessed in all sectors and planned ahead of time to shift cost-effectively from a fossil fuel-based energy system toward one dominated by renewable energy. This is because most power systems are not yet designed to deal with the variability and uncertainty of renewable energy generation at scale and thereby integrate a large and growing share of intermittent power generation from renewables.

5. Energy access remains a key development constraint. Nearly a billion people still do not have access to electricity and 2.7 billion lack access to clean cooking facilities, relying instead on biomass, coal, or kerosene as their primary cooking fuel.[6] In many contexts, effective access is further complicated by affordability constraints that prevent households from lower income tiers from accessing electricity. The gender of the head of the household can also affect energy access. Female-headed households,

[1] IEA (2018), *Global Energy & CO_2 Status Report 2018.*
[2] IEA (2018), *Global Energy & CO_2 Status Report 2018.*
[3] IEA (2018), *Global Energy & CO_2 Status Report 2018.*
[4] In the provision of heat, renewables need to rise from 10 percent today to 25 percent. In transport, renewables need to rise from 3.5 percent today to 19 percent, including both direct and indirect use, e.g. renewable electricity for heating and electric vehicles. IEA (2018), *Global Energy & CO_2 Status Report 2018 –* Sustainable Development Scenario; *NCE (2018)*, *Unlocking the Inclusive Growth Story of the 21st Century – Accelerating Climate Action in Urgent Times.*
[5] Flexibility refer to technical and operational aspects. Technical flexibility sources refer to a set of supply-side, demand-side and grid related measures including energy storage, demand-side management programs and transmission networks-related interventions. Operational flexibility refers to how the assets in the power system are operated. Beyond the constraints associated to each technology's capabilities, it is dependent on the regulatory and market environment that surrounds the physical system and drives system operations. (Source IRENA (2018), *Power System Flexibility for the Energy Transition*).
[6] IEA 2017 data available at *Sustainable Development Goal 7.*

in particular, typically have lower rates of energy access compared to male-headed households as for instance shown in Kenya Multi-tier Energy Access Framework survey results.[7] Finally, as documented by the Multi-Tier Energy Access Framework[8] on quality of energy services, even where power generation and distribution exist, there exist questions of capacity, reliability and duration of electricity provided. Decentralized systems, led by solar photovoltaic (PV) in off-grid and mini-grid systems, are considered the least-cost solution for three-quarters of the additional connections needed to provide universal electricity for all.[9]

6. **Driven by higher energy demand, global energy-related carbon dioxide (CO2) emissions rose 1.7 percent to a historic high of 33.1 gigatons of CO2 (GtCO2) in 2018**.[10] **Coal-fired power generation accounted for 30 percent of global energy-related CO2 emissions**, continuing to be the single largest emitter and the single largest contributor to the growth in emissions observed in 2018. Coal is also the single largest source of global temperature increase. Most of coal generation is found today in Asia, where average plants are only 12 years old, decades younger than their average economic lifetime of around 40 years.

7. Increased use of renewables helped avoiding 215 Mt of emissions in 2018, the vast majority of which is due to the transition to renewables in the power sector.[11] Increased nuclear power generation also helped reducing emissions, averting almost 60 Mt of CO2 emissions. Overall, without the transition to low-carbon sources of energy in 2018, emissions growth would have been 50% higher.

8. Even though energy efficiency was the biggest source of CO_2 emissions abatement in the energy sector in 2018, its contribution was about 40% lower than in 2017, marking 2018 as the third consecutive year in which the improvement rate for energy efficiency slowed.[12] This largely because of a continued slowdown in the implementation of energy efficiency policies. The average rate of energy intensity improvement needs to accelerate to 3.4 percent annually.[13]

9. Despite continued growth in emissions and slowdown in energy efficiency, the power sector has seen significant transformation in recent years. Thanks to improvements related to reducing carbon intensity, the average carbon intensity of electricity generated is 10 percent lower than the intensity from 2010. Without such improvements, global CO_2 emissions would have been 1.5 Gt higher, or 11 percent of current power sector emissions. To avoid any increase in emissions from electricity generation since 2010, an additional 10 percent improvement in terms of carbon intensity reduction would have been needed.[14]

10. The increasing prominence of renewable energy, including the significant drop in the cost of renewable energy technologies, is among the most important drivers of power system transformation. Costs of key renewable energy technologies have plummeted so substantially that

[7] 50% of Kenyan female-headed households in rural areas do not have access to electricity compared to 45% of male-headed households, and 16% of female-headed households living in urban areas do not have access to electricity compared to 9% of male-headed households in urban areas in Kenya. See "*Multi-Tier Framework Survey Kenya: Preliminary Results for 14 Underserved Counties in Kenya*."

[8] For more information, please see the World Bank's Energy Sector Management Assistance Program's web page.

[9] IEA (2018), *World Energy Outlook 2018*.

