UN GLOBAL SOLUTIONS SUMMIT 2023

Thematic Session 2: Technology Roadmaps and Needs Assessments
For Technology Deployment and Sustainable Development

IEEE Advancing Technology for Humanity

IEEE EMPOWER A BILLION LIVES
An IEEE-PELS Initiative

Georgia Tech Center for Distributed Energy

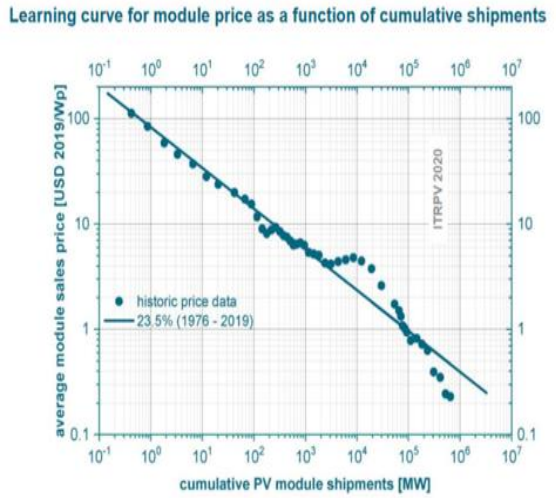
Democratization of Energy Technology Needs and Roadmap

Prof Deepak Divan
Global Chair – Empower a Billion Lives
Director, Georgia Tech Center for Distributed Energy
May 5, 2023

Energy Transition … *massive global disruption underway*

Georgia Tech Center for Distributed Energy

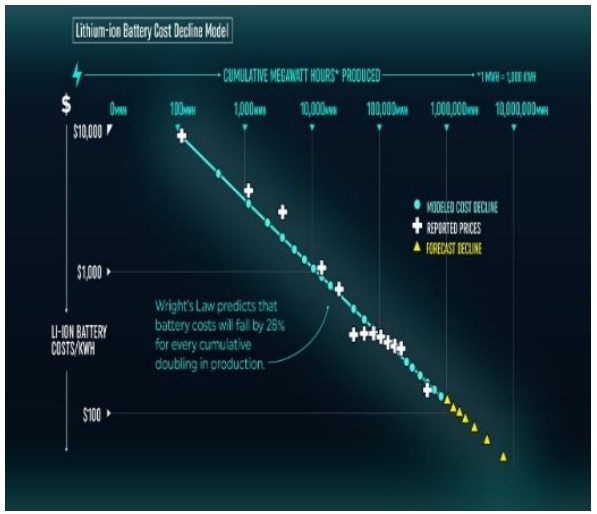
- Energy controlled by a few powerful nations (geopolitics of oil) or corporations, top-down regulated utilities are risk averse and cannot respond to rapid change
- All predictions for slow and planned growth disrupted by rapid growth of PV, wind, EV, & storage – <u>energy transition heralds major paradigm shift w/ unpredictable outcomes</u>
- In 2010 there was no major utility or automotive that believed EVs, PV or storage would be cost competitive over the next 10 years – boy, were they wrong!!

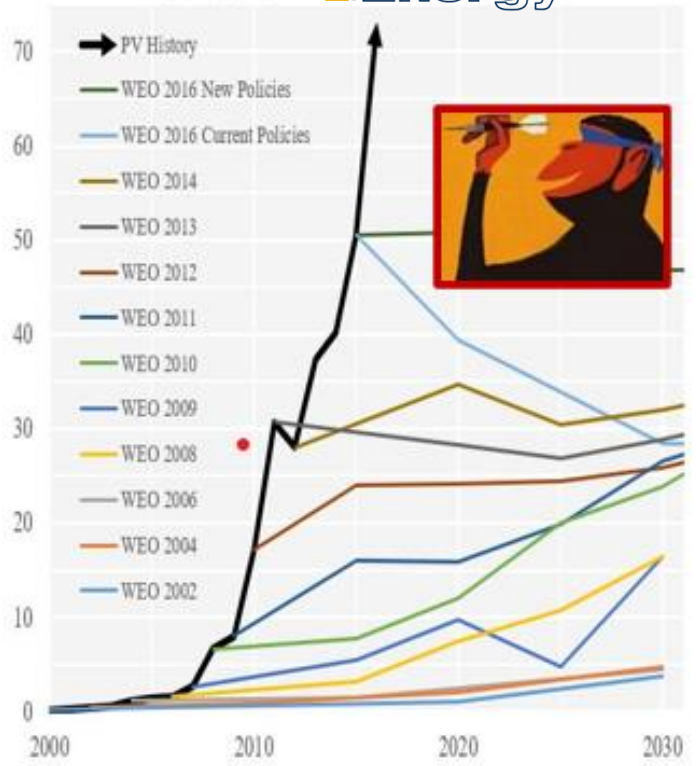


Driver: Steep & Sustained Learning Curves

<u>PV Cost</u>
$/MWHr
2000 - $850
2022 - $22
2040 - $5

<u>Battery Cost</u>
$/kWHr
2000 - $1500
2022 - $120
2040 - $60





PV – IEA Projections vs Real Growth

Climate or Growth?

