Ethiopian Metal Sector development through establishment of a Wind Turbine Industry

Summary Presentation June 2009
The ecbp assignment was to prepare Ethiopian decision makers towards the establishment of an Ethiopian-based wind turbine industry – for promotion of the metal and energy sector

Assignment in October 2008:

- what is the strategic need for having an Ethiopian wind turbine industry?
- what will be the cost of an Ethiopian produced wind turbine?
- what will be the benefits of Ethiopian made wind turbines?
- which wind turbine technology is suitable for Ethiopia?
- where could it be produced in Ethiopia?
- to which markets could wind turbines be exported?
- what is the impact on the Ethiopian industrial structure?
- what is the socio-economic impact of enhanced electrification?
- what are optimal structures for financing wind parks?
- who would be interested to provide finance?
- who would be interested to provide technology?
- what contribution can and should Ethiopian universities make?
- which overall energy technology strategy might Ethiopia adopt?

Source: Dr Peer Ederer
Main outcome: negotiations are initiated to establish an Ethiopian wind turbine industry

Ministry of Mines and Energy: In principle decision to explore Aysha as site for Ethiopian made wind turbines

Ministry of Trade and Industry: In principle decision to privatize Akaki Spare Parts Factory to make it available as facility for manufacturing renewable energy generation equipment

EEPCO: In principle decision to accept up to 300 MW wind generated energy from Ethiopian made wind turbines at Aysha at prices that are comparable to hydro generated electricity

DanoTek, Ryle and EnerveSt: in principle decision to transfer critical technologies to Ethiopia

Source: Dr Peer Ederer
The ecbp intervention has led to a significant paradigm shift

Status October 08:
- 0% local value added
- 3 m$ per 1 MW rated power
- Wind power considered a luxury to be funded externally, donor driven

ecbp intervention

Status May 09:
- 60% local value added
- 1.6 m$ per 1 MW rated power
- Wind power considered a strategic opportunity for an export-led energy sector

Source: Dr Peer Ederer
Brazil, Egypt, Korea and Thailand are benchmarks for Ethiopia

Share of labor force in agricultural sector (2007)

- Brazil: 20%
- Egypt: 32%
- South Korea: 7.2%
- Thailand: 42.6%

Industrial production value-added (1998-2007)

- South Korea
- Brazil
- Thailand
- Egypt

Sources: CIA; Undata

Source: C4SL, Prof Dr Ron Meyer
Every $ GDP requires 250 Wh electricity supply

<table>
<thead>
<tr>
<th>Country</th>
<th>Energy Demand</th>
<th>GDP (bn $)</th>
<th>Current Energy Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>Electricity</td>
<td>390 TWh</td>
<td>1,800 bn $</td>
</tr>
<tr>
<td>Egypt</td>
<td>102 TWh</td>
<td>400 bn $</td>
<td></td>
</tr>
<tr>
<td>South Korea</td>
<td>389 TWh</td>
<td>1,253 bn $</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>132 TWh</td>
<td>519 bn $</td>
<td></td>
</tr>
</tbody>
</table>

The current energy demands of Brazil, Egypt, South Korea and Thailand can serve as benchmarks for 2030 energy demands of Ethiopia’s potential export countries.

Energy demand of these countries in 2007 [Wh per $ GDP]

Sources: IEA; IMF

Sources: C4SL, Prof Dr Ron Meyer

Current GDP (PPP) and energy demand
Ethiopia: 48-fold electricity supply increase needed to ensure growth

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP (PPP)</th>
<th>Energy Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>62.2 bn $</td>
<td>2.9 TWh(^1)</td>
</tr>
<tr>
<td>2030</td>
<td>365 bn $</td>
<td>557 bn $</td>
</tr>
<tr>
<td>2030</td>
<td>2030</td>
<td>843 bn $</td>
</tr>
</tbody>
</table>

Energy needed to ensure growth projection (Assumption 250 Wh / $ GDP)