[10] IEA (2018), *Global Energy & CO_2 Status Report 2018.*

[11] IEA (2018), *Global Energy & CO_2 Status Report 2018.*

[12] IEA (2018), *Global Energy & CO_2 Status Report 2018.*

[13] IEA *Global Transition Indicators.* As a measure of total primary energy use per unit of gross domestic product (GDP), energy intensity is affected by changes in both energy efficiency and structural changes in economies.

[14] IEA (2018), *Global Energy & CO_2 Status Report 2018.*

wind-and solar-generated power today are regularly cost-competitive in many parts of the world without the benefit of subsidies.

11. Other key drivers and emerging trends setting the path towards the transformation of the energy system that is worth noting include:[15]

 - **Policy and regulatory-related drivers:** Governments around the world are developing the pathways and setting the targets to meet national and international commitments. Renewable energy generation is seen as a valuable input on energy security, and an opportunity to diversify risks and enhance resilience to climate shocks.
 - **Economic drivers:** The technology learning curve on renewable energy technologies such as solar and wind energy, together with the progressive reduction of costs of energy storage and alternatives such as power to fuels are key drivers behind enhanced renewable energy generation. Furthermore, as market actors will increasingly become aware and capable of pricing the transition risks associated with fossil fuels assets, they will set targets to go green by e.g. purchasing energy from renewable sources and procuring green certificates under the, for instance, RE100 pledge.[16]
 - **Social drivers:** From global to local, from consumers to prosumers. The distribution of electricity production in developing and developed countries widens because of solar technologies, from thousands of central to millions of distributed power plants. Changing preferences and the increase of demand for transparency are another social driver of the energy transition. Spatial inequalities, including rural-urban gaps in access, are also a key driver. Decisionmakers are seeking socio-economic convergence in area coverage, household access, and support to productive use applications, particularly for women.
 - **Technology drivers:** Digital technologies support the decentralization through analysis of large amounts of sensor data and determination of optimal settings for the control software systems. In mature energy systems, end users become an active part of the energy sector with smart homes and appliances, electric vehicles, domestic storage, and in-house electricity generation enabling them to sell back any surplus to the grid. In developing regions, distributed renewable energy solutions (standalone and mini-grids), particularly significant for regions such as Sub-Saharan Africa and India, will be incrementally added to enhance energy access. This will also enable under-served energy communities to leapfrog over traditional centralized systems.

2. Climate challenges facing the energy sector in developing countries

12. **The integration of variable renewable energy into the grid poses certain unique challenges and is emerging as a key barrier to the scaling up of renewable energy.** Solar, wind and other forms of renewable energy produce variable and uncertain electricity that most power grids are not designed to accommodate. Key characteristics of renewable energy generation include the following:

 - Output variability, leading to increased reserves/ramping requirements, or curtailment of renewable energy
 - Location dependence, requiring upgrades to distribution/transmission power transfer capabilities to accommodate renewable energy
 - Changes to voltage, frequency, reactive power and/or fault current performance, leading to the grid operating close to or outside established operating parameters

[15] DNV GL (2018), *Energy Transition Outlook*.
[16] RE100 is a global corporate leadership initiative committed to 100% renewable electricity. See http://there100.org

- A general increase in price volatility for countries with spot markets, otherwise lower marginal costs resulting in impacts on the revenue stream of existing generation assets.

13. The impact of, and challenges associated with variable renewable energy generation depend mainly on the level of deployment, the context and size of the power system,[17] including the geographic dispersion of related renewable power generating facilities and the technology used by many of the generators, market design, regulation and supply/demand fundamentals. Such challenges can increase over time along with the increase in variable renewable energy generation.

14. A power system must be able to cope with the variability and uncertainty that solar and wind energy introduce at different time scales (from the very short to the long term) to avoid curtailment of power from these variable renewable energy sources and reliably supply all customer energy demand.[18] In the absence of such capability, the energy transition risks risk proceeding on a suboptimal path, with power systems reliant on fossil backup. In many developing countries highly-polluting diesel generators and heavy fuel oil are being used as sources of flexibility.

15. A diverse range of emerging technologies is already available to enhance the flexibility of energy systems such smart grids, energy storage, demand response, and green hydrogen. Operating a reliable electricity system requires the instantaneous matching of supply and demand. Renewable energy- enabling technologies can help maintain the supply-demand balance by acting as either supply or demand, making it a flexible resource that can help grid operators manage the integration of renewable resources and respond to changes in system conditions almost instantaneously. For example, storage assets can participate in energy markets in a variety of ways: 1) as a generation asset, storage can provide energy, capacity, and ancillary services, 2) as a transmission and distribution network asset, storage can provide congestion relief, enhancing the capacity of the network to accommodate new power and avoiding the need for new transmission or distribution infrastructure, and 3) as a load asset, storage can participate in demand response programs, reducing the power demanded during certain periods of the day. Storage can be directly connected to the grid and optimized by grid operators. It can also be part of an isolated mini grid system, or it can be located behind-the-meter directly at a customer site.