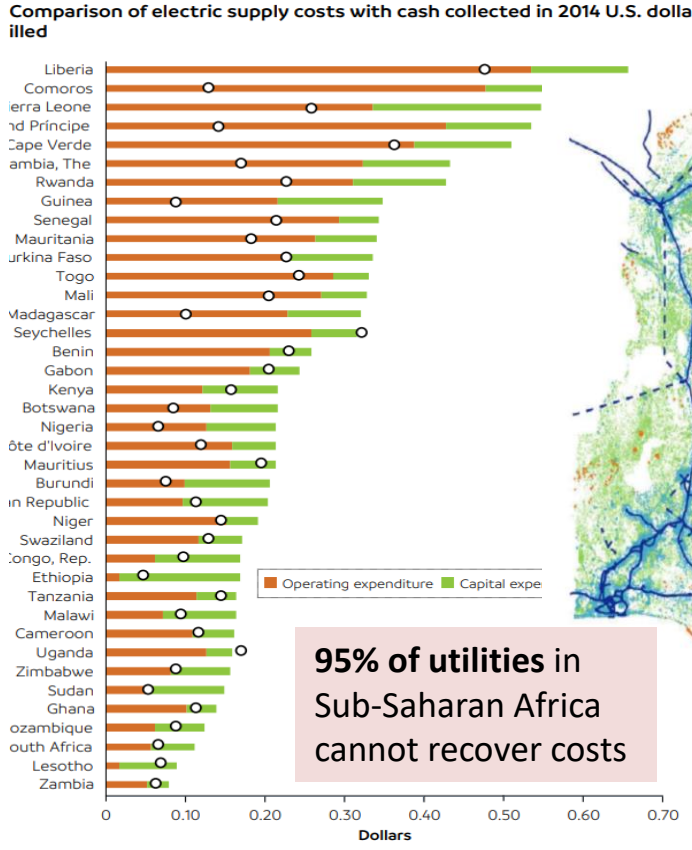
Reducing CO2 emissions is not a humanly relatable goal

For the first time, economics & climate actions are aligned

Will the least developed nations be left behind – once again!

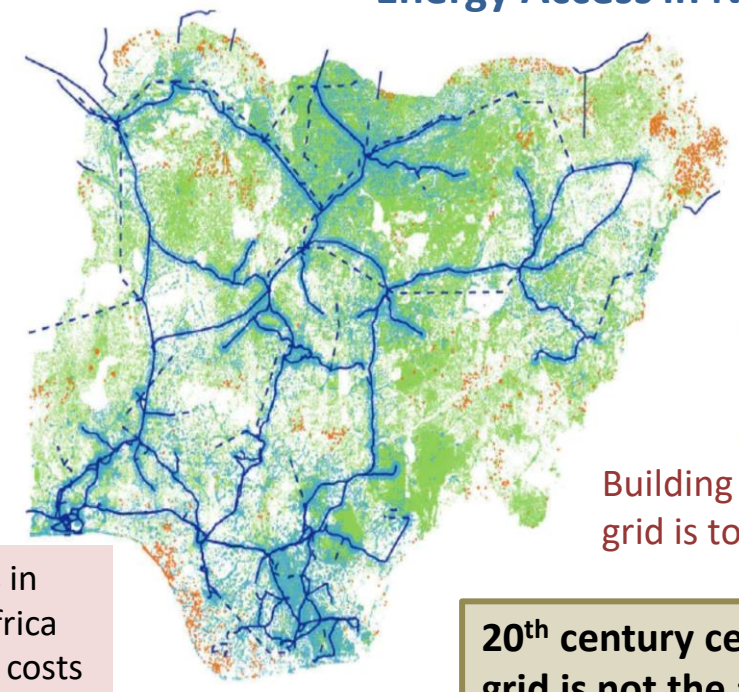
Energy Access – The Elephant in the Room

Georgia Tech Center for Distributed Energy



95% of utilities in Sub-Saharan Africa cannot recover costs

Energy Access in Nigeria



Building centralized grid is too expensive

20th century centralized grid is not the answer!

