AHEAD ENERGY

ENERGY FOR AFRICAN DEVELOPMENT

Green Energy for Africa: Stranded Gas or Coal and CO_2-Enhanced Oil Recovery

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AHEAD Energy 501(c)(3)

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Outline

- AHEAD Energy 501(c)(3)
- Fast track to carbon free ammonia: CO_2-EOR
- Synergies with Renewables
- Why Africa? Example of Mozambique
- Future Vision
  - UPSTREAM technologies
  - DOWNSTREAM technologies
- Role of AHEAD Energy

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- PREMISE: **ACCESS to energy a key factor in economic development**

- Not-for-profit formed in 1988 at the University of Rochester
- First project in Mozambique: low-cost natural gas infrastructure.
- Recent projects in Uganda, Ghana, Mozambique, Kenya: renewable energy for schools, orphanages, clinics:
  - Photovoltaic
  - Wind Turbine
  - Bio-digester
  - Small-Scale Hydroelectric

AHEAD Energy builds on this legacy:

(1) Production of low carbon electricity and GREEN FUELS

(2) Combining clean, efficient DISTRIBUTED GENERATION with RENEWABLES

Fast-track to carbon-free ammonia

- **AMMONIA** and **HYDROGEN** are **GREEN FUELS,** made from many energy sources. For a rapid transformation to **GREEN FUELS**, these fuels must be:
  - SCALEABLE
  - COMPETITIVE with current power generation fuels
- Stranded natural gas and coal are the cheapest feedstocks for **GREEN FUELS** (for foreseeable future)
- Delivered ammonia can be cheaper than delivered natural gas and coal
  - Infrastructure is cheaper and more efficient [1]
  - End use efficiency can be much higher [2]

[1] for example, a given pipeline has 1.5 X higher capacity transporting ammonia and pumping work is much lower
[2] for example, ammonia can be used in small scale SOFC CHP systems with 2 X the total efficiency of current coal plants.

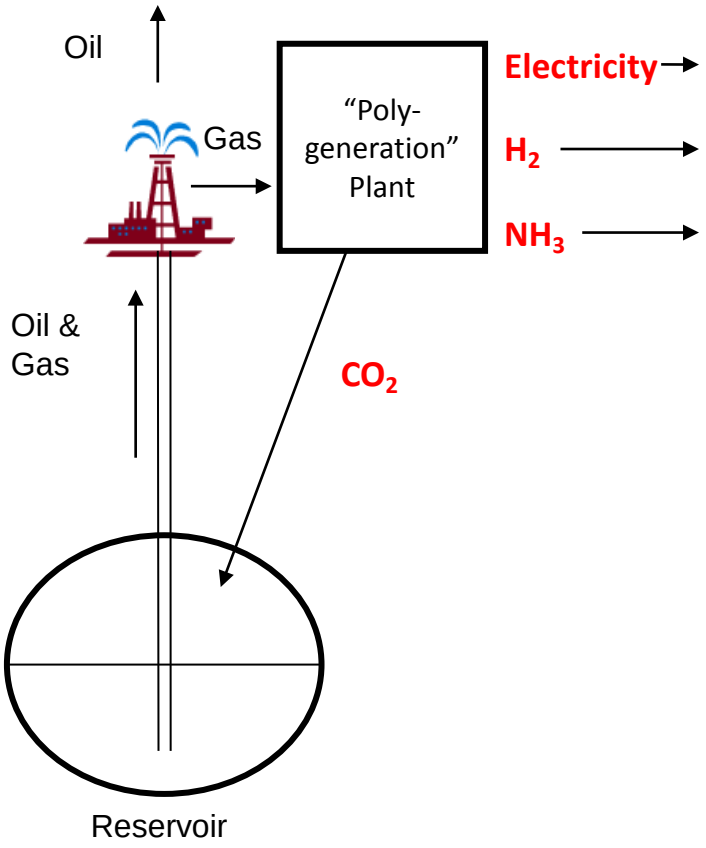
Fast-track to carbon-free ammonia

AHEAD ENERGY: THREE-STEP STRATEGY

(1) "Associated Gas" to produce **ELECTRICITY**, **HYDROGEN**, **AMMONIA** and **CO_2** at the well-head (at **VERY LOW COST**) [3].