2007 (Based on annual growth rates 2002 – 2007)

2030 Projection: 10% growth

EEPCO demand forecast (2003): 8 TWh/year in 2025; See under additional information

Sources: IEA; IMF; UNdata; UNDP

\(^1\) EEPCO (2008): 3.3 TWh

Source: C4SL, Prof Dr Ron Meyer
Ethiopia: Possible output of wind turbines is 5,400 MW to 10,800 MW until 2030

Actual electricity production in Ethiopia: 2.9 TWh

Prospective electricity production in Ethiopia in 2030: 141 TWh

Scenario 1 (Share of wind energy: 10%)
- Hydro 98.5%
- Oil 1.5%

Scenario 2 (Share of wind energy: 20%)
- Hydro 80%
- Oil 10%

△ 5,400 MW installed wind turbines
△ 10,800 MW installed wind turbines

Source: C4SL, Prof Dr Ron Meyer

1 (Assumption: Capacity Factor = 30%)
Kenya will increase its electricity need 15-fold to 79 TWh until 2030 at an annual growth rate of 7.5%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need for **3000 MW** installed capacity of wind turbines.

Ghana will increase its electricity need 8-fold to 55 TWh until 2030 at an annual growth rate of 8.8%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **2100 MW** installed capacity of wind turbines.

Tanzania will increase its electricity need 45-fold to 102 TWh until 2030 at an annual growth rate of 9.6%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **3900 MW** installed capacity of wind turbines.

Mozambique will increase its electricity need 4-fold to 37 TWh until 2030 at an annual growth rate of 9.7%. However, these numbers for Mozambique are misleading, because most of its current electricity generation is from the Cabora Bassa hydro station, whose electricity output is contractually sold to South Africa. Nonetheless, at 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **1400 MW** installed capacity of wind turbines.

Madagascar will increase its electricity need 37-fold to 33 TWh until 2030 at an annual growth rate of 9%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **1300 MW** installed capacity of wind turbines.

Yemen will increase its electricity need 10-fold to 42 TWh until 2030 at an annual growth rate of 5%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **1600 MW** installed capacity.

Pakistan will increase its electricity need 6.6-fold to 493 TWh until 2030 at an annual growth rate of 7%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **19000 MW** installed capacity.

Afghanistan will increase its electricity need 46-fold to 37 TWh until 2030 at an annual growth rate of 9%. At 10% share of wind energy of the total energy production and at 30% capacity factor the country will have a need of **1400 MW** installed capacity.

Source: C4SL, Prof Dr Ron Meyer
# Results of financial business planning scenarios

## Scenario 1 - Base
- **Size of turbines**: 1000 kW
- **Production volume**: 200 MW pa
- **Technology transfer**: in 5 years completed

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross value of production 2017:</td>
<td>259,800</td>
</tr>
<tr>
<td>Import value of production 2017:</td>
<td>115,140</td>
</tr>
<tr>
<td>Local value added of production 2017:</td>
<td>144,660</td>
</tr>
<tr>
<td>Export value of production 2017:</td>
<td>129,900</td>
</tr>
<tr>
<td>Balance of payments of production 2017:</td>
<td>14,760</td>
</tr>
</tbody>
</table>

**Cost of naked wind turbine**: 1,299,000

## Scenario 2 - Smaller turbines
- **Size of turbines**: 800 kW
- **Production volume**: 200 MW pa
- **Technology transfer**: in 5 years completed

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross value of production 2017:</td>
<td>244,275</td>
</tr>
<tr>
<td>Import value of production 2017:</td>
<td>107,750</td>
</tr>
<tr>
<td>Local value added of production 2017:</td>
<td>136,525</td>
</tr>
<tr>
<td>Export value of production 2017:</td>
<td>122,138</td>
</tr>
<tr>
<td>Balance of payments of production 2017:</td>
<td>14,388</td>
</tr>
</tbody>
</table>