Feedback – Global Energy Access Forum Workshop:

- Utilities pursue grid extension model even when demand is too low & economics doesn't work.
- In the decentralized space, utilities left out of the discussion while they must be part of the solution.
- US$41 billion needed annually, **$16 billion spent in 2018, 1% of it for off-grid** which will electrify 30%

- >700 million live with no electricity, and 3 billion live with extreme energy poverty (<$1.90/day), but pay the most/kWh
- After 30 years & $B's spent, only **15 million** living off-grid have Tier 2 access (200 Wh/day)

- Maybe energy access is not an access problem, but is a 'demand' problem

- Maybe energy poverty is not an energy problem but is a 'poverty' problem

Challenges with Existing Approaches

Centralized: High cost, long implementation cycles, skilled labor to install & operate, inflexible, fossil fuels, needs non-existent base load

Distributed: Top down microgrids and SHS too expensive & customized, cannot start small and expand as needed. Need for future integration with the grid poses a challenge.

Enabling Technologies & Services Needed: Ecosystems for data analysis, pay-go, efficient appliances, finance, business development & ability to monetize multiple value streams.

Loads Served: Significant progress in solar lights and phone charging, but **virtuous cycle will not start until productive uses are addressed, and livelihoods are improved – high cost of energy is challenging**.

Today's solutions are customized, not-interoperable, require expert technical support in the field and are generally difficult & expensive to scale

Grain Milling Transformation

Source: Silard Liptak, Agsol, IEEE Energy Access Workshop, June 30, 2021

Technology Innovation and Energy Access

- Technologies needed to solve energy access problems for LDCs existing and mature?
- Are policy, finance and the invisible hand of the market all that is needed for success?
- Can current strategies be technically and economically viable at scale?

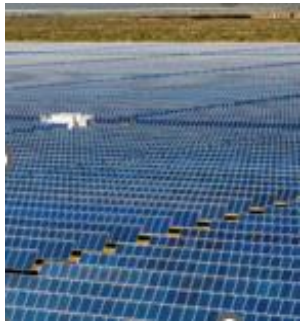
→ **NO!**

- **Technology Needs** – connectivity, lighting, cooking, cooling & cold chain, water, transportation, productivity, health, sanitation, agriculture, etc.
- **Attributes for Scaling** – affordable; flexible; start small & expand; easy to install, use & maintain; interoperable across vendors; life cycle; e-waste

Power of the Sun

Nigeria - 12.5 GW pk
- 36.4 GWH/yr

PV farm of ~20 x 20 km can meet energy need



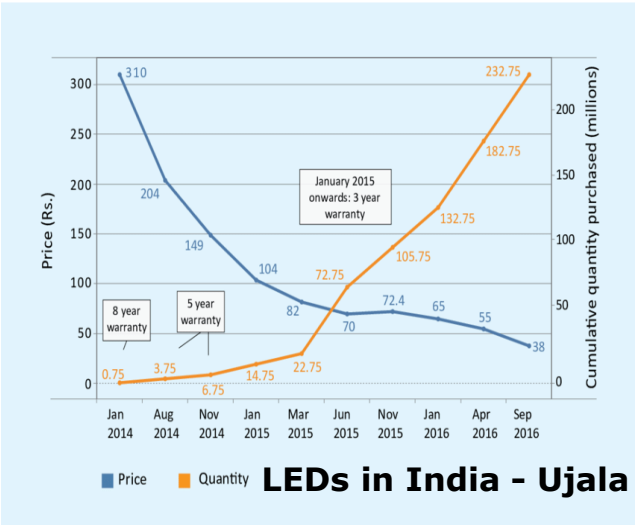
JOHN KEANE

Let's Get Real: Energy Access is Leaving Everyone Behind

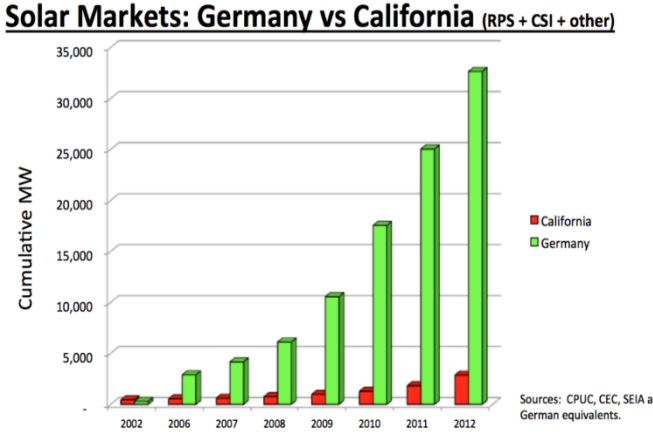
Next Billion Series: New Frontiers in Renewable Energy

CLIMATE AND ENVIRONMENT

Bill Gates: 'We need an energy miracle'