(2) Inject **CO_2** for **ENHANCED OIL RECOVERY**, reducing the variable cost even further, by co-producing **HIGH VALUE CRUDE OIL**.

(3) Distribute **HYDROGEN** (locally) and **AMMONIA** (more broadly) as **GREEN FUELS** for carbon-free distributed generation and transportation.



[3] Note: Coal and water can be used as the input to the polygeneration plant instead of natural gas, where natural gas is not available.

Synergies with Renewables??
The situation in California, Denmark, Germany etc.

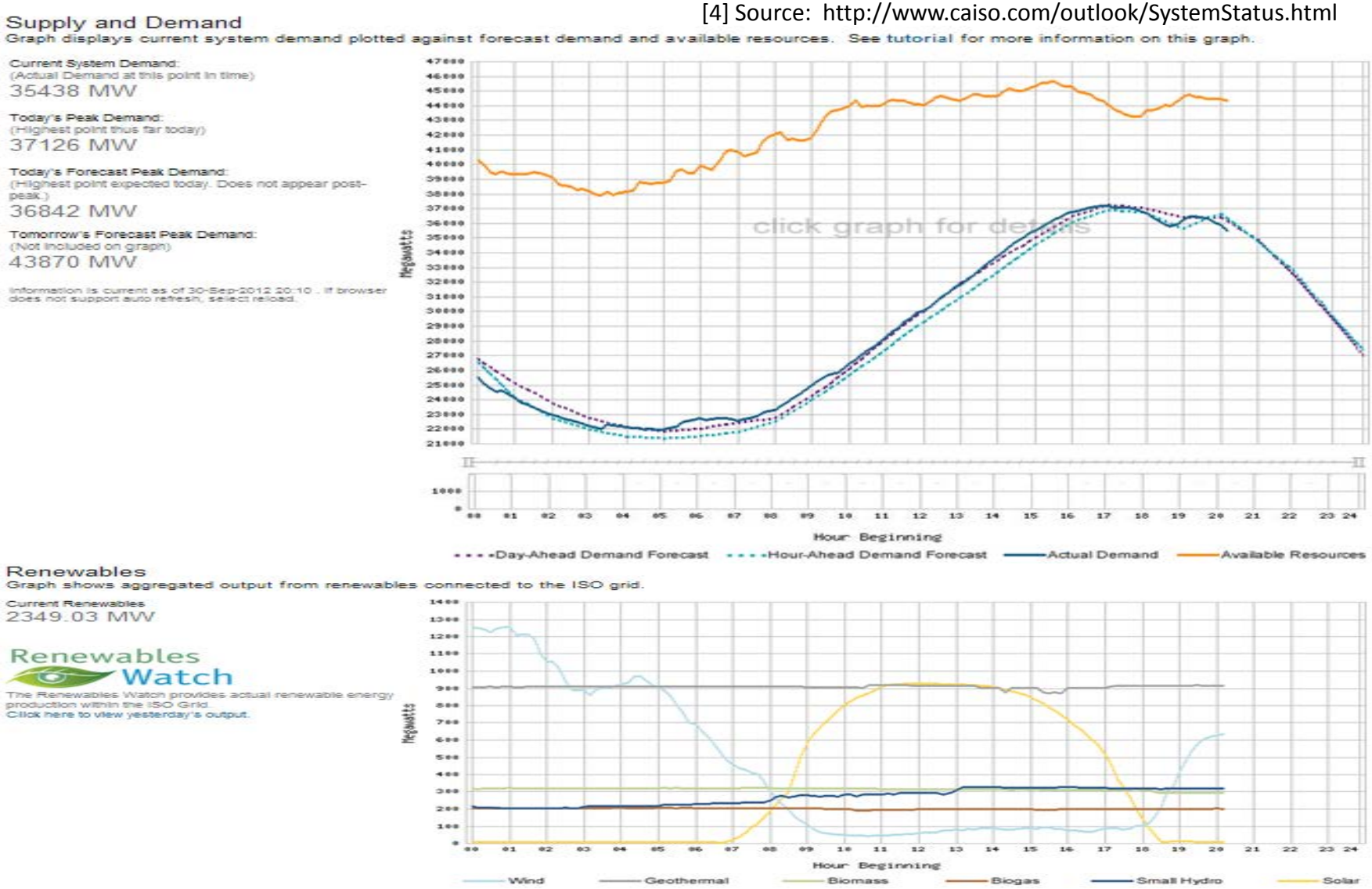
- **Critics (rightly) claim that Renewable Power in USA and EU:**
  - requires large tax credits and other incentives (burden to tax and ratepayers)
  - adds capacity where it is not needed
  - relies on mandates forcing the grid to buy power on unfavorable terms
  - relies on the grid and excess capacity to back-up intermittent availability
  - may result in idling of coal power plants (so CO_2 reduction is less than expected)

