# Renewable Mini-Grids Innovation Outlook


International Off-Grid Renewable Energy Conference and Exhibition
IOREC 2016
Nairobi, Kenya
30 September and 1 October 2016

# Opportunities for renewables in off-grid systems

- Some 1.16 billion people without electricity access today
- 26 million households served through off-grid systems
- 50 – 250 GW potential to hybridise existing diesel generator capacity, 12 GW on islands
- 1 million telecom towers in South Asia and Sub-Saharan Africa

# Mini-grid types

| | Lower Tier of Service | Higher Tier of Service |
|---|---|---|
| Autonomous | **Autonomous Basic (AB mini-grids)**<br>**Generation Sources:** PV, hydro and biomass<br>**Tier of service:** less than 24 hour power<br>**End-users:** Remote community without major commercial or industrial activity<br>Added value:<br>• Enable enhanced energy access<br>• Alternative to grid-extension<br>• Improve quality of life | **Autonomous Full (AF mini-grids)**<br>**Generation Sources:** PV, hydro and wind<br>**Tier of service:** 24/7 power<br>**End-users:** Remote communities, islands, with major commercial or industrial requirements; Industrial sites disconnected from grid<br>Added value:<br>• Alternative to expensive polluting imported fuels<br>• Diversification and flexibility of supply |
| Interconnected | **Interconnected Community (IC mini-grids)**<br>**Generation Sources:** PV, wind and biomass/biogas<br>**Tier of service:** High critical/ interruptible<br>**End-users:** Medium to large grid- connected community (*e.g.* university campus)<br>Added value:<br>• Community control<br>• Improve reliability<br>• Response to catastrophic events | **Interconnected Large Industrial (ILI mini-grids)**<br>**Generation Sources:** PV, wind and biomass/biogas<br>**Tier of service:** Very high: Critical/ uninterruptible<br>**End-users:** Data centres, industrial processing or other critical uses<br>Added value:<br>• High reliability for critical loads<br>• Enhance environmental performance<br>• Resiliency |