16. Demand management solutions also offer significant opportunities to increase grid flexibility. Several energy applications, such as pumping, heating, and cooling, can be managed to better match the profile of availability from variable renewable electricity generation. This has the dual benefit of reducing system costs as well as enhancing the ability of national grids and grid operators to integrate renewable energy in an effective way.

17. Further, the transformation of the energy systems implies also harnessing the potential of e-fuels (i.e. synthetic gaseous and liquid energy carriers and feedstocks produced from renewable electricity) as a complement to other energy transition approaches. This is because, inter alia, they allow to reduce emissions of applications that cannot be directly electrified and provide additional options for other sectors that are mainly supplied with fossil fuels (e.g. aviation, maritime shipping or heavy-duty long-distance road transport).[19]

18. A range of a range of solutions suitable for off-grid applications to enhance energy access in lower income countries is also available. Decentralized systems, led by solar photovoltaic (PV) in off-grid and mini-grid systems, are considered the least-cost solution for three-quarters of the additional

[17] See https://www.iea.org/topics/system-integration-of-renewables.

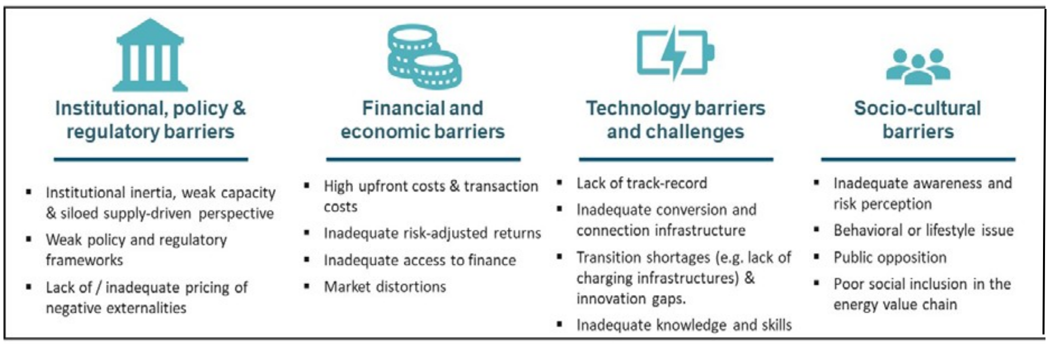
[18] IRENA (2019), *Innovation Landscape for a Renewable-powered Future: Solutions to Integrate Variable Renewables.*

[19] Global Alliance Powerfuels (2019), *Powerfuels: Missing Link to a successful global Energy Transition.*

connections needed to provide universal electricity for all.[20] Lack of access to clean fuels has negative health impacts that fall disproportionately on women and children, due to the gender division of labor and more time spent in proximity to polluting combustion sources.[21]

19. While tools, technologies, and services to address key challenges to the integration of variable renewable energy and investment opportunities exist, as highlighted in the paragraphs above, they fail to attract enough investment by both public and private actors because of several barriers. Figure 1 provides an overview of such barriers. Market rules need to be overhauled to consider new technologies, and market design and new financial instruments need to be deployed to manage energy price volatility risks.

Figure 1: An overview of key barriers to investments in renewable energy integration



20. Among the key financial and technological-related barriers, it is worth noting that in certain developing markets, typically those with sub-investment grade ratings or not fully developed financial markets, inadequate availability of non/limited-recourse project financing (particularly in terms of tenors, but also in terms of currency, among other) does not allow investments in relative more capital-intensive clean technologies such as energy storage to be competitive. Even in established markets, revenue uncertainty associated with energy storage investments deters investors. Further, business models for technologies that support renewable energy integration are still emerging. They may not be revenue generating in the first instance and may represent additional costs to be recovered by the project sponsor. Additionally, there are specific technical challenges involved in integrating renewable energy generation into the grid, such as impacts on reactive power control, advanced metering standards and control communications, and bespoke connection infrastructure.

21. The proposed *Integration of Renewable Energy into Power Systems Program* seeks to help address system-wide barriers to the integration of higher shares of intermittent renewable energy generation into the grid and take advantage of the opportunities arising from the energy transition.

[20] IEA (2018), World Energy Outlook 2018.

[21] Women and girls are often responsible for collecting fuelwood and other biomass, which reduces time available for economic and educational activities, and can increase risk of gender-based violence due to further travel from their homes. In Benin, girls spend more than 30 hours per week gathering wood (and water) for use on inefficient cookstoves. The World Bank has estimated for Lao PDR, for example, that household air pollution from the incomplete combustion of solid fuels is the top health risk in the country, costing 3.5 per cent of GDP in lost productivity. Investments in decentralized systems can also help spur women's economic empowerment and entrepreneurship due to productive use application of energy in such service enterprises as petty trade, food processing, and small-scale agro-processing. Source: WHO (World Health Organization) (2016), *Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children*. Geneva: WHO.