LEDs in India - Ujala



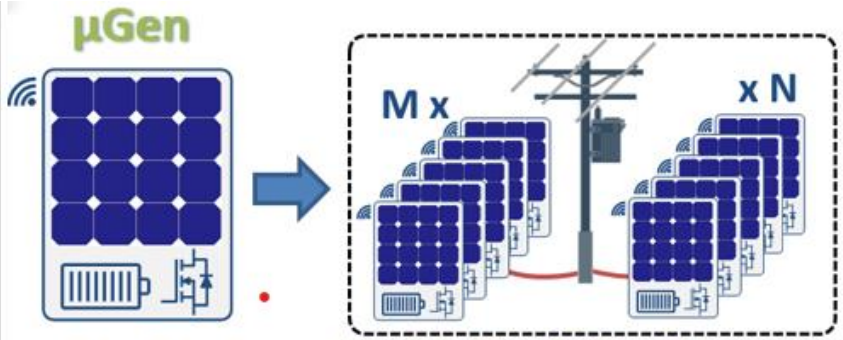
German solar FIT program

<u>Leapfrog Opportunity</u>: 21st Century Technologies with Steep & Sustained Learning Curves Meet Forward Leaning Incentives to Spark Growth

Bottom-up Scalable Electricity Ecosystem

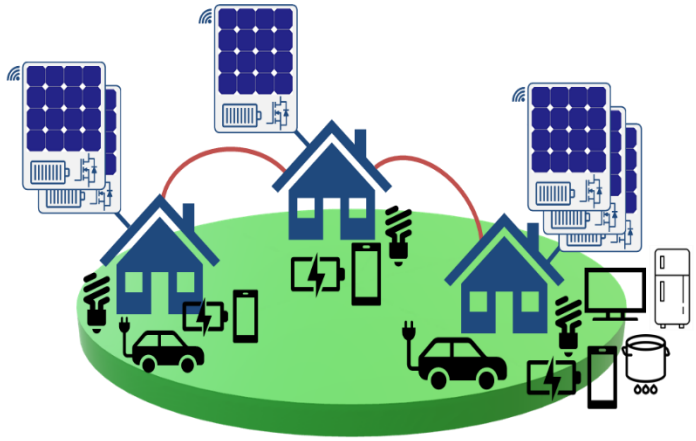
Georgia Tech Center for Distributed Energy

Miracle: Magical plug-n-play modules that can realize a bottom-up decentralized grid at any scale – DC nanogrids, single-home systems, small microgrids to large utility scale systems - flexible, collaborative, interoperable & low cost



Mass-Manufactured Modular Plug-&-Play (Solar + Storage) Generator Block for 250 W to 250 MW!

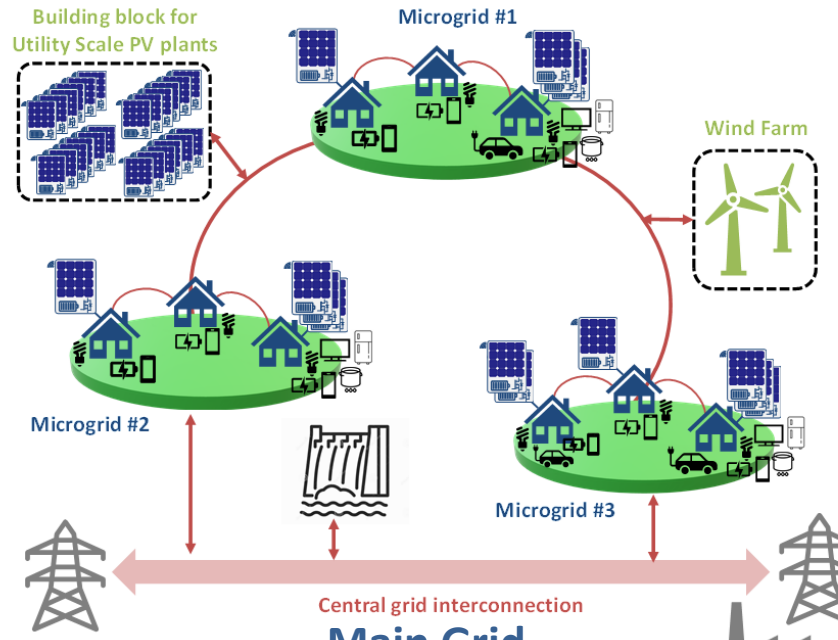
Single Home



Multi-Home Microgrid

Community Microgrid

Swappable 48 V 1 kWH Battery Packs



Key Elements:

Solar panels – 250W to 500W, 24-48 VDC

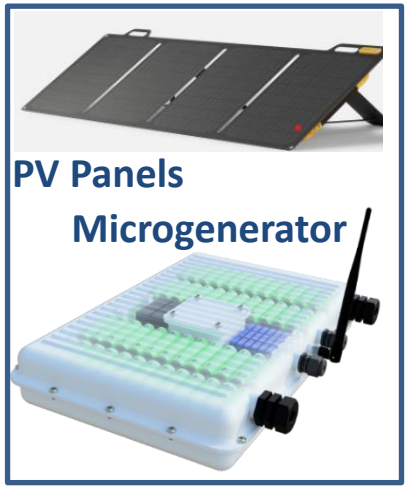
Battery Storage – 4-8 hours 48 VDC swappable modules

Standard AC/DC voltages – 240 VAC 1 ph, 415 VAC 3 ph, 48 VDC

Start small & expand as needed – 250 watt to 100 MW+

Supports multi-vendor supply – modular interoperable design

Intrinsically safe and self protecting, easy to use



PV Panels

Microgenerator

Such a scalable system seems aspirational and impossible - but is now viable!