# Deployment today

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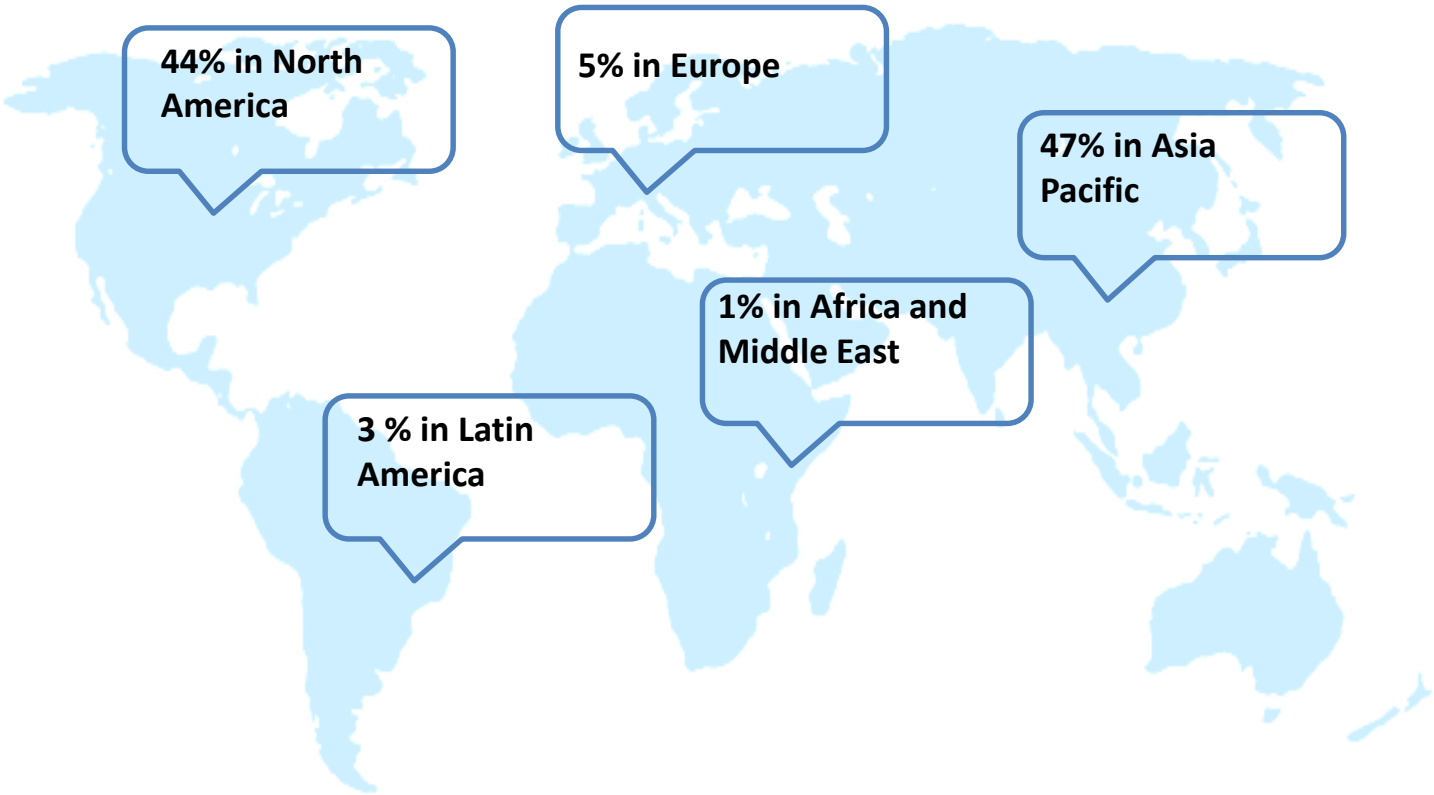
| Limited | Pilots | Emerging | Mature |
|---|---|---|---|
| ● | ● | ● | ● |

| Region | Autonomous Basic | Autonomous Full | Interconnected Community | Interconnected Large Industrial |
|---|---|---|---|---|
| Canada and USA | ● | ● | ● | ● |
| Caribbean, Central America, Mexico | ● | ● | ● | ● |
| South America | ● | ● | ● | ● |
| Europe | ● | ● ● ● | ● | ● |
| North Africa | ● | ● | ● | ● |
| Sub-Saharan Africa | ● ● | ● | ● | ● |
| Central and North Asia | ● ● | ● | ● | ● |
| East and South Asia | ● | ● ● ● | ● | ● |
| Middle East | ● | ● | ● | ● |
| Oceania | ● | ● ● | ● | ● |
| Antarctica | | ● | | |

# Renewable mini-grids




Great untapped potential in Africa and Latin America

Source: Navigant (Asmus and Lawrence, 2015)