Box 1: Example battery storage market

Battery storage deployment in developing countries faces two major obstacles. First, the market for stationary batteries still represents just a small part of the global batteries market driven completely by the electric vehicles market (11 GWh of stationary batteries vs. ~400 GWh of electric vehicle batteries, cumulative, in 2017). Second, based on the World Bank Group estimates, there was roughly 4.5 GWh of cumulative installed capacity of batteries in developing world in 2017, mainly used in mini-grids and island applications. There is a need to create a separate market segment that caters to the needs of stationary battery storage (and not just electric vehicles) and addresses challenges that stationary battery applications will encounter in developing countries, such as extreme temperatures, irregular operational regime, need for long duration storage to serve off-grid areas, and a lack of local capacity to maintain and operate the facility, among other issues.

3. Concept proposal

22. **There is an urgent need to demonstrate, at scale, the integration of high volumes of variable renewable energy into power systems in a way that maintains safety, reliability, and security of energy supply** while establishing alternative investment pathways that are consistent with a 2°C warming scenario.

23. In the current energy sector context and the climate change goals established by the international community, accelerating the energy transition requires a full package of measures to enhance flexibility in energy systems and, to this end, concessional capital to push boundaries and increase the penetration of renewable energies in the energy mix.

24. A low-carbon economy will result when a high share of renewable energy is achieved in the energy system and incorporated to the end-use sectors. New forms of flexibility – such as energy storage, smart-charging electric vehicles, demand response and interconnectors, are key to an affordable, renewables-led power system. Growing the market demand for electrification, e-mobility and green/e-fuels in sectors like transportation, buildings or industry will further accelerate renewable energy uptake at scale. Such a pathway will also generate important co-benefits relating to energy security, energy efficiency, air quality, health impacts, and women's economic empowerment.

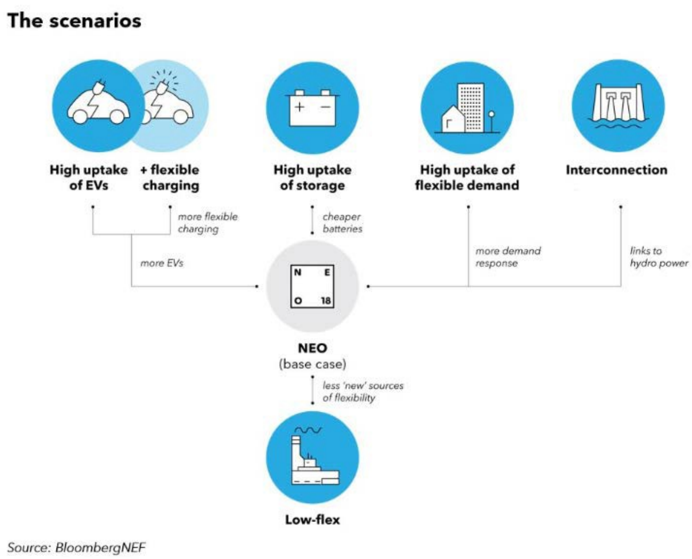
25. **CIF proposes a Program to support the integration of renewable energy into power systems through different flexible solutions**. It would provide concessional climate finance through its partner MDBs to support developing and emerging countries in accelerating the deployment of an integrated mix of supply/demand side flexibility measures according to the best combination of technology pathways that balance the need for different infrastructure requirements across the sector. Areas that would be supported by this Program include:

    - Enabling technologies
    - Enabling infrastructure
    - Electrification and demand management
    - Market design and system operations improvement

Box 2. Pathways to renewable energy integration.

Figure 2 provides an example prepared by BloombergNEF for the UK of the different possible pathways for solving the power system flexibility challenge in the U.K.
The study explores alternative futures for the power system, depending on how each flexibility technology might develop.
It underscores that flexible technologies do help integrating large volumes of renewable generation and displacing fossil backup capacity. They help doing so by storing the excess renewable generation for periods of high demand or by shifting excess demand to periods of high renewable generation. The study also highlights the associated benefits in terms of system costs and carbon emissions.

Figure 2: Example of flexible solutions pathways/scenarios[22]



26. **This CIF's Program proposal responds to the growing need to address underlying technical, operational, and financial barriers hindering the integration of renewable energy generation into the power grids,** being therefore the only major initiative with this explicit focus, rather than focusing on accelerating the deployment of renewable energy generation itself, as other initiatives do. Experience in countries around the world with growing shares of renewable energy generation show that unless these barriers are tackled, they can inhibit and discourage investment in renewable energy generation at the speed needed to achieve global climate change goals.

