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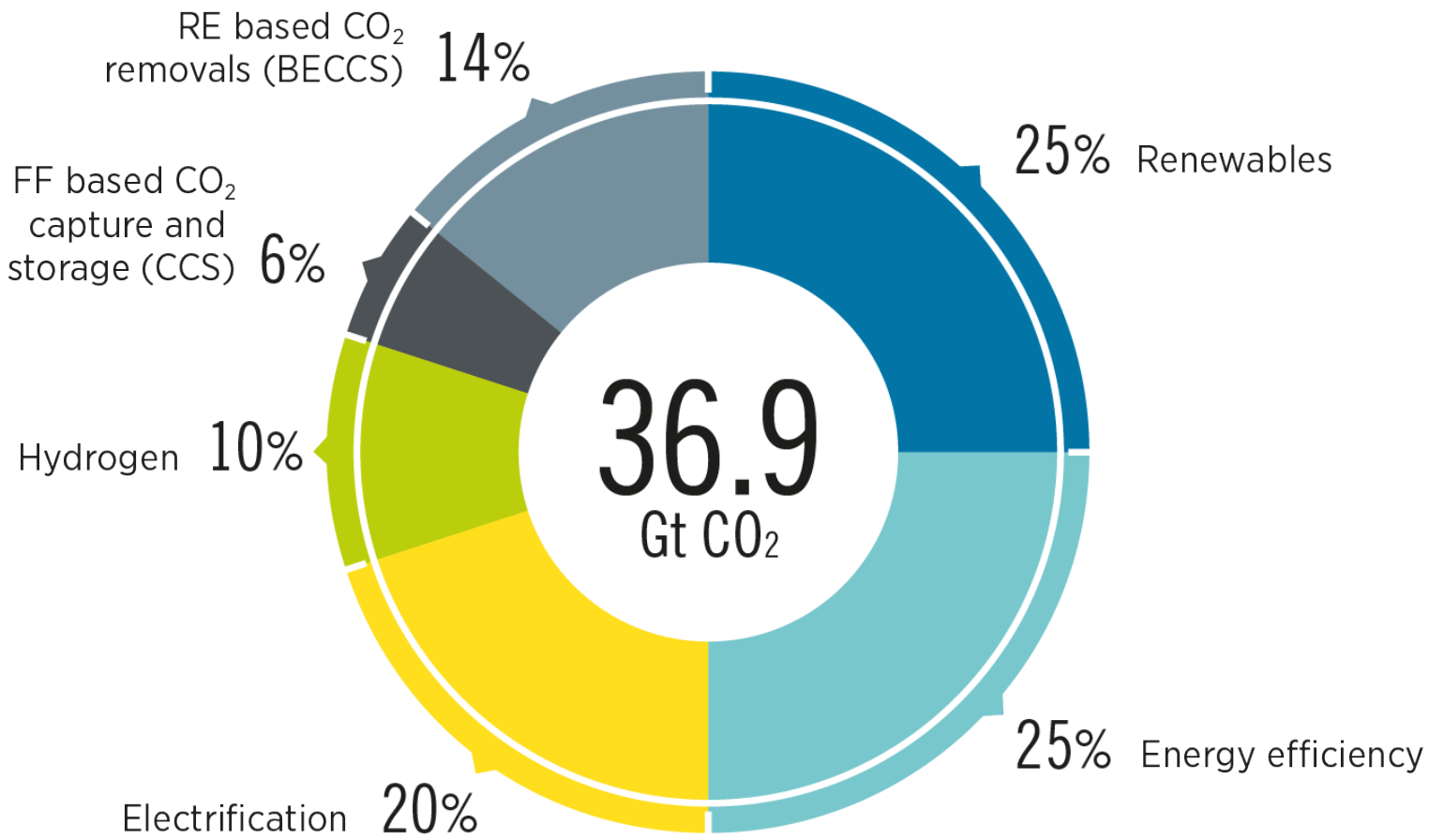
Innovation landscape for renewable powered systems