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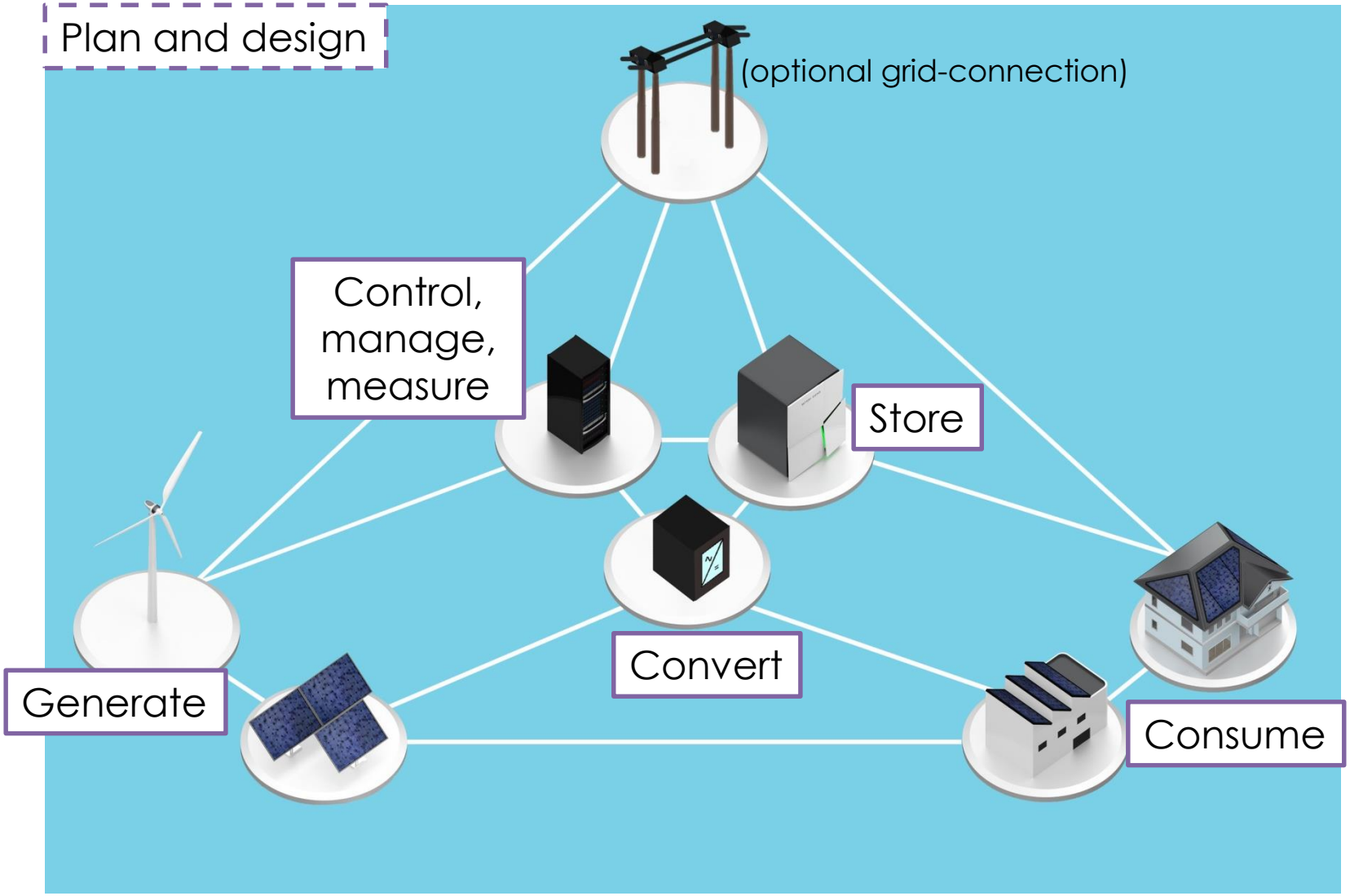
# Functionalities



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# Opportunities for innovation

| | | Impact | | | |
|---|---|---|---|---|---|
| **PLAN AND DESIGN** | | **Cost** | **Reliability** | **Ease** | **Environmental** |
| 1 | Standardised planning and design | **** | ** | **** | ** |
| **CONTROL, MANAGE, MEASURE (CMM)** | | | | | |
| 1 | More intelligent controls | *** | **** | **** | ** |
| 2 | Improved communications and standards | ** | **** | **** | * |
| 3 | Improved metering and monitoring | ** | *** | **** | *** |
| 4 | Simplify connecting equipment together | ** | * | **** | * |
| **STORE** | | | | | |
| 1 | Use less expensive, more abundant and less resource-intensive materials | **** | ** | * | *** |
| 2 | More robust, lower-maintenance technologies to reduce life-cycle costs for storage | *** | **** | *** | ** |
| 3 | Improvements in long-term storage capability | ** | ** | ** | **** |
| 4 | Improvements in high power output capability | ** | *** | ** | *** |
| **CONVERT** | | | | | |
| 1 | Lower capital costs of converters | **** | * | ** | * |
| 2 | Combine diverse function into inverters | ** | ** | **** | * |
| 3 | Improve efficiency, particularly at partial load | ** | ** | * | *** |
| 4 | More converter options for diverse renewable mini-grid markets | ** | ** | **** | * |
| **CONSUME** | | | | | |
| 1 | Increased commercial availability of efficient end-uses | **** | * | ** | **** |
| 2 | Better user tools for adapting consumption to energy supply (DSM) | **** | ** | *** | **** |