27. To achieve long-term decarbonization goals, it is acknowledged that national governments must put in place ambitious, flexible, and feasible decarbonization policies and underlying regulatory frameworks. Absent such government direction, investors will not be able to deploy capital at the speed and volume necessary to deliver on those goals. It is therefore expected that up to 5 percent of the Program resources be deployed as a non-reimbursable Technical Assistance resources to

[22] Source: BNEF (2018), *Flexibility Solutions for High Renewable Energy Systems*. *Note: NEO refers to BNEF's New Energy Outlook scenario.*

provide policy reform, market design, and system operation support to client countries. Technical assistance resources would also be needed to support pipeline and project preparation and structuring. Table 1 provides an indicative list of activities to be supported.

Table 1: Possible activities to be supported under non-reimbursable Technical Assistance resources

Facilitating sector policy level activities	▪ Technical and market studies for preparing pilot bankable projects
	▪ Policy targets and roadmap for deep decarbonization (low carbon pathway for energy and related sector)
	▪ New or improved auctions/procurement mechanisms for renewable energy
Promoting market and system design and operations	▪ Advanced weather forecasting and training on renewable energy integration for grid operators ▪ Enhanced STEM[23] education and internship training to expand women's employment in energy utilities, including in managerial roles
	▪ Increased time and space granularity in electricity markets
	▪ Country diagnostics, studies, and recommendations regarding market structures, policy frameworks, etc. to create regulatory/market frameworks for innovative services (e.g., balancing market/ancillary services, capacity market, energy storage, etc.)
	▪ Net billing schemes and social impact assessments of these, with consideration of both tariffs and subsidy design, particularly on women's access to energy services
	▪ New roles of distribution companies
	▪ Renewable certificate (iREC)
	▪ Long-term contracting of energy or hedging strategies

28. The Program's investment strategy envisages the deployment of most of the concessional resources in support of key flexibility technologies and services. Key measures proposed for financing are listed in Table 2.

[23] STEM = Science, Technology, Engineering and Mathematics

Table 2: Proposed activities to be supported under the majority of Program funding

Scaling up renewable energy - enabling technologies	▪ Energy storage technologies, such as batteries, pumped hydro, and green hydrogen, which can back up the variability of renewables and provide various services to
	▪ New technologies for real-time grid management that enhance electricity system flexibility and facilitate distributed generation, such as advanced metering systems, wireless network control, and demand side management, including outreach to women and men users
	▪ Technologies that enable electrification of other sectors, such as electric vehicle charging infrastructure, to open doors to new markets for renewable generation and new ways to store the generation surplus
	▪ Green fuels/e-fuels in sectors like transportation or heating
Enhancing infrastructure to be renewable energy -ready	▪ Grid interconnection to integrate regional markets and increase their flexibility
	▪ New and smart grids, both large and small scale, that complement each other and enable new ways to manage variable renewable energy generation.
	▪ Changes in the operation of existing hydropower plants to accommodate more penetration of VRE.
Supporting renewable energy innovation[24]	▪ Business models that empower women and men consumers, turning them into active participants in demand-side management
	▪ Innovative schemes that enable renewable energy supply, in both off-grid and connected areas
Enhancing system and market design and operation	▪ New regulations in the wholesale markets that encourage flexibility from market participants, better signal firming power supply's value, and properly remunerate their grid support services
	▪ Design and regulatory change in the retail market that stimulate flexibility on the consumer/prosumer side, including on pricing structures
	▪ New operation procedures that improve predictability of renewable energy such as advanced weather forecast procedures.

29. The proposed *Integration of Renewable Energy into Power Systems Program* complements and would expand upon the dedicated Global Battery Energy Storage Systems Program established in June 2019 under the Climate Investment Funds' Clean Technology Fund.[25] Such Program focuses on one of the possible energy integration approaches – energy storage – with the aim of supporting CIF countries in accelerating its deployment to enable the scale up of renewable energy generation.

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[24] This proposal acknowledges that in some regions, direct investment in solar PV and wind (onshore and offshore) may still require concessional support subject to the degree of maturity of the renewable energy market in that specific country or region.

[25] For more information, please see CIF's web site at https://www.climateinvestmentfunds.org/documents/dedicated-private-sector-program-%E2%80%93-battery-storage-dpsp-iv.

30. The proposed *Integration of Renewable Energy into Power Systems Program* would build upon the decade-long experience of CIF in partnering with MDBs in both middle and least developed countries to advance the penetration of renewable energy into power mix and enhance access to clean energy. The Program's strategy is also complementary and supplementary to the programming strategies of other multilateral climate finance vehicles as shown in Table 3. To ensure effective and efficient use of scarce concessional resources, the CIF partners will actively pursue opportunities for complementarity and collaboration with other multilateral climate funds and development efforts.