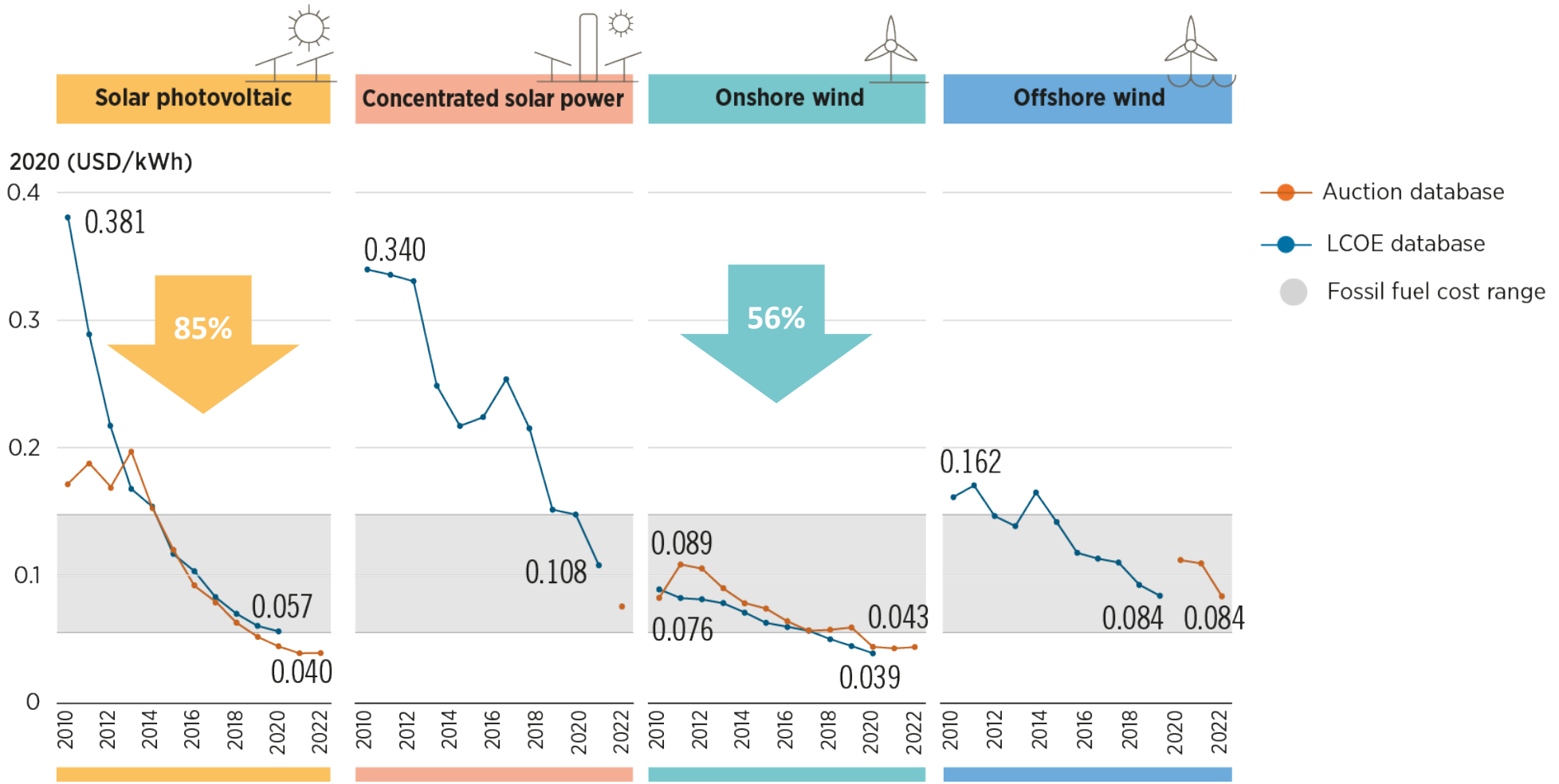
Renewables, efficiency and electrification dominate energy transition

Reducing emissions by 2050 through six technological avenues



90% of all decarbonisation in 2050 will involve renewable energy and energy efficiency

Renewables-based electricity is already the cheapest power option in most regions



In the last 10 years, the global weighted average levelised cost of electricity from utility-scale solar photovoltaic (PV) projects fell by 85%, concentrating solar power (CSP) by 68%; on-shore wind by 56%, and off-shore wind by 48%.

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Emerging innovations for the integration of solar and wind power