Democratize Energy… *empower the local communities*

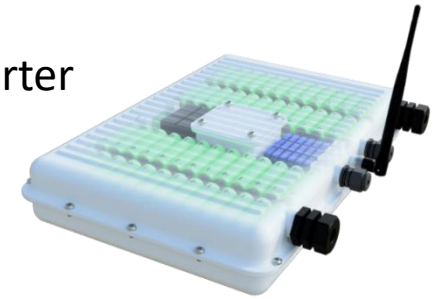
Georgia Tech Center for Distributed Energy

Attributes:

- Globally sourced modules from multiple vendors
- Local low-skill assembly, install & maintainence
- Interoperability and flexibility (tech agnostic spec)
- Incentives to accelerate scaling & breakeven
- Enable additional value streams w/ connectivity
- Standard AC & DC power for standard appliances
- Connect to the AC grid when it is built

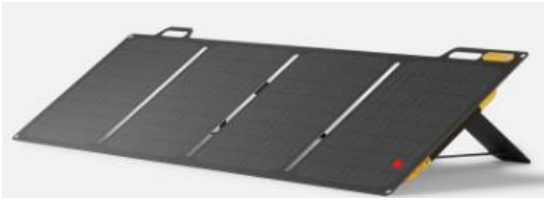
- Tiered real-time pricing provide service options –
  - lowest cost energy (direct solar) - $
  - reliable minimal service (w/ storage) - $$
  - high reliability energy (w/ generation) - $$$

Storage + Microconverter



All elements exhibit steep learning curves!

PV Panels



AC systems from SHS, microgrids, community grids to utility scale grids

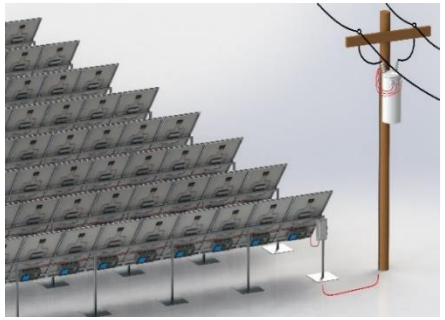
Swappable Battery Packs

Offgrid 48 VDC systems for appliances, DC nanogrids, transportation, tools, cooking, portable uses

Enabling Technologies: Power electronics, IoT, Pay-Go, LEDs, motor drives, automation, communications, digital devices, fin-tec, recycle

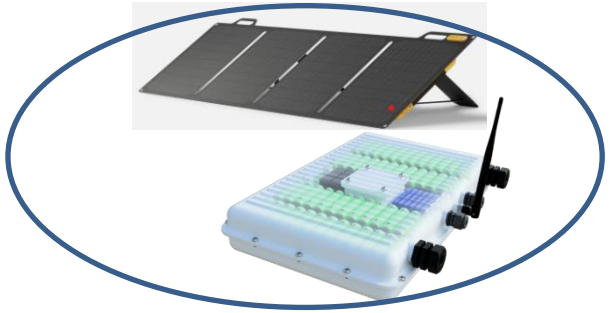
Energy access needs sophisticated 21st century exponential technologies, that are made simple to use – e.g. mobile phones!

Bottom-up Scalable Electricity Ecosystem



Main Grid

DC Ecosystem



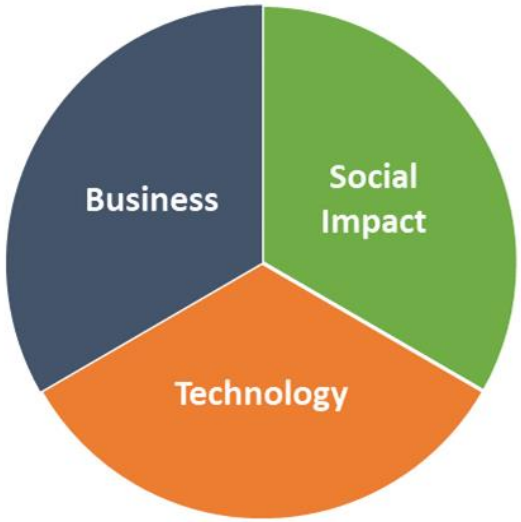
AC Ecosystem

Both DC and AC ecosystems can be built using a few standardized smart interoperable devices for plug-n-play operation, allowing scale and economic viability by riding on steep learning curves