# Control, manage, and measure

| Opportunity for Innovation | Cost | Reliability | Ease | Environment |
|---|---|---|---|---|
| More intelligent controls | ★★★ | ★★★★ | ★★★★ | ★★ |
| Improved communications and standards | ★★ | ★★★★ | ★★★★ | ★ |
| Improved metering and monitoring | ★★ | ★★★ | ★★★★ | ★★★ |
| Simplify connecting equipment together | ★★ | ★ | ★★★★ | ★ |

## STATE OF THE ART TODAY

- Specialized and expensive controls
- Non-economic, non-predictive controls
- Moderate plug-and-play capability
- High utility interest, but limited to pilot projects
- Numerous competing standards
- One to two hours renewable resource prediction with high accuracy

## FUTURE

- Low cost modular controls
- Economic and predictive controls
- Seamless plug-and-play capability
- Standard interconnection terms for utilities
- Common, open-source standards
- Day-ahead renewable resource prediction with high accuracy

# Control, manage, and measure

## STATE OF THE ART TODAY

**Meters help supply match demand**
Circutor's Electricity Dispenser BII incorporates an algorithm that limits the daily energy consumption and power based on an Energy Daily Allowance (EDA). The EDA is not pre-fixed but all parameters can be modified through an RFID card. There are more than 2000 Dispensers installed in 10 different countries, most of them using the EDA with a service-based tariff.

## NEW INNOVATIONS

**Public-private alliances to enhance interoperability**
Industry accepted standards underpin the increasing ease of connecting together diverse hardware and software. These groups include the Smart Grid Interoperability Panel (SGIP), Smartgrid Alliance, Smart Grid Coordination Group, Korea Smart Grid Association, India Smart Grid Forum, and Japan Smart Grid Alliance. These organizations bring together diverse stakeholders with a common goal of facilitating the intelligent use of information in the electrical sector.

# Consume

| Opportunity for Innovation | Cost | Reliability | Ease | Environment |
|---|---|---|---|---|
| Increased commercial availability of efficient end-uses | ★★★★ | ★ | ★★ | ★★★★ |
| Better user tools for adapting consumption to energy supply (DSM) | ★★★★ | ★★ | ★★★ | ★★★★ |

## STATE OF THE ART TODAY

- Mini-grids are currently feeding mostly AC loads
- The use of DC power is primarily explored in commercial buildings and in smaller energy access applications/mini-grids

## FUTURE

- Increasing use of high-efficiency and DC appliances reduce electricity costs for home owners and businesses.
- High-efficiency and DC appliances are standard, further reducing electricity costs for home owners and businesses

# Consume

## STATE OF THE ART TODAY

**University mini-grids: living research on DC mini-grids**

The mini-grid of the new Xiang An Campus at Xiamen University is based on a DC distribution line of 380V and consists of a 150 $kW_p$ PV array and lead-acid batteries. It powers a commercial-type building on the campus, including LED lighting, office appliances, and air conditioning. The mini-grid is planned to eventually power a data centre and an EV charger; all loads use DC energy.