SYSTEM OPERATION

- Operation of a decentralised system
- Electrification of end-use sectors

ENABLING TECHNOLOGIES

- Digitalisation
- Hydrogen
- Blockchain
- Storage
- Electric vehicles

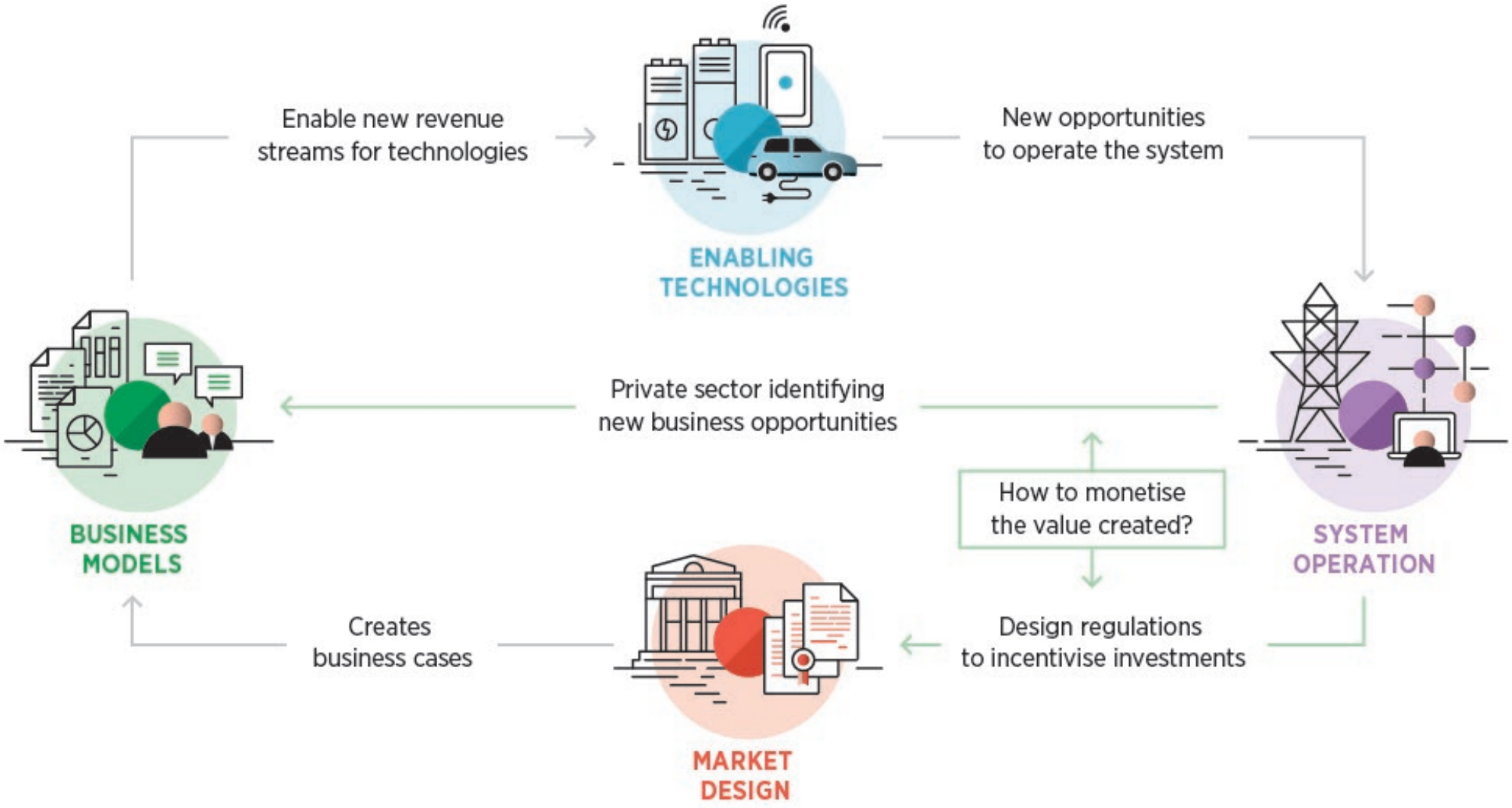
BUSINESS MODELS

- Energy as a service
- Peer-to-peer electricity trading
- Aggregators

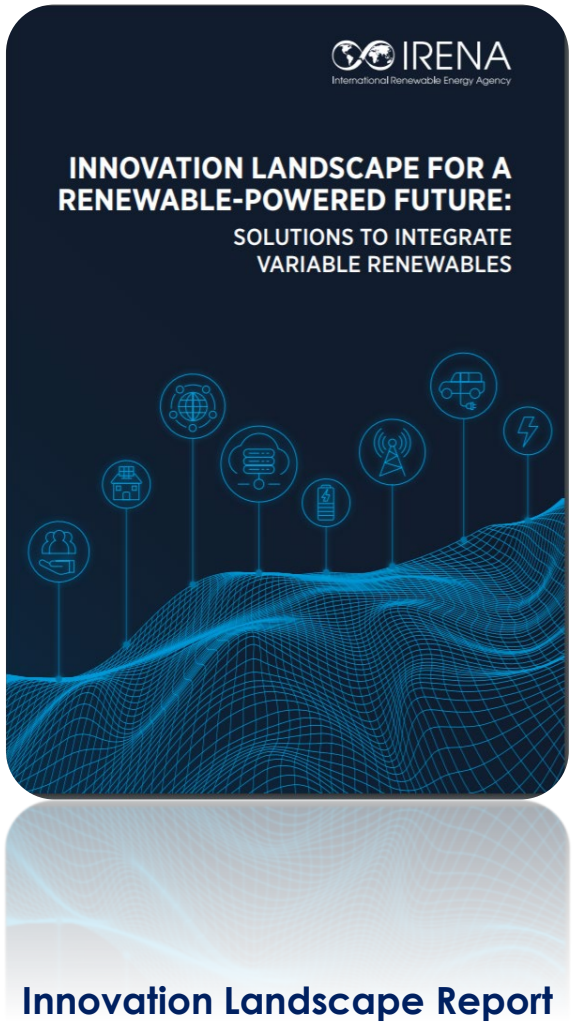
MARKET DESIGN

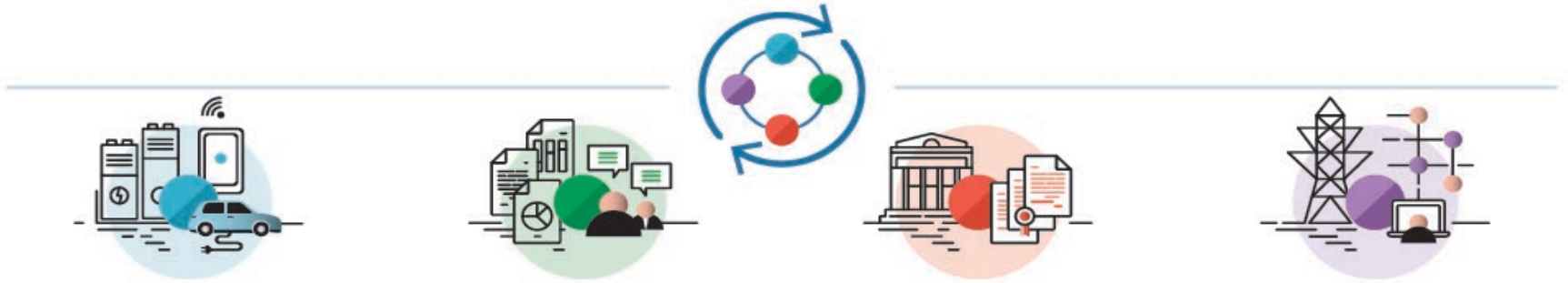
- Value complementaries in renewable generation
- Encourage flexibility
- Empowering consumers
- Value spatial complementaries

Systemic innovation



Innovations for integration of wind and solar PV generation





ENABLING TECHNOLOGIES

1	Utility-scale batteries
2	Behind-the-meter batteries
3	Electric-vehicle smart charging
4	Renewable power-to-heat
5	Renewable power-to-hydrogen
6	Internet of things
7	Artificial intelligence and big data
8	Blockchain
9	Renewable mini-grids
10	Supergrids
11	Flexibility in conventional power plants

BUSINESS MODELS

12	Aggregators
13	Peer-to-peer electricity trading
14	Energy-as-a-service
15	Community-ownership models
16	Pay-as-you-go models

MARKET DESIGN

17	Increasing time granularity in electricity markets
18	Increasing space granularity in electricity markets
19	Innovative ancillary services
20	Re-designing capacity markets
21	Regional markets
22	Time-of-use tariffs
23	Market integration of distributed energy resources
24	Net billing schemes

SYSTEM OPERATION

25	Future role of distribution system operators
26	Co-operation between transmission and distribution system operators
27	Advanced forecasting of variable renewable power generation
28	Innovative operation of pumped hydropower storage
29	Virtual power lines
30	Dynamic line rating

Source: IRENA (2019), Innovation landscape for a renewable-powered future: Solutions to integrate variable renewables

How to achieve a sustainable and socially inclusive growth powered by renewables?