Table 3: Selected initiatives supporting renewable energy integration

Initiative/Partnership	**Concessional Finance for Investments**			**Technical Assistance**			
	Explicitly support the integration of renewable energy	Investment lending at scale	Upstream finance	Policy support	Capacity building	Knowledge sharing	Pipeline creation
Climate Investment Funds – Renewable Energy Integration Program *(proposed)*	■	■	■	■	■	■	■
Green Climate Fund – Renewable Energy Sector Strategy[26]		■	■	■	■	■	■
Global Environmental Facility- Climate Change Focal Area Strategy**			■	■	■	■	
*New GCF Renewable Energy Sector Strategy includes T&D storage, utility scale storage and behind the meter storage as priority areas. GCF aims to deliver USD 3.65B to the energy sector. So far, new GCF strategy does not include, explicitly, support to integrate renewable energy into the power system through flexible solutions (consultation process stage). ** The GEF will support countries that have identified power sector transformation through mini-grids, energy storage, and new business models.							

4. Rationale for Concessional Finance and the Climate Investment Funds

4.1 The comparative advantage of CIF

31. **CIF's business model is particularly well suited to deliver on the *Integration of Renewable Energy into Power Systems Program's*** objectives and thereby address those key integration issues that hinder the higher penetration of renewable energy into power systems. This is thanks to, in particular, the following key features of CIF's business model:

- Country-led programmatic participatory approach

[26] Source: GCF (2019), *The Strategic Plan for the GCF: 2020–2023*. GCF/B.24/Inf.01, October 11, 2019. The GCF 2020–2023 Strategic Plan, not yet approved by GCF's Board, will be complemented by more detailed sectoral guidance which will likely become available during the first quarter of 2020.

- Risk-appropriate financing tools at scale
- Ability to target new sectors and technologies for transformational impact
- Flexibility

32. CIF's programmatic approach encompasses the development and implementation of a country-led investment plan — supported by MDB collaboration, informed by multi-stakeholder consultation, and associated with a predictable and flexible resource envelope —that sets out strategically linked investments, unified by a transformative vision.

33. CIF's programmatic approach aligns well with the Program's focus on both policy and investment barriers. It is intended to offer a holistic approach to renewable energy integration in national power grids, beginning with long-term decarbonization planning, assessment of business models for encouraging renewable energy integration, translating these models into legal and regulatory frameworks, and providing investment support to deal with commercial and financial barriers to public and private sector investment.

34. Accelerating the energy sector transformation and ensuring continued system efficiency and reliability requires efficient institutional dialogue and long-term coordination and planning between national, regional, and local governments and with other stakeholders of the energy system. CIF's programmatic approach is particularly well suited to facilitate such dialogue and coordination with a view of providing long-term market signals that can accelerate decommissioning of coal and diesel generation and replacement by large-scale renewables.

35. Mobilizing private capital at scale (for example, by piloting new blended finance solutions) calls for CIF's toolbox of flexible cost and risk-bearing instruments. Meeting context-specific investment needs and achieving risk-return profiles attractive to private investors requires, in fact, a wide array of tailored financial and non-financial instruments.

36. CIF's programmatic approach, together with flexibility and dedicated private sector solutions, make CIF the partner of choice to support countries' sustainable development goals and achieve internationally agreed climate goals.

Box. 3. Evidence of CIF's comparative advantage in enabling the deployment of unproven renewable energy technologies

The ten-year track record of CIF's business model shows that MDBs and flexible, programmatic concessional capital at scale play a critical role in driving and enabling transformational investments that would not otherwise happen.

The scale, predictability, and flexibility of CIF's resources have proven critical in overcoming institutional inertia and successfully changing risk perceptions among investors, leading to acceptable risk-adjusted returns.

Access to scaled-up amounts of CIF's concessional climate funds have enabled MDBs and recipient countries to take on early-stage risk and cost barriers in ways that demonstrate economic viability and crowd in investment.[27]

In Morocco, for instance, concessional capital from CIF deployed as part of the country's renewable energy program has been instrumental in kickstarting solar thermal and unlocking investments in a new technology: utility-scale concentrated solar power. The flexibility and the degree of concessionality of CIF's resources has improved the project's financial viability by allowing partner MDBs to match repayments with the revenue profile of the investment, and the developer to hedge foreign exchange risk.

4.2 Need for concessional finance

37. **Targeted application of concessional finance can lower investment costs and risks and help initiate investments that go beyond the grid's business-as-usual needs**. As described in Section 2, there are a range of barriers to investments in energy integration measures that the target use of concessional capital can help address. These range from regulatory gaps, high up-front capital costs, revenue uncertainty, lack of non/limited-recourse project financing, and unproven business models.

38. For example, concessional capital can help enhance the cost-competitiveness of battery projects by helping to lower the cost of capital. This is relevant because, as evidence shows,[28] for each percentage point rise in the overall cost of capital for a lithium-ion battery project, for example, its levelized costs of electricity (LCOE) rises by USD10/MWh. Availability of concessional finance could hence prove crucial in incentivizing new-build storage globally.

