Sharing of Low-carbon Development Technologies and Experiences in Rural Areas in the United States and Internationally

Presentation for the ***Asia-Pacific Forum on Green and Low-Carbon Development, Session 4: Low Carbon Energy Access for Rural Revitalization***

David F. von Hippel

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ADB

Low-carbon Development Technologies and Experiences in Rural Areas: Outline of Talk

- Low-carbon/Renewable Energy (RE) Benefits, Challenges, and Strategies for Rural Areas
- Renewable Energy Trends
- Key Technologies for Renewable Energy Use in Rural Areas
  - Non-electric Rural Renewable Energy Systems
  - Rural-located Renewable Electricity Systems: Central Grid, Mini- and Micro-grids, and Stand-alone Rural Renewable Electricity Systems
  - Heat and fuels based on renewable electricity
- Conclusions

Low-carbon/Renewable Energy, Benefits for Rural Areas (beyond GHG reduction)

- Providing **new sources of revenue**, thus increasing the tax base to provide services for rural communities, providing additional, stable income stream for farmers/landholders
- Providing **new job and business opportunities**, especially when many actors are involved and renewable energy activities are embedded in the local economy
- Spawning **innovations** in products, practices and policies
- Providing **capacity building and community** empowerment
- Providing **affordable energy** by providing rural regions with opportunities to produce their own energy

Low-carbon/Renewable Energy, Supporting and Impeding Factors for Rural Areas

Supportive	Impeding
High quality RE resource	Low to moderate quality resource
Relatively expensive current energy	Low-cost conventional energy
Provision of small subsidies	Provision of large subsidies
Ability to link RE to existing economic activity	RE is a standalone sector within the regional economy
Good existing energy transport/transmission infrastructure	Project produces stranded energy that cannot be exported
Strong local community support	Significant local opposition
Integration of RE within a broader energy framework that facilitate dispatch	Inadequate backstop energy for intermittent power sources
Mature technology	Novel or infant technology
RE relies on regional inputs that have limited current uses/RE complements existing input uses	Inputs for RE project have high opportunity cost in current use
RE policy aims at producing cheap energy (renewable heat)	Excessive focus on job creation absorbs public resources better spent connecting RE to rural economy

Low-carbon/Renewable Energy, Strategies for Rural Areas (from OECD study)

- Embed strategies in local economic development reflecting local potential and needs
- Integrate RE within larger supply-chains within rural economies, such as agriculture, forestry, traditional manufacturing, tourism
- Limit subsidies in both scope and duration, and only use them to induce RE projects that are close to being viable in the market
- Avoid imposing types of RE on areas that are not suited to them
- Focus on relatively mature technologies
- Create integrated energy system with small grids to support manufacturing
- Recognize RE competes with other sectors for inputs, particularly land (e.g. tourism)
- Assess potential projects using investment criteria
- Ensure local social acceptance by ensuring clear benefits to local communities engaging them in the process

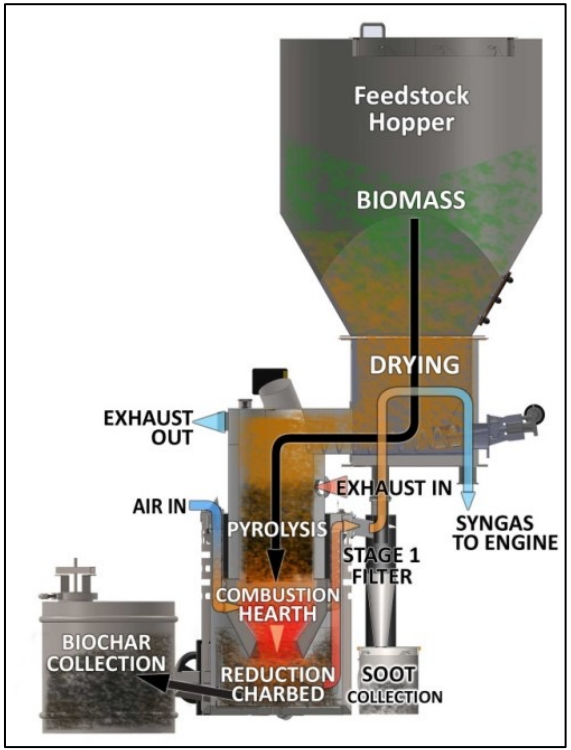
Key Technologies for Renewable Energy Use in Rural Areas: Heat Production