- **In AFRICA, however, it is viable and appropriate to deploy Renewable Power Systems, given:**
  (1) electric-grid power is expensive and in short supply!
  (2) current off-grid energy practices (wood, diesel, kerosene) compromise human health and environment!

Synergies with Renewables?? Not in California!!

Supply, Demand and Renewables in CA on 9/30/2012

[4] Source: http://www.caiso.com/outlook/SystemStatus.html



AHEAD Energy sees strong synergies between **GREEN FUELS** and **RENEWABLES** in **AFRICA**

- PREMISES:
  - Renewable energy capacity should be deployed **where capacity is needed**.
  - In absence of a robust grid, back-up support must be **distributed generation**.

- AHEAD ENERGY SOLUTION FOR OFF-GRID AREAS IN AFRICA:
  - Modest use of **RENEWABLES**: WIND, SOLAR and BIOGAS, where it makes sense.
  - Mass deployment of **GREEN FUELS** and mass-produced **small engine generators**, **micro-turbines** and **fuel cell systems**.

- BENEFITS of the AHEAD ENERGY SOLUTION:
  - AVOIDS Large Investments in Grid, Power Plants and Energy Storage
  - LEVERAGES Small Generators as a Virtual Power Plant supporting local needs of a SMART MICROGRID by filling the gaps in renewable supply.
  - HYBRID SOLUTION that is low-cost, flexible, environmentally sound and sustainable!

AHEAD: Why Green Energy for Africa?

- **2.7 billion (+) people rely on biomass as a major source of energy** [5]
  - 1.5 million (+) premature deaths per year due to air pollution from cook-stoves
  - Heavy use of firewood/charcoal, and high soot emissions (black carbon) from cook-stoves play a significant role in deforestation and climate change.