39. There is also need for concessional capital in a set of relevant areas besides energy integration technologies. For example, there are specific technical challenges involved in integrating renewable energy generation into the grid, such as impacts on reactive power control, advanced metering standards and control communications, and bespoke connection infrastructure. Further, encouraging sustained investments in multiple infrastructure areas to achieve long-term impacts requires consistent policies coordinated across various energy sectors and developed based on the policy objectives of the many facets of government and business decision-making (e.g., taxation, urban planning, trade, innovation). The availability of concessional support can help private and public entities to overcome such challenges and address multiple policy and regulatory gaps.

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[27] ITAD et al., (2019), *Final Evaluation Report - Evaluation of Transformational Change in the Climate Investment Funds*; BNEF (2019), *The Clean Technology Fund and Concessional Finance - Lessons Learned and Strategies Moving Forward*.

[28] BNEF (2019), *The Clean Technology Fund and Concessional Finance. Lessons Learned and Strategies Moving Forward*.

4.3 CIF can help innovate how concessional finance is delivered on the ground

40. **CIF's business model holds a proven comparative advantage in enabling innovation.** The CIF-MDBs partnership can help to further innovate how concessional finance is delivered on the ground. Over the past ten years, CIF has helped MDBs to develop and test new products and learn lessons that were later replicated with their own resources and/or with resources from other partners.[29] CIF has helped MDBs "learn by doing" in relation to blended finance structures,[30] and mitigate risks to the deployment of unproven renewable energy technologies in politically unstable markets.

41. CIF can continue pushing the boundaries in climate finance and tackle areas previously underserved by traditional financial instruments. To this end, it would need to ensure high risk appetite and tolerance.

42. Under the *Integration of Renewable Energy into Power Systems Program* CIF will seek to enhance MDBs' ability to innovate how concessional finance is delivered on the ground by supporting them in the design and implementation of innovative financing strategies. Table 4 provides some examples of blended finance structures that could be explored under the Program.

[29] ITAD et al., (2019), *Final Evaluation Report - Evaluation of Transformational Change in CIF.*
[30] ITAD et al., (2019), *Final Evaluation Report - Evaluation of Transformational Change in CIF.*

Table 4. Examples of innovative blended finance instruments for the Integration of Renewable Energy into Power Systems Program[31]

Instrument/Facility	Description	Innovative Features
Technology Innovation Facility To support cutting-edge technologies and business models	Multi-instrument facility emerged in the context of the Global Innovation Lab for Climate Finance with the aim of helping to overcome the main financing barriers facing viable and semi-commercial projects, through a) Grants through a working capital initiative to support project preparation, R&D, and other upfront costs for selected and promising climate solutions, b) Grant/reimbursable grant support for a dedicated 'Accelerator' to focus on scaling up green businesses c) Equity to provide anchor capital to riskier sectors and countries, to support market development of new technologies.	• Would allow CIF to support 'seed' investments to enable innovative new ideas, models and technologies. • Would support many project ideas that otherwise would not be developed because of lack of start-up capital, in particular for new technologies or models, or for MSME borrowers with inadequate credit history and track record.
Sustainable Energy Bonds To drive impact investors to sustainable energy projects	Class of debt instruments targeted to impact investors looking for debt exposure in the sustainable energy sector	• Aggregates small-scale sustainable energy projects • Provides a platform for monitoring the impact created through standardized impact reporting • Establishes a track record of debt servicing
Green Aggregation Tech Enterprise To unlock private investment for mini-grids to enhance energy access	A vehicle developed to address demand and revenue risk through a risk pooling guarantee. Proposes to provide a baseline revenue guarantee to ensure that mini-grids can meet debt obligations in the event of revenue shortfalls	• Creates a guarantee business that effectively pools mini-grid revenue risk • Addresses revenue risk, a key obstacle to private investment in mini-grids and the subsequent scale-up of the market. This can transform the financing of mini-grids from donor grants to debt finance.
Solar Securitization To increase investment for clean energy technologies	An instrument being developed in Rwanda which bundles receivables from solar developers, thus freeing up working capital of solar companies to enable them to further increase their investments in clean energy infrastructure	• Securities can target different types of investors and lower the risk perception of the sector while also expanding the pool of investment for solar energy. • Can be highly replicable, not only in the energy infrastructure sector but also in e-transportation and utilities.
Risk management instruments To mitigate 'deal-breaker' risks through high-impact de-risking instruments	Blending concessional capital to credit enhance projects or portfolios whose real or perceived risks may not meet the requirements of certain capital market participants.	Guarantees represent only 5 percent of MDB operations, although they account for 45 percent of total private resource mobilization. There are opportunities to expand the use and reach of these instruments.