- Heat from **wood or biomass-fired boilers/furnaces**, CHP
  - Used for many decades in food processing, lumber, pulp and paper industries
  - Can also serve rural factories, clinics, hospitals—heat/hot water
- Active or passive **solar** technologies
  - Space and water heat

Key Technologies for Renewable Energy Use in Rural Areas: Gaseous Fuels

- **Biogas**—China is a world leader
  - Methane (CH_4) plus carbon dioxide (CO_2) produced via anaerobic digestion
  - Substrates such as animal manures, human wastes, crop wastes, other biomass
  - Closed reactors, covered lagoons
  - Reduction of CH_4 emissions an important co-benefit

Key Technologies for Renewable Energy Use in Rural Areas: Gaseous Fuels

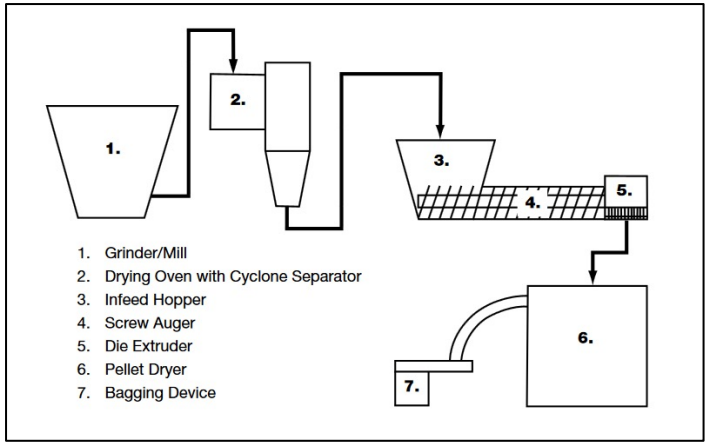


- **Producer gas** (or syngas)
  - Produced from a **wide range of biomass** materials, or coal, via thermal gasification
  - Resulting gas is rich in hydrogen (H_2) and carbon monoxide (CO)
  - Can be burned directly as a fuel, reformed via chemical processes to fuels such as methane, methanol, ethanol, or converted to electricity
  - Gasifiers available from very small (residential) to large industrial sizes
  - Can be used to produce **biochar** as a soil amendment, for carbon storage

Key Technologies for Renewable Energy Use in Rural Areas: Solid Fuels

- **Wood chips** as an input to space heating, water heating, electricity generation
  - Whole trees, pruning wastes, forest thinnings and residues are shredded or chipped, transported in vans (truck trailers) from harvest sites, sometimes dried
  - Used with automated boiler feed systems or gasifiers

Key Technologies for Renewable Energy Use in Rural Areas: Solid Fuels



- **Wood pellets** produced by extruding dried, ground wood chips or other biomass materials through dies
  - Produces a standard product used for space heating at residential, commercial scales in rural areas
  - Biomass materials typically chipped or otherwise size-reduced first
  - Used with automated furnace or boiler feed systems, or with gasifiers

Key Technologies for Renewable Energy Use in Rural Areas: Electricity Generation

- Large arrays of **wind turbines** are becoming commonplace on windy farmlands and rangelands worldwide
  - Use only a small portion of the land on which they are sited (bases and roads)
  - Provide stable income for landowners, jobs for installers, maintenance

Key Technologies for Renewable Energy Use in Rural Areas: Electricity Generation

- "**Agrivoltaics**" use special frames to site PV panels on crop lands, rangelands
  - Do not interfere with cropping or grazing; can help to optimize light input to crops, provide shade for animals
  - Provide additional, stable source of farmer income
  - Provide installation and maintenance jobs

Key Technologies for Renewable Energy Use in Rural Areas: Stand-alone Mini/Micro-grids