- **1.4 billion (+) people lack access to grid-electricity**

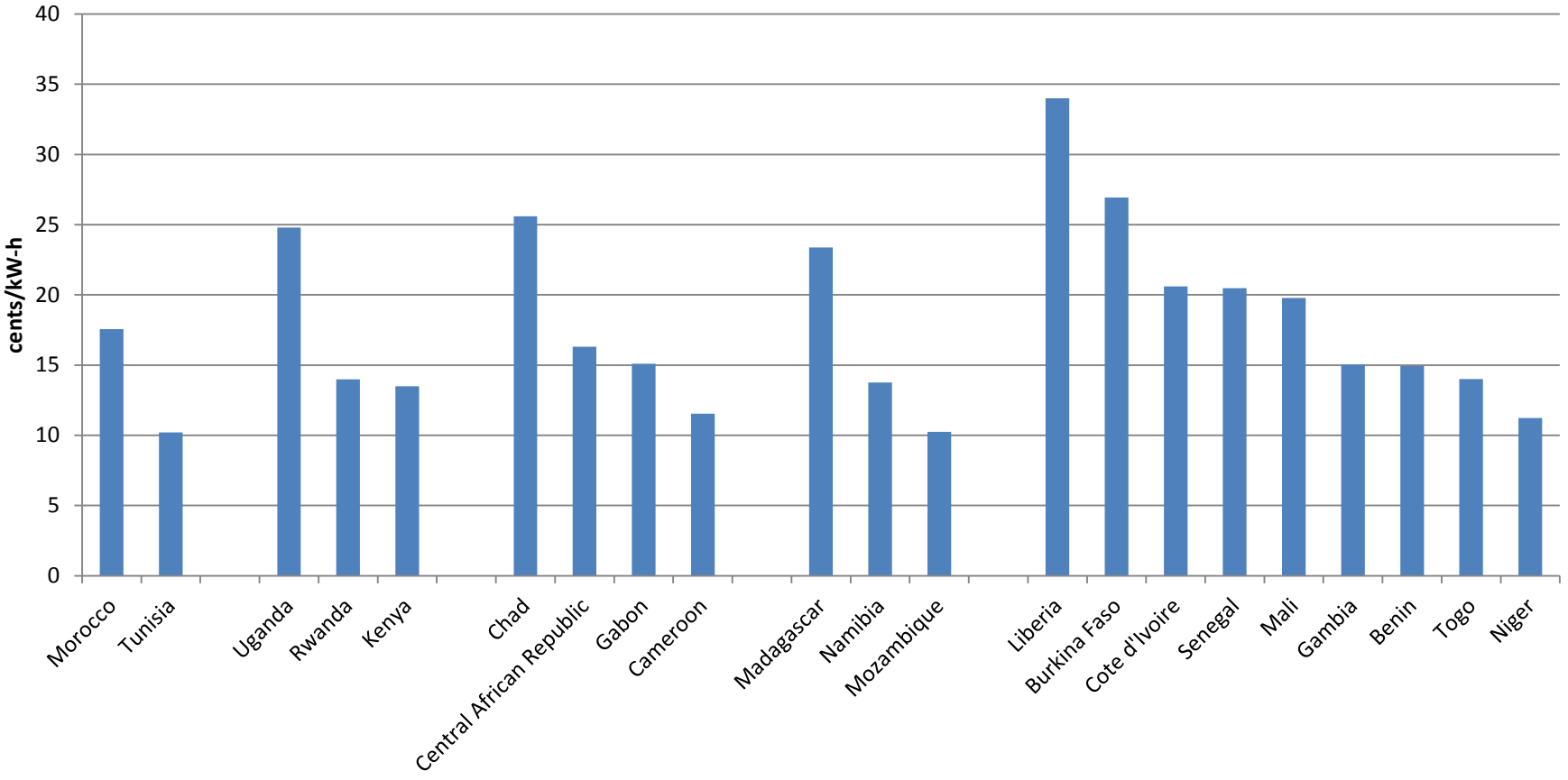
- **1.0 billion (+) additional people have access only to unreliable electricity networks** [5]
  - 85% of the "powerless" live in rural areas
  - Unreliable electricity service constrains health and medical practices, education, economic activity, and hinders business operation and growth.

- **Majority of the world's underserved live in AFRICA**

[5] Source: International Energy Agency, UNDP, & UNIDO, *Energy poverty: How to make modern energy access universal*, 2010

AHEAD: Why Green Energy for Africa?

- **Retail cost of electricity is PROHIBITIVELY HIGH in parts of AFRICA [6]**



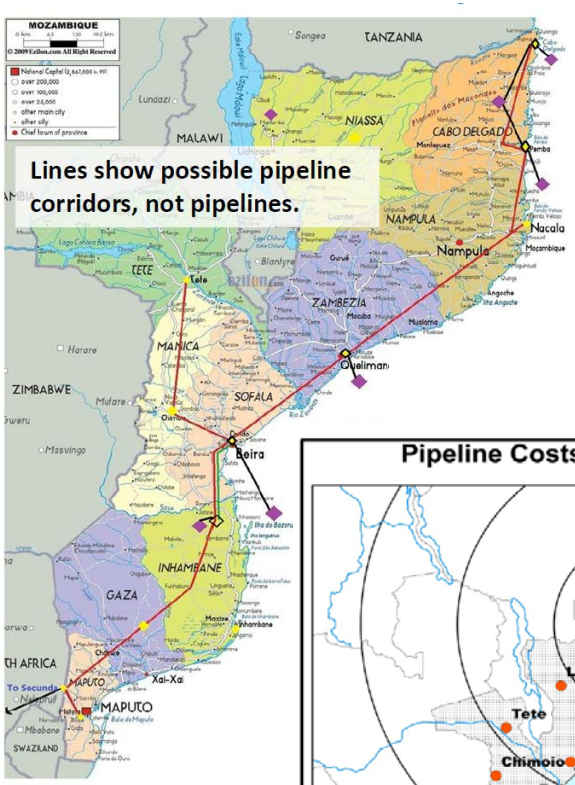
[6] Source: UPDEA, Comparative Study of Electricity Tariffs Used in Africa, Residential rates, 4 kW single phase, December 2009