How to achieve

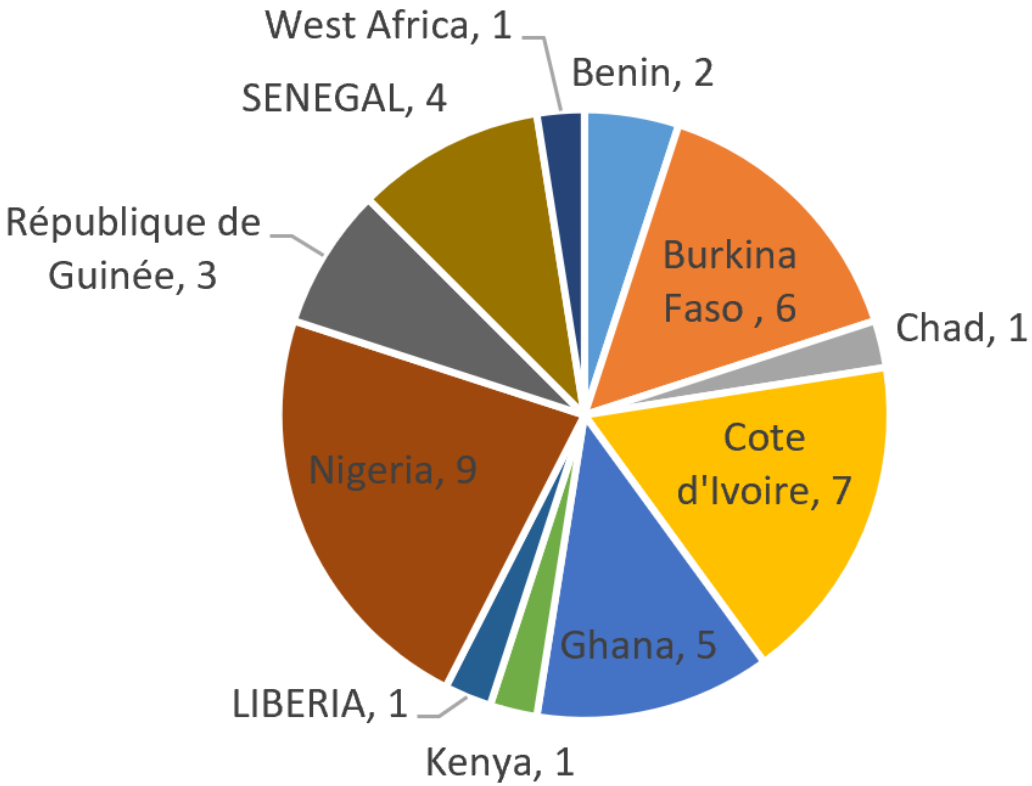
- **Cooperative and resilient power systems**
- **Inclusive rural development through decentralised productive uses**

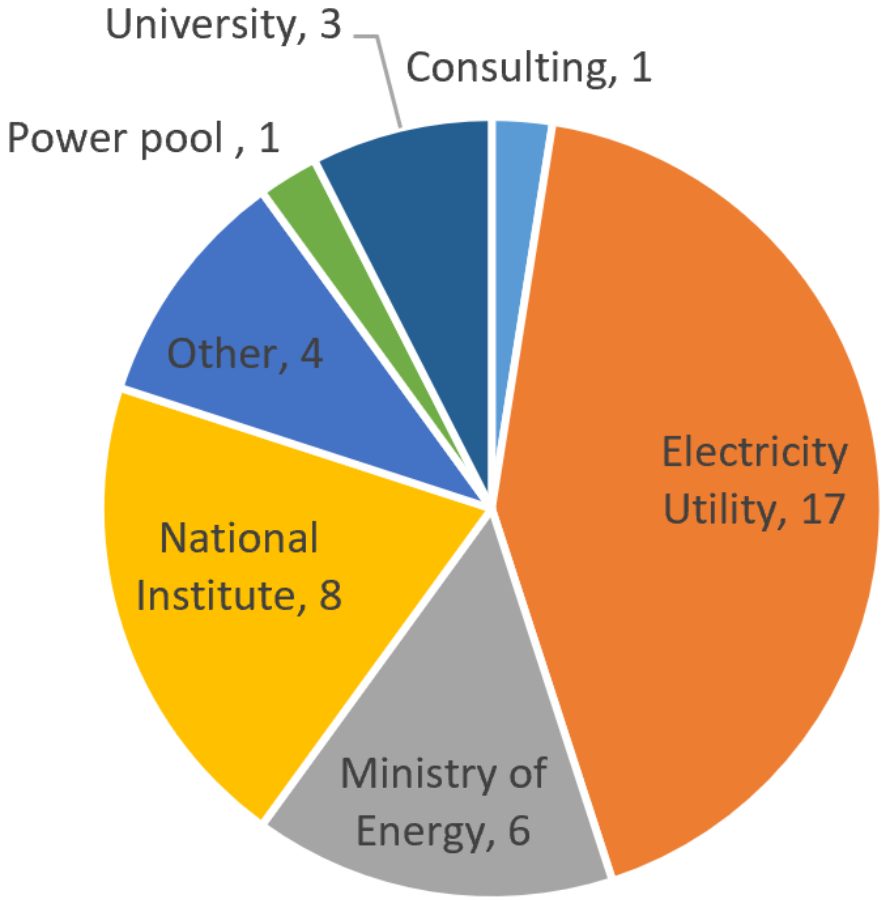
Technology and Infrastructure	Business Models and key change agents	Market design and regulation	System Planning and Operation
Supply demand balancing	**Consumer at the center**	**Regulated and fiscal support for RE deployment**	**Grid-strengthening solutions for weak grids**
1. Increased flexibility in conventional hydropower and thermal plants 2. Utility scale batteries 3. Small scale batteries	13. Community ownership model 14. Decentralized productive uses 15. Peer to peer trading 16. Aggregators 17. Storage as a service	25. Fiscal instruments 26. Auctions design and regulated tariffs 27. Renewable portfolio standards	34. Storage as virtual power lines to defer grid investment 35. Dynamic line rating for increased transmission capacity 36. Installing innovative compensation devices on the grid
Digitalisation	**Innovative funding models**	**Designs for end-users**	**Strategic long-term planning**
4. Data acquisition and monitoring 5. Advanced monitoring systems 6. Ubiquitous digitalisation	18. Pay as you Go (PAYGO) 19. Crowdfunding and financial bundling 20. Corporate renewable sourcing	28. Tariff design to shape the load 29. Innovative pricing for prosumers 30. Regulations for mini-grids	37. Enhanced forecasting of variable renewable energy generation 38. Transmission and distribution efficiency improvements 39. Planning for harmonized grid and off-grid developments 40. Planning for regional interconnections
Electrification of end-uses and energy efficiency	**Ecosystem enablers: key change agents for viable business environment**	**Designs enhancing operational reliability**	
7. Energy efficiency appliances 8. Electric vehicles 9. Green hydrogen 10. Renewable-based electrification of end-uses (heating, cooling, cooking, etc.)	21. Key change agents to support renewable based development programs 22. Powering a green health and education ecosystem 23. RE synergies for modernized railway infrastructures 24. RE for resilient agriculture and farming systems	31. Regional markets integration 32. Innovative ancillary services 33. Grid connection codes	
Future grids			
11. Renewable mini-grids 12. Supergrids – green corridors			