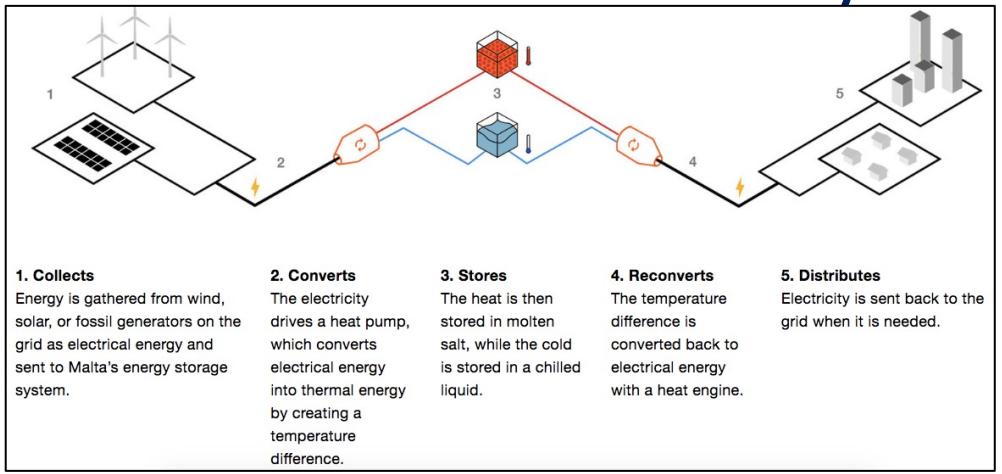
- "**Mini-grids" or "micro-grids"** designed to provide local power with an interconnection to grid typically configured to supply local power needs, use central power grid for back-up, sell power to grid when there is an excess
- Reasons for adopting mini-grids include desire to use local resources, reduce and control electricity costs, to improve reliability (including resilience to climate change), add another stream of income through power sales
  - Mini-grids in remote locations served by the central grid also help to stabilize grid connections, reduce transmission losses

Key Technologies for Renewable Energy Use in Rural Areas: Mini/Micro-grids off Main Grid

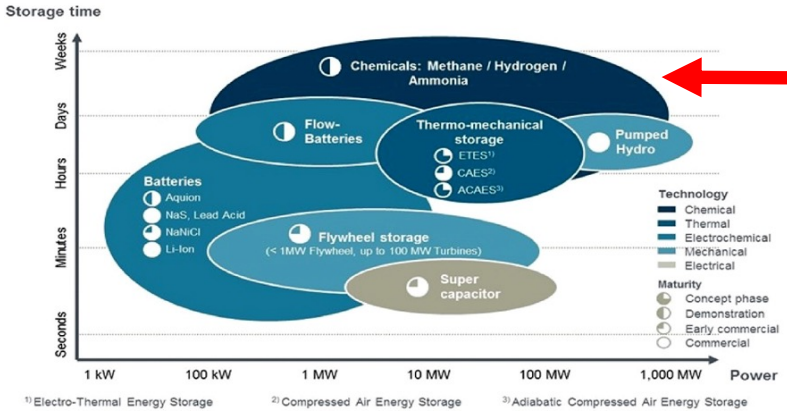
- Used in places, such as **islands and remote locations**, where connecting to a grid is impossible or prohibitively expensive, power from central grid is unreliable and/or poor quality
- **Micro-grids** or even smaller **home energy systems** can be used for residential compounds or other buildings in isolated locations, including holiday homes
  - May use battery storage, pumped-storage hydro to store electricity
  - In the future, hydrogen or ammonia may be produced when excess electricity is available, turned into electricity using engine or fuel cell when demand is greater than renewable generation

Key Technologies for Renewable Energy Use in Rural Areas: Heat Production from Electricity

- Electricity **used to generate heat** for storage when electricity needs (or prices) are lower
  - Hours, days, even weeks
  - Such as when solar or wind power is plentiful
  - District heating to water heating for dairies, heat inputs for processing agricultural products…
  - High-efficiency heat pump used for conversion—could be coupled with refrigeration and/or electricity generation systems