## NEW INNOVATIONS

**Internet of Things (IoT)**

The main technological drivers are increasingly low cost wireless hardware, proliferation of smartphones, and expanding mobile networks. It is estimated that by 2030, the number of connected devices worldwide will reach 100 billion. Even though the exchange of information between appliances and users is already widespread, the communication between the devices alone with IoT is supposed to gain momentum and give the responsibility to the smart meters to take decisions.

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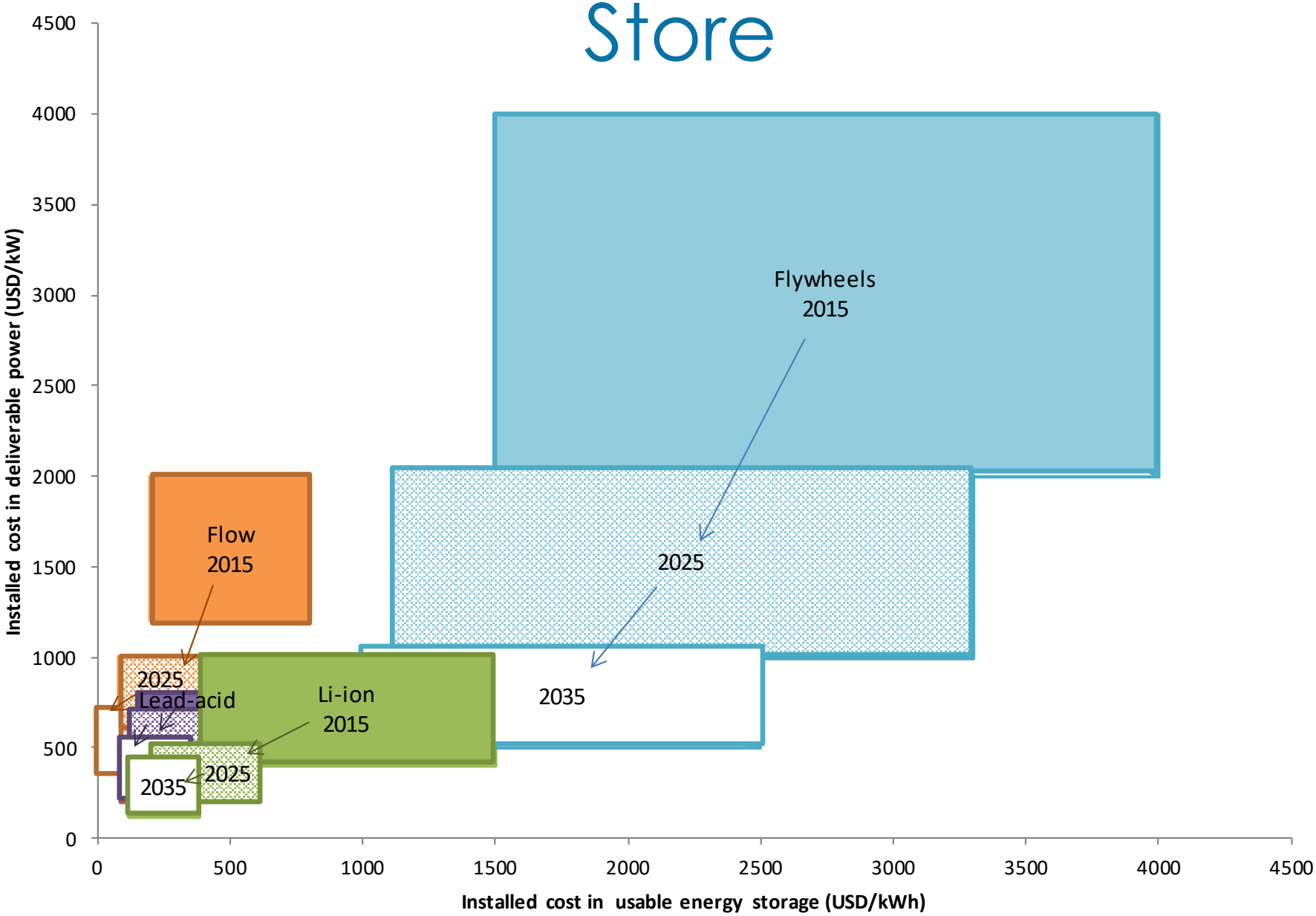
# Store