IEEE PELS ENGAGEMENT IN ENERGY ACCESS

- Empower a Billion Lives
  Foster global innovation
- Global Energy Access Forum
  Provide technical leadership, facilitate multistakeholder dialogue towards alignment in goals, strategy and approaches

IEEE EMPOWER A BILLION LIVES (EBL)
Recurring competition to foster interdisciplinary innovation in the global community to develop/demonstrate/derisk scalable sustainable energy access solutions



EBL Approach:
Bottom-up needs assessment
Local entrepreneurial teams
Develop/demonstrate/derisk
Scalable sustainable exponential-technologies
Technology/Business/Impact

Empower A Billion Lives (EBL-II) Global Competition

www.empowerabillionlives.org

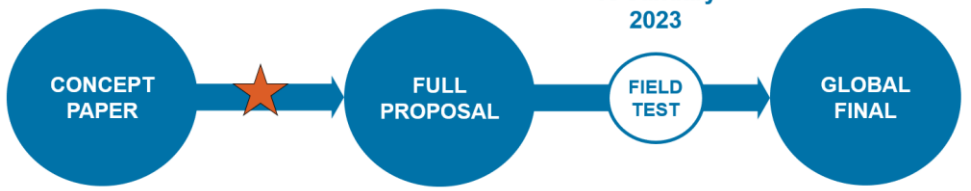
TRACK D: DECENTRALIZED UTILITY MODEL
TRACK C: CENTRALIZED UTILITY MODEL
TRACK A: AUTOMATION-CENTRIC SOLUTION
TRACK P: END-USE ENERGY (PRODUCTIVE USE)
TRACK E: ENABLING TECHNOLOGIES
TRACK S: STUDENT TEAMS

TECHNOLOGY
BUSINESS MODEL
SOCIAL IMPACT
FIELD TESTING

PRIZES & AWARDS
~$600,000
2 STUDENT TEAMS

EBL-I (2019)

EBL-II (2023)



March 2023
Orlando, FL

Orlando, Florida, USA

EBL-2: 100 teams from 43 nations

Select EBL Teams

Turning organic waste into food & energy

D-OLIVETTE'S PRODUCTS

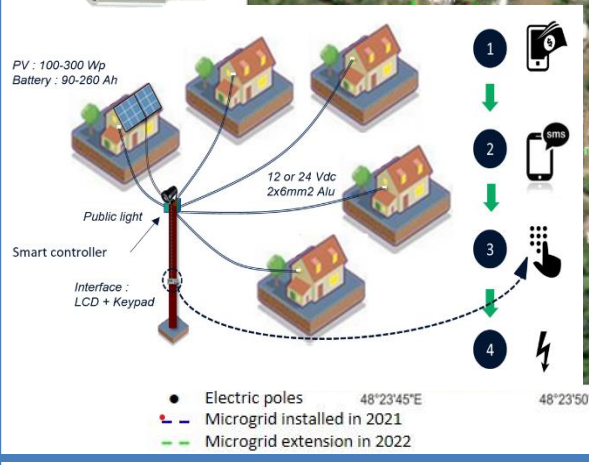
D-Olivette's Kitchen Box turns household organic waste to clean cooking For Rural & Urban Woman – Used in Kitchens -- $99.00 & Above

D-Olivette's Bio-tank: Turns Animal, Farm & Human Waste into Biogas & Fertilizer. Used as Bioseptic Systems for homes, farms, communities & businesses – Buried underground. – Only $248 & Above