Key Technologies for Renewable Energy Use in Rural Areas: Non-Electric Fuels from Electricity

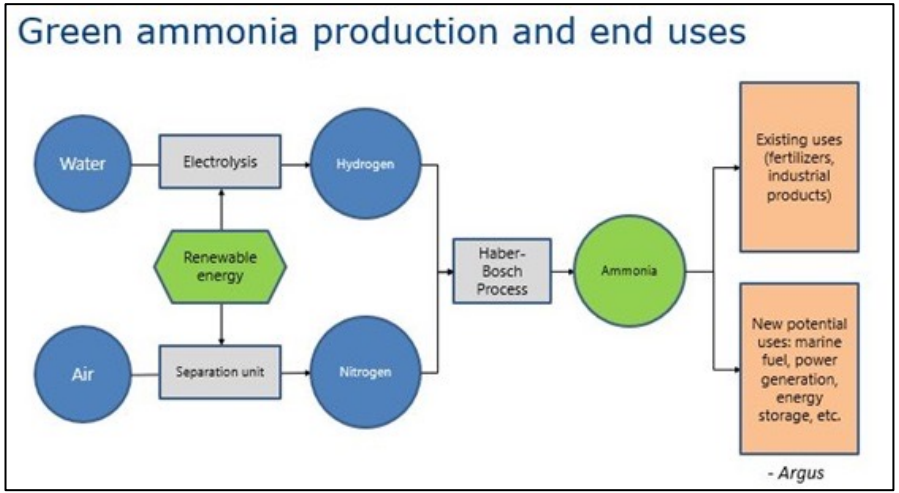


> Conversion of renewable electricity as **clean fuels** such as "green hydrogen", methane (CH_4, made from hydrogen and recycled CO_2), ammonia (NH_3, made from nitrogen in air and hydrogen) allows renewable energy to be stored indefinitely, at any scale

- Hydrogen (H_2) can be produced by electrolysis of water, producing H_2, oxygen
- H_2 is a clean fuel, can be burned to generate electricity in engine or turbine, converted to electricity directly in fuel cell; compressed for storage, stored in metal hydrides for vehicles
- NH_3 has physical properties similar to bottled gas (LPG), key input to fertilizer (thus with potential to improve agriculture)
- Conversion of electrical energy to H_2, CH_4, or NH_3 provides flexibility, rural RE markets

Key Technologies for Renewable Energy Use in Rural Areas: Ammonia from Electricity

- **Ammonia** can be produced with electricity via electrolysis using the well-established Haber–Bosch process that "fixes" atmospheric nitrogen
- Yet-to-be-commercialized electrochemical synthesis of ammonia may someday allow direct production of ammonia from electricity, water, and air
- Renewable ammonia can offset production from fossil fuels, imports
- Offers rural renewable electricity producers the option of storing energy as ammonia when markets not favorable
- At provincial, county, town, and enterprise levels, ammonia made locally can be used as a fertilizer, to power transport/ machinery, reconversion to electricity



Conclusions: Benefits of Renewable Energy

- RE can be used to provide new **job/business opportunities** involving many actors, embed RE activities in the local economy, retain populations and reinforce rural communities
- RE can provide new **sources of revenue**, increasing tax base to provide services for rural communities, stable income
- RE can spawn **innovations** in products, practices and policies
- Renewables can serve electricity, heating end uses, produce fuels for storage and other uses, fertilizer
- Wind and solar systems are **compatible with agriculture**, and thus do not need to displace farming operations

Conclusions: Policy Support for Rural RE

- Establish **renewable electricity standards** with shares increasing over time at national, provincial levels
- Establish **feed-in tariffs** (FIT) providing long-term payments at specified prices for developers, mechanisms for revision
- **Guarantee grid access** with clear and consistent interconnection standards and net metering policies
- Improve **forecasting of renewable system output** to aid transmission grid operators
- **Carbon taxes** and carbon trading programs to reflect carbon cost
- Support for **research and development** (technical, economic)
- Provide **access to financing, guarantees** for RE adopters

David F. von Hippel (dvonhip@igc.org, dvonhippel@gmail.com)

Thank You