External engagement with experts in Africa

This collection of innovation was a result of consultations with experts in the region, via a Workshop and survey (English and French)

- **40 answers to the survey**



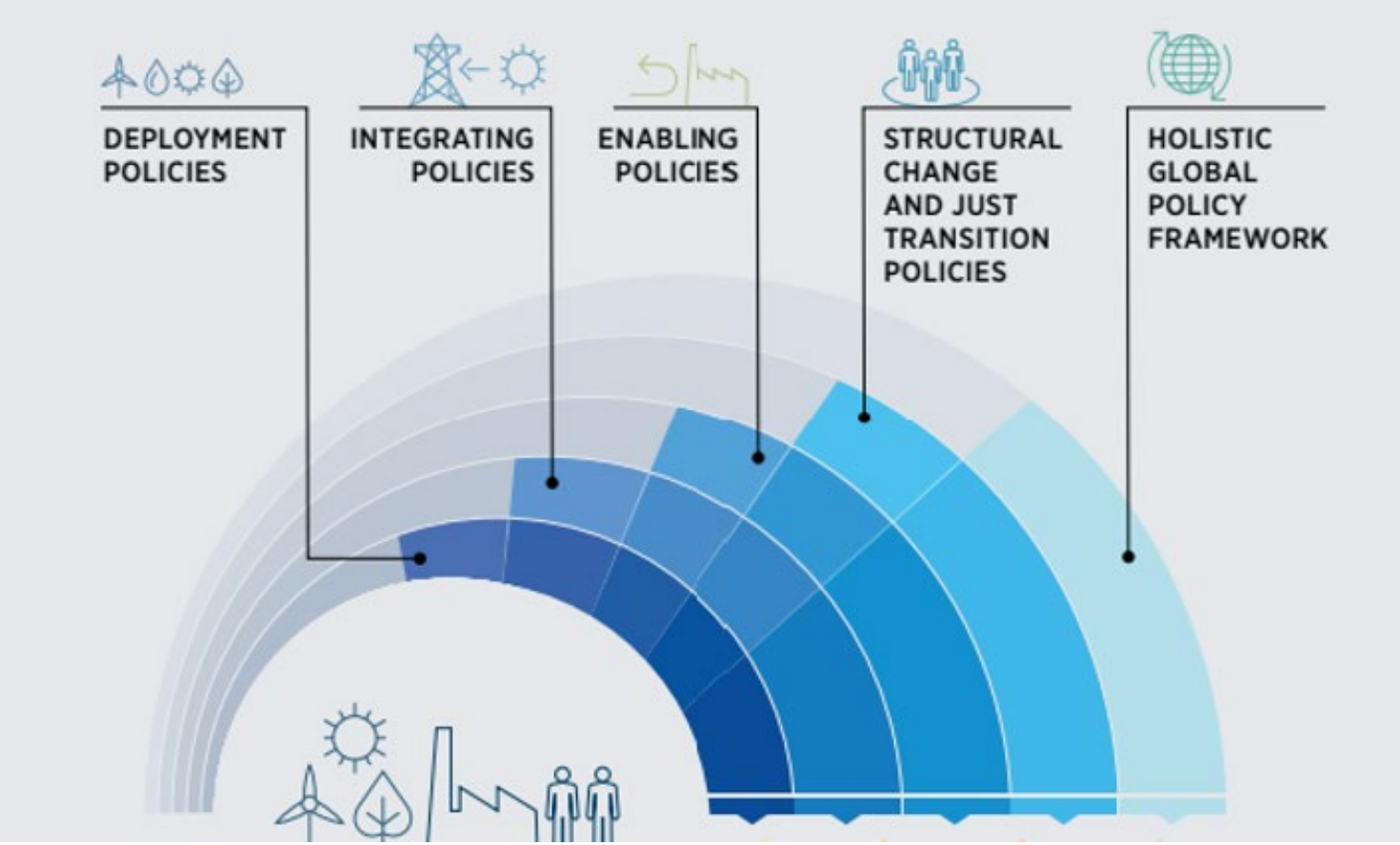


A comprehensive policy framework is the key to a just and inclusive transition

Integrating policies to bring transition-related technologies into the energy system and harness the potential of the African power pools

Structural policies to improve domestic skills, leverage local resources and develop homegrown industries – all to allow the energy transition to yield maximum socio-economic benefits

Deployment policies to promote the uptake of renewables, the electrification of end uses, and the direct use of renewables for heating, cooling and transport



Policy to research

At the core of innovation are public investments in research and development (R&D).

R&D spending, as a percentage of GDP, is relatively low in Africa (below 1%)

R&D could become an essential tool during the energy transition, especially for African nations wanting to shift from mere technology consumers to producers and innovators.

	Center	Focus
North Africa		
	Research Institute for Solar Energy and New Energies (IRESEN), Morocco.	Specialises in PV and concentrated solar power (CSP), particularly in the development of PV modules; new generation, development and testing of CSP air condensers with low water consumption; and sizing and optimisation of solar power plants. Developed a solar mapping of Morocco in particular and Africa in general.
West Africa		
	Center of Studies and Research on Renewable Energies (CERER) at the University Cheikh Anta Diop DE Dakar, Senegal	Promotes technological innovation in the field of renewable energy. Through its Solar PV Components Quality Control Laboratory, CERER ensures follow-up monitoring of PV components installed throughout the country.
	Kwame Nkrumah University of Science and Technology (KNUST), Ghana.	Focuses on PV panels, CSP and bioenergy (biogas, biodiesel and bioethanol), providing consultancy services to policy makers. Studies include one on biogas production from kitchen waste generated on the KNUST campus, and another on the technical challenges and impact of integrating high penetration PV systems into the Ghanaian transmission grid.
	International Institute for Water and Environmental Engineering (2iE), Burkina Faso	Develops academic research programmes and courses focused on strategic sectors for the social and economic development of Africa including renewable energy, water and waste treatment, mining and the production of eco-materials.
East Africa		
	Centre for Research in Energy and Energy Conservation (CREEC) at Makerere University, Uganda.	Conducts largely applied research on energy management, solar PV, pico-hydropower and biomass, with a focus on clean energy technology transfer to the business community and general public. Studies include one on small hydropower in rural Uganda, and another on solar energy kiosks.
Southern Africa		
	Centre for Renewable and Sustainable Energy Studies (CRSES) at Stellenbosch University, South Africa.	Performs state-of-the-art research on renewable-energy-related technologies and their applications. Conducts laboratory testing of renewable energy equipment to evaluate performance characteristics. Studies include one on the development of a biofuels engine testing facility, and another on the design and development of a novel wave energy converter.
	Power Futures Lab (PFL) from the University of CapeTown (UCT), South Africa.	Focuses on infrastructure investment, power sector reform and regulation in Africa. Since 2013, PFL has released at least eight studies on renewable energy auctions in Africa. The latest was titled "Counteracting Market Concentration in Renewable Energy Auctions: Lessons Learned from South Africa".

Thank you!