REEDDI

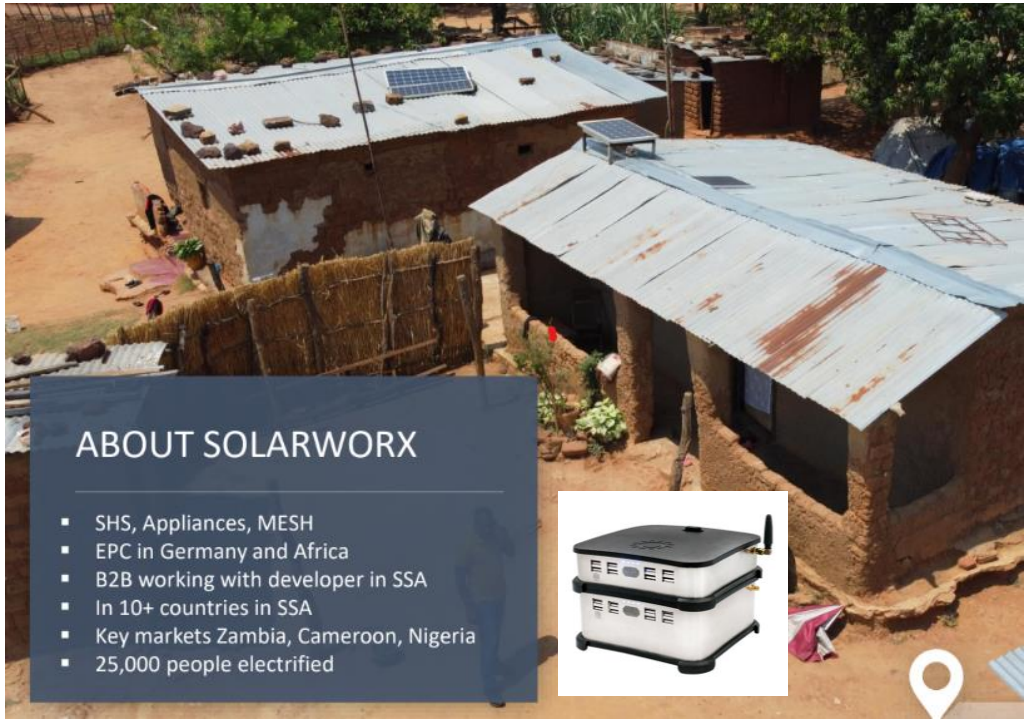
SOLAR FREEZE

2023 1st prize: Nanoe Nanogrid, Madagascar

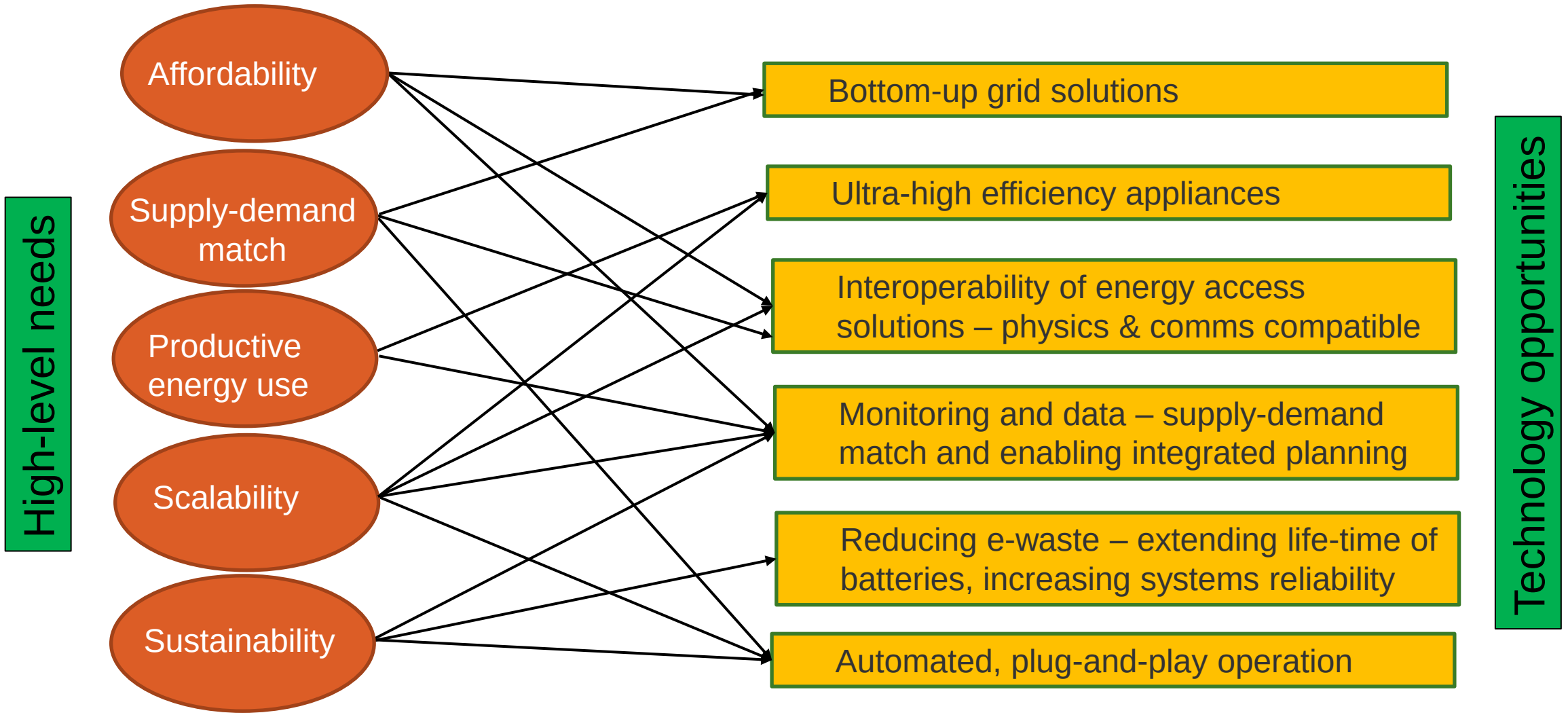


Standard Microgrid
www.standardmicrogrid.com
USA | Zambia | South Africa | DRC

SoULS : To create an open-source market ecosystem for off-grid solar products through sustainable local supply, assembly & service – **Production by the Masses, not for the Masses**