**Cost of naked wind turbine**: 1,221,375

## Scenario 3 - Larger turbines
- **Size of turbines**: 1500 kW
- **Production volume**: 200 MW pa
- **Technology transfer**: in 5 years completed

<table>
<thead>
<tr>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross value of production 2017:</td>
<td>303,200</td>
</tr>
<tr>
<td>Import value of production 2017:</td>
<td>132,027</td>
</tr>
<tr>
<td>Local value added of production 2017:</td>
<td>171,173</td>
</tr>
<tr>
<td>Export value of production 2017:</td>
<td>151,600</td>
</tr>
<tr>
<td>Balance of payments of production 2017:</td>
<td>19,573</td>
</tr>
</tbody>
</table>

**Cost of naked wind turbine**: 1,516,000

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Source: Dr Philipp Schuller
What is the industrial impact?

**Economy**  
Impact (value-added): 1.5% of GDP  
**Economy**

**Industry**  
Impact: 7.6%  
**Industry**

**Manufacturing**  
Impact: 34.1%  
**Manufacturing**

**Metal & Machinery**  
Impact: 401%  
**Metal & Machinery**

Establishment of Wind Turbine Manufacturing  
6,000 new employees

Source: University of Manchester, Dr Raimondo Guerra
Establishment of Wind Turbine Manufacturing

Employment:
Creation of 6,000 new jobs

Explanation of the assumptions:
1. 200 MW of turbines produced per year in 2014
2. In Germany and US, one MW of wind turbine production typically generates 10 jobs
3. Manufacturing depth in Ethiopia will be 75% of the level of the German wind turbine industry
4. Productivity of Ethiopian work force is 25% of the German work force
5. 200 MW * 10 workers / 25% Ethiopian productivity * 75% manufacturing depth => 6,000 jobs in the metals and machinery sector
6. These assumptions are independently verified by a per components manufacturing analysis of expected Ethiopian productivity for wind turbine manufacturing

Value Added:
Additional $108M per year

Explanation of the assumptions:
1. 200 MW of turbines produced per year in 2014
2. Production cost of turbines to be USD 1.3 Mio
3. 55% local value added in Ethiopia on the turbines
4. 75% of the local value added in the metals and machinery sector
=> USD 108 Million

Source: University of Manchester, Dr Raimondo Guerra
What is the socioeconomic impact of electrification?

Case studies illustrate how electrification yields substantial socioeconomic benefits to the Ethiopian society 1/2

**Social Benefits**

- Improved education is realized through the increased study time and evening classes for adults that electric lighting allows as well as TV and radio use.
- On average electric lighting adds an extra 77 minutes/day for pupils and 27 minutes/day for adults. This increases the annual study time of pupils by more than 400 hours/year.
- The increased study time also results in a higher number of school leaver qualifications. In Bonga, Ethiopia the rate of qualifications attained went from 10% in 1986 to 80% in 1990 after electrification.
- Increased TV and radio use particularly by women has increased the awareness of healthcare issues, especially the knowledge about methods of contraception. This has led to a statistically significant decrease in the fertility rates.
- Besides the improved healthcare knowledge of women improved healthcare comes in the form of longer opening hours of local clinics, better treatments due to the use of electrical equipment and clean water and the refrigeration of vaccines and other medical supplies.
- Electric lighting means that on average Kenyan local health clinics are now providing services for 15 rather than 11 hour each day and in Ribaue District it even allows a 24 hr emergency attendance increasing the number of treated patients per day.
- The use of electrical equipment and safe drinking water has also leads to improvement of the quality of care provided.
- The cool storage of vaccines and other medical supply make it possible to use them over much longer periods of time and make their application safer.

Source: University of Manchester, Dr Raimondo Guerra
What is the socioeconomic impact of electrification?