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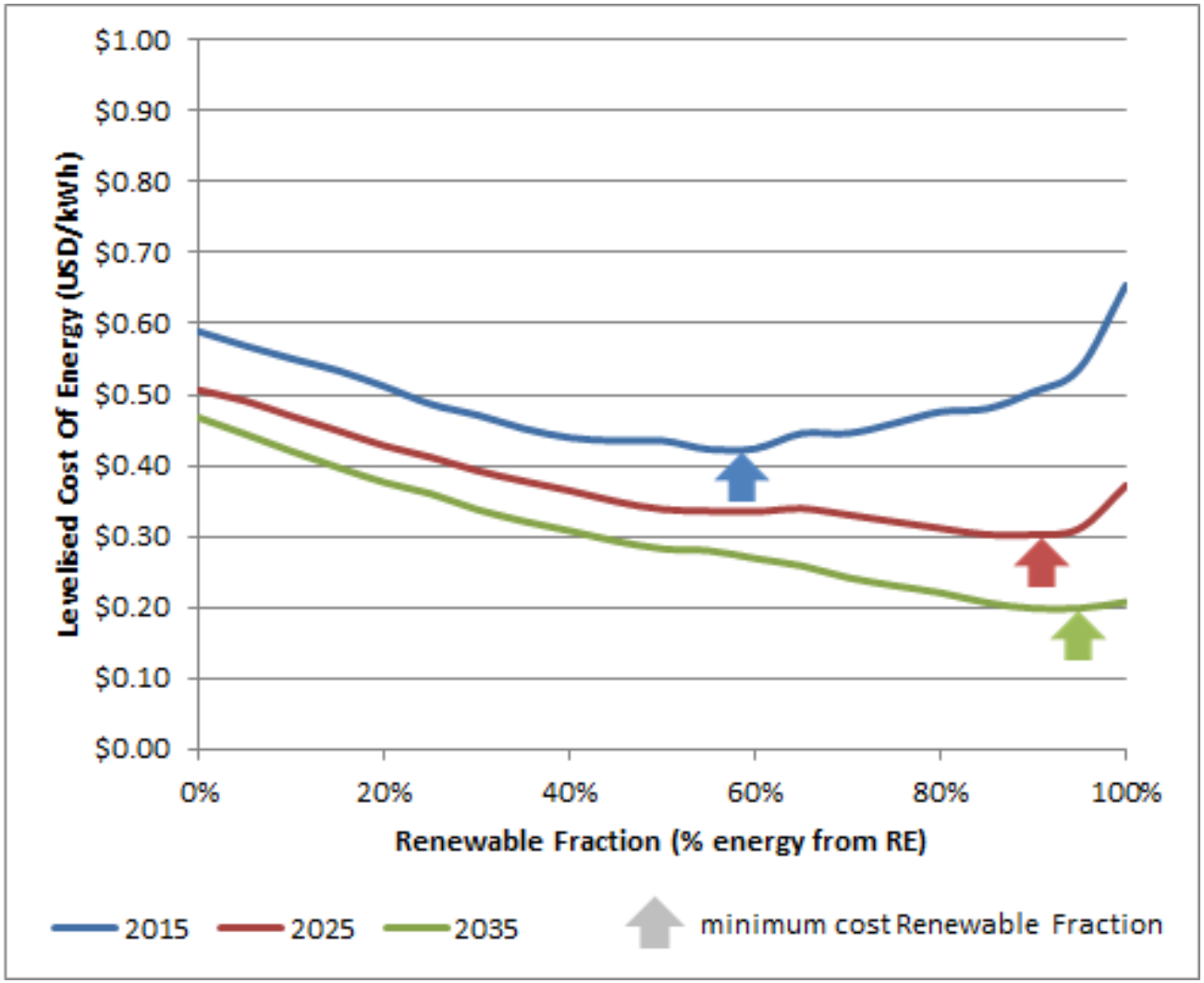
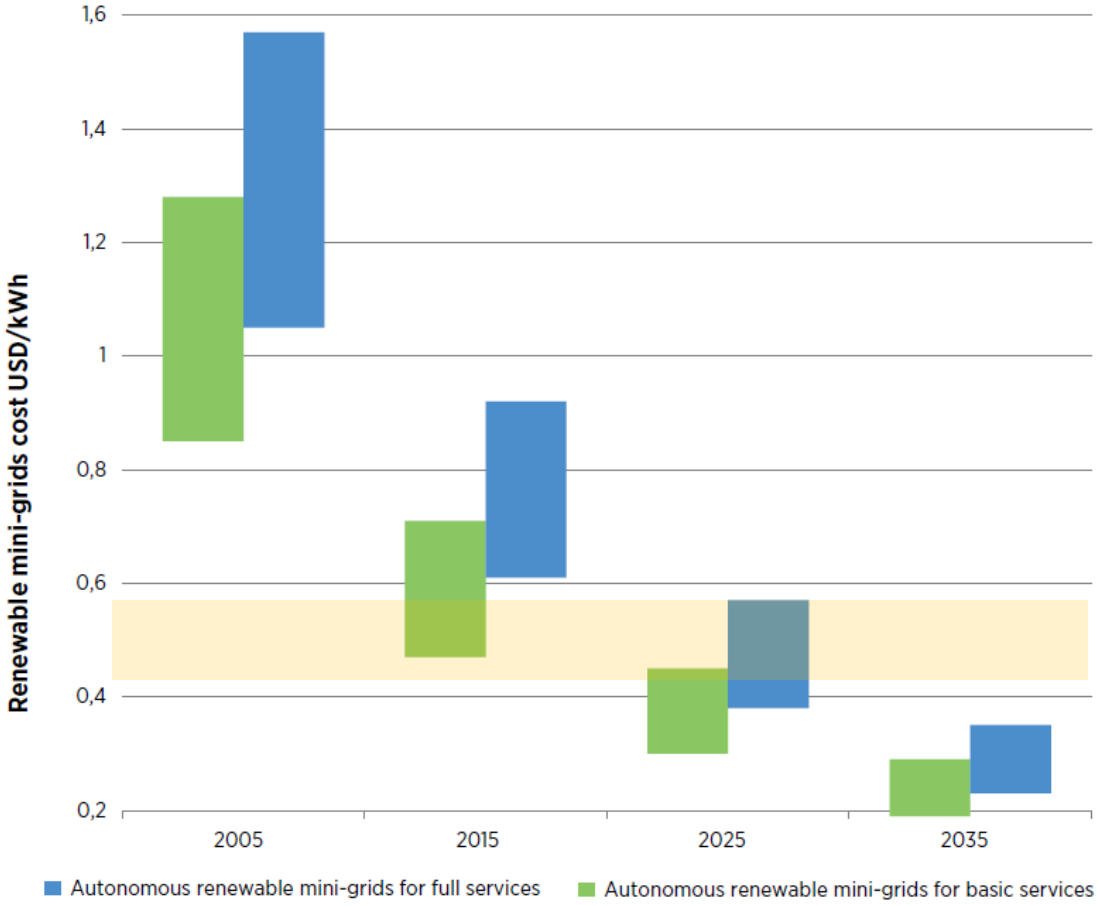
# Declining cost / increasing RE



# Innovation making renewable mini-grids competitive




Unsubsidised cost ranges for renewable mini-grids from 2005 to 2035 for a 100% renewable energy community system

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# Thank you

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