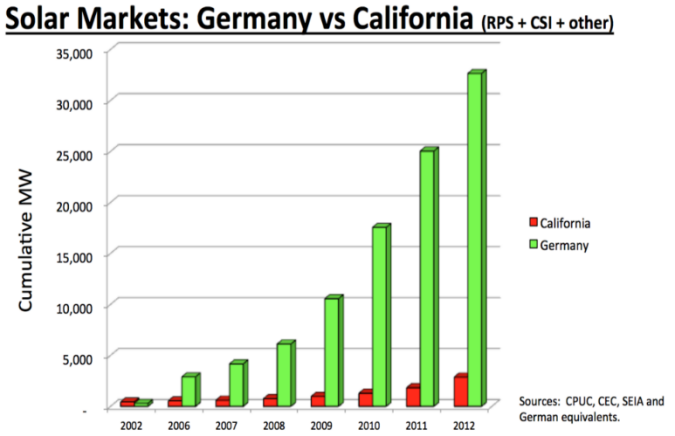
Technology Needs and Leapfrog Innovation Opportunities



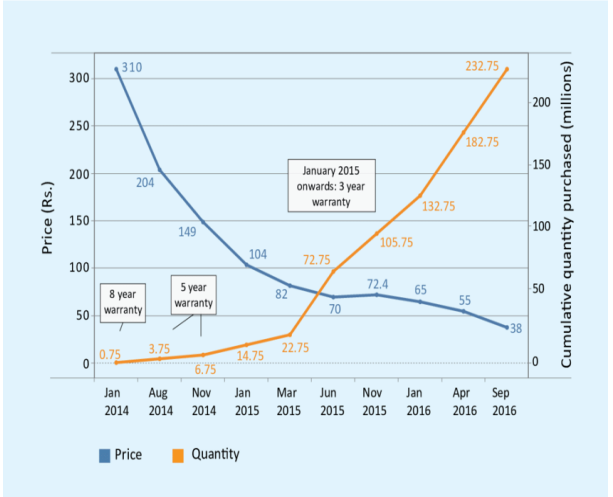
Enable foundational scalable building blocks & human ingenuity will apply them

TNA Recommendations – EBL Perspective

- **Working in Organizational Silos**
  - Each stakeholder operates with their own organizational priorities, targets and KPIs typically focusing on different small-scale interventions over short time horizons
  - Assessing fast-moving technologies is a challenge for policy makers, funders, NGOs. Involve relevant stakeholders in the process — tackle organizational silos
  - Shared vision of success and holistic solutions through a joint effort of all relevant stakeholders towards strategic and pragmatic aligned vertical specific activities
- **Integrated Energy Plans**
  - Robust national plans with government buy-in and long-term commitment create a point to converge around - enables coordination by govt, private sector & finance
  - Correctly timed incentives around high potential technologies with steep learning curves can have dramatic impact in rapidly evolving technology landscape
- **Major Challenges: Productive Use of Energy, Transportation, Clean Cooking and Cooling**
  - Productive Use of Energy is key to economic development and climbing energy ladder solar pumps, cold storage, agri-processing, cooking, cooling & transportation
  - Important issues: context customization & affordability; data analysis, finance access, business development support, stronger domestic value chains, market linkage.



German solar FIT program



LEDs in India - Ujala

TNA Recommendations – EBL Perspective

Don't need energy – need livelihood & services

Technology Approach

- Identify desired high-level attributes which meet social and financial objectives, rather than creating a repository of existing technologies – enabling technologies can alleviate many challenges that are perceived as socio-economic
- Develop requirements and specifications that are holistic and tech-agnostic (including sustainability & life cycle) & support modular interoperable solutions for scaling
- Policies need to accelerate fast-moving technologies with steep learning curves that are nearing parity, and to integrate them with national plans to achieve multiple objectives
- Consider energy as an ecosystem, defining a bottom-up architecture that can start small and expand as needed, integrating with the national level grid when it arrives
- The new energy system represents a paradigm shift – from centralized dispatched system to a decentralized system that is based on many advanced enabling technologies
- Look for technology synergies across Global South & North – with Global South as the testbed for scaling new innovative technologies thru energy access

"An energy ladder without increasing incomes is a ladder to nowhere"
Greg Neichin/ Diane Isenberg, Mary Roach, Next Billion

For the first time ever, forces of economics & climate are aligned!

Forward leaning policies and incentives are key to accelerating energy access

EMPOWER
A BILLION LIVES

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www.empowerabillionlives.org

Thank you