5. Theory of Change and expected outcomes

43. The Program would draw on lessons learned from previous experiences in CIF programming and project design. These can be synthesized in the following five key points, which indicate that climate investments may be more transformational when their design:

- **Promotes country ownership**. Climate solutions must align with the political agenda and institutional context. Furthermore, project and program design should be able to address key policy and regulatory frameworks, involving regulators from the beginning with a view towards changing norms.
- **Supports innovative finance**. Solutions that advance "disruptive" business models for private sector involvement and financial intermediation are relevant enablers of change, especially when they support a move towards non-concessional finance.
- **Meaningfully incorporates range of national and local actors**. Investment preparation, monitoring, and assessment of benefits to end-users and wider community should involve a wide diversity of stakeholders beyond governmental counterparts, including private sector and CSO actors, particularly women's organizations.
- **Promotes cross-sectoral collaboration**. The design of interventions should seek to create synergies across sectors and make visible how climate interventions have co-benefits in the wider development agenda.
- **Crowds-in private investment and mobilizes resources**. Climate solutions should prove their commercial or financial sustainability from the design stage and operate knowing that concessional finance is temporary support. The Program would aim to establish public and private partnerships around innovative, first-of-a-kind initiatives, preferably by maximizing the involvement of the private sector (including the supply chain) and bringing forward market-development intermediation.

44. The resources of the Program would be deployed through national and regional investment plans that address both the policy and market barriers preventing further penetration of renewable energies into the grid and promote specific investments with demonstration effects in enabling technologies, infrastructures, or business models (i.e., a regulatory reform to compensate ancillary services and investment in first-of-its-kind energy storage investments in the country or region). In addition, a dedicated private sector window would be set up to invest in countries or regions where the regulatory framework and market design already allow for direct investment in flexibility and niche innovations.

45. The Theory of Change of the proposed Program presented in Figure 3 demonstrates how the key elements of the Program would achieve significant impacts in terms of contributing towards the overarching CIF's impact of '*improved low-carbon and climate-resilient development*'.

46. The results pathways developed for this Program's Theory of Change are based on the principle that: *"If we improve market design and system operations, provide enabling technologies and infrastructure, and develop new business models, we will be able to increase renewable energy penetration in the energy mix, have a more flexible and decentralized energy system, improve policies*

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[31] For more information, please see the Global Innovation Lab for Climate Finance web site. These instruments and facilities are examples of those that emerged from the work that the CIF Administrative Unit has undertaken with Climate Policy Initiative in 2019. The CIF AU and CPI also organized a workshop with MDBs to discuss these and other innovative financing structures and engage in prototyping.

and capabilities, mobilize capital, increase energy access, reduce systems' costs and foster innovation, which will contribute to CIF's transformative impact".

47. **The expected outcomes of the proposed Program are as follows:**

Institutional

- **Improved policies, plan and institutional capabilities:** Governments will be able to provide suitable policies and enabling environment that will minimize trade-off, optimize synergies and increase uptake of flexible energy systems and integration of higher shares of variable renewable energy. The program will increase the institutional capacity of governments to plan and sustainably manage flexible energy systems.

Socio-economic development

- **Mobilized public and private capital:** Public and private investments are expected to help integrate high volumes of variable renewable energy into power systems in a way that maintains safety, reliability, and security of energy supply.
- **Increased energy access:** The program is expected to promote an uptake in energy access through different solutions.
- **Reduced total system cost:** The program promotes demand management solutions to increase grid flexibility, which can reduce system costs as well as enhance the ability of national grids and grid operators to integrate renewable energy in an effective way.

Innovation

- **Fostered innovation:** The program supports early-stage ventures, technologies and business models with high impact potential, and promote the uptake of innovative solutions for enhanced flexibility of energy systems.

48. The Theory of Change was developed based on the assumptions that there is enough demand and enough interest in scaling-up renewable energy; the services and technologies provided through the Program are of good quality, and represent a good return on the investment; confidence in investing in renewable energy is stable or increases; the regulatory environment is favorable to the Program and does not worsen; the adequate enabling conditions remain over the time of Program implementation or improve.

49. The risks that may have to be taken into consideration include: the choice of Program partners and their ability to deliver; technologies which may not deliver the expected results; lack of interest or engagement from the Program stakeholders; public opinion turning against the solutions promoted by the Program; and any social or environmental damage that may arise from the Program's implementation.

Figure 3: Theory of Change **Integration of Renewable Energy into Power Systems Program**

Risks:

- Choice of partners and their ability to deliver
- Technologies do not lead to expected results
- Lack of interest/engagement from key stakeholders
- Public opinion turns against the solutions promoted by the Program
- Power market volatility driven by supply (incl. fossil fuel prices) and demand fluctuations
- Unintended social or environmental consequences

Assumptions:

- There is enough demand and interest among stakeholders
- Services and technologies supported are of good quality and provide a good return on investment
- Confidence in renewable energy is stable or increases
- The regulatory environment does not worsen
- The enabling conditions remain or improve