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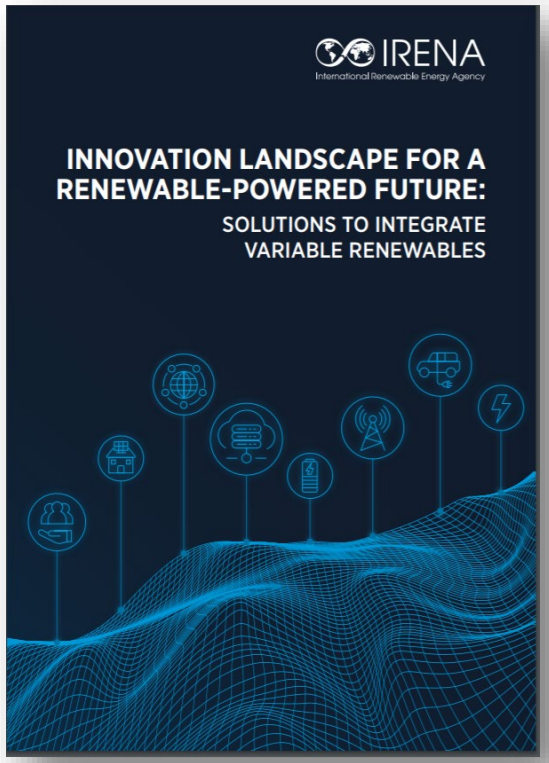
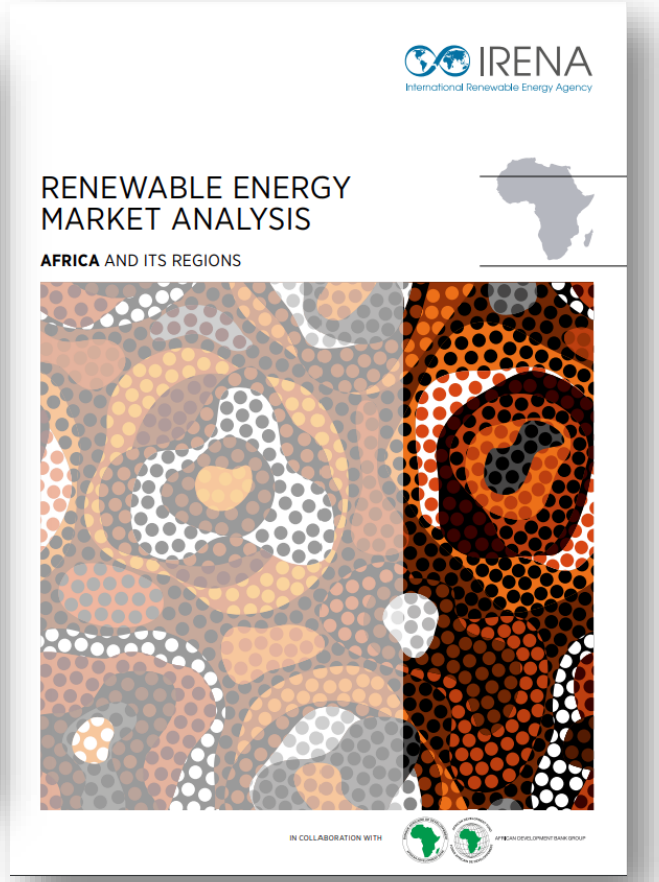
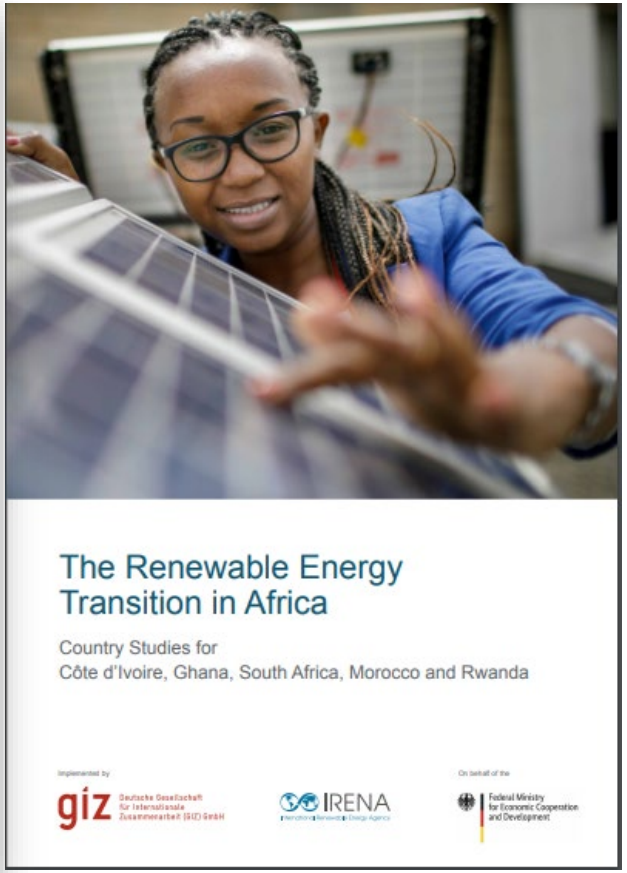


[Innovation Landscape for renewable integration]

[Innovation Landscape for smart electrification]



[Renewable Energy Market Analysis - Africa]



[The Renewable Energy Transition in Africa]