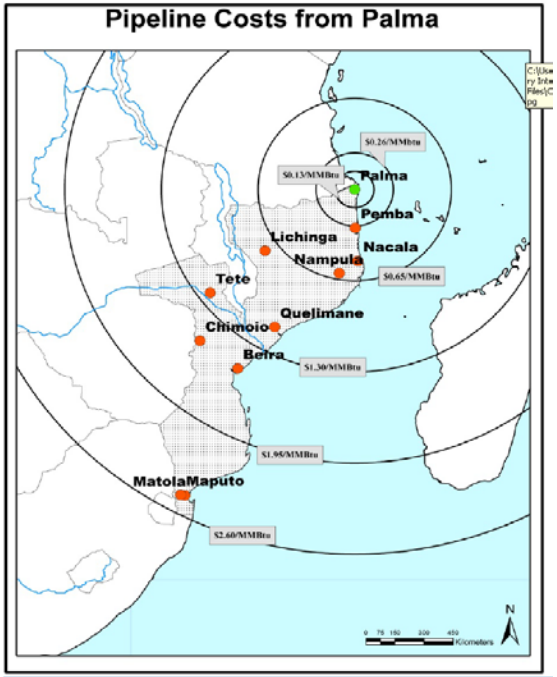
Underserved Example: Mozambique

- POTENTIAL: Natural Gas and Coal bonanza, plus wind, solar, hydroelectric.
- EXPLORATION: Major off-shore gas discovery in Palma, in far north
- COMMERCE: Capital (Maputo) and local export market (South Africa), in far south
- ENERGY: Limited Electric Grid, very limited natural gas distribution.

- Roads and Port Facilities, **GREEN FUELS** plants, and **Distributed Generation with Renewables** may be a better development plan than export LNG and domestic pipeline infrastructure.

- More than 1500 miles from Palma to Maputo (same as San Antonio, TX to Washington, DC)!





AHEAD Energy: Future Vision

UPSTREAM technologies

- Polygeneration
- Small Ammonia Plants
- Small Hydrogen Plants
- CO_2 separation/compression
- Enhanced Oil Recovery

- Storage and Distribution Services

DOWNSTREAM technologies

- ENGINE GENERATORS
- FUEL CELLS (PEM, SOFC)
- MICROTURBINES

- Power Electronics
- Emission Controls
- Exhaust Heat Recovery
- Communication
- Remote Monitoring, Diagnostics and Control

Role of AHEAD Energy

USA / Europe:

- Technical and Economic Consulting:
  - Governments
  - Financial Institutions
  - Energy Companies
  - Product Developers
- Product Evaluation, Testing and Validation

AFRICA:

- Demonstration: Integrate new technologies to help the 700,000,000 people off-the-grid in Africa
- Reduce environmental impact by using GREEN FUELS and RENEWABLES instead of gathering wood, and heavy use of polluting fossil fuels.
- Outreach to Underserved as Beta Customers.
- Training and Follow-up.

AHEAD Energy: Call to Action

- Stay apprised of AHEAD Energy's projects!
- Keep in touch, with ideas and inspirations!
- Partner with AHEAD in responding to energy challenges in Africa with practical, scalable, environmentally and economically sound solutions!
- Support AHEAD, a not-for-profit undertaking, with a donation of time, talent, or resources!

Summary

Getting the word out

- AHEAD Energy's Not-for-profit philanthropic path is promising

First step to fuel market

- Wellhead NH_3 coproduction with **CO_2-Enhanced Oil Recovery**

Synergies

- Renewables and NH_3 distributed generation

Opportunity

- AFRICA is a huge market for Stranded Gas or Coal and **CO_2-Enhanced Oil Recovery**

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Green Energy for Africa: Stranded Gas or Coal and CO_2-Enhanced Oil Recovery

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Thank you for your time and attention.

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