**Socioeconomic benefits continued**

**Economic Benefits**

**Case study Bebeka-Kite in Ethiopia**

- The overall amount of hectarage of the local coffee plantation has increased from 10 ha in 1980 to more than 6,700 ha in 1990 after electrification.
- The use of electrical equipment for the washing and dehusking of first class Arabica coffee has caused an increase in productivity of 35-40%.
- Over the 10 year period from 1980 to 1990 the coffee plantation has generated total net benefits of 4.35 times the total costs for both the equipment and the electricity consumption.
- Based on relatively expensive diesel-generated electricity prices of US$ 0.2 per kWh the total net benefits of using relatively cheaper grid-electricity should have been even greater.

**Case study Ribáuè District in Madagaskar**

- The extension of the national grid from the provincial capital Nampula had initial investment costs of US$ 4.0 million or US$ 2,100 for each of the existing 1,900 customers in 2005.
- The main economic player is the cotton factory which increased its productive efficiency by 30% between 2000 and 2005. In addition the local maize mills provided a more reliable service and local shops, bars and restaurants opened.
- While the project has created positive benefits from year one and generated net benefits of US$ 1.698 million over the 5 year period these have only become cash-flow positive in 2004.
- The cotton factory has contributed 39% of total net benefits in the form of commercial energy savings and another 24.4% through productivity gains in the cotton processing while the local shops, bars and restaurants have contributed 8% of total net benefits.
- While the forecast ranges between US$ 20 million to 40 million total net benefits at a discount rate of 5%, the project would still produce US$ 4 million to 6 million total net benefits in 2020 at a discount rate of 20%.
- Over this period education evolves as a major contributor to total net benefits.

Source: University of Manchester, Dr Raimondo Guerra
**What is the most suitable technology for Ethiopia?**

Smaller scale, western technologies are most suitable for an Ethiopian production of wind turbines

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Vestas V 52</th>
<th>Gamesa G 58</th>
<th>Fuhrländer 1250 kw</th>
<th>Mitsubishi MWT 1000 kw</th>
<th>DeWind D4 600 kw</th>
<th>SEC SeWind D6 1250 kw</th>
<th>Goldwind 543 600 kw</th>
<th>China Windy 750 kw</th>
<th>Sinovel 600 kw</th>
<th>Suzlon S64 1250 kw</th>
<th>Innovative Power-1250 kw</th>
<th>Conergy PW56 900 kw</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1): Track Record; # of sold turbines</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>(2): Track record: # of licensed sold</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>(3): Complexity of design and difficulty for production</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>(4): Reach of the supply chain of components</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>(5): Willingness and experience to work in least developed countries</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>(6): Infrastructure requirements in terms of weight of turbine</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Score of wind turbine design: 3.9 3.5 3.9 2.5 4.2 2.5 3.3 2.7 2.6 4.2 3.7 3.0 3.0

Source: Renewco GmbH, Jörg Kubitz

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- **Smaller scale, western technologies are most suitable for an Ethiopian production of wind turbines.**
  - **Vestas V 52:** 850 kW
  - **Gamesa G 58:** 850 kW
  - **Fuhrländer 1250 kw:** 1250 kW
  - **Mitsubishi MWT 1000 kw:** 1000 kW
  - **DeWind D4 600 kw:** 600 kW
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  - **Goldwind 543 600 kw:** 600 kW
  - **China Windy 750 kw:** 750 kW
  - **Sinovel 600 kw:** 600 kW
  - **Suzlon S64 1250 kw:** 1250 kW
  - **Innovative Power-1250 kw:**
  - **Conergy PW56 900 kw:**

---

- **Criteria:**
  1. Track Record; # of sold turbines
  2. Track record: # of licensed sold
  3. Complexity of design and difficulty for production
  4. Reach of the supply chain of components
  5. Willingness and experience to work in least developed countries
  6. Infrastructure requirements in terms of weight of turbine

---

- **Score of wind turbine design: 3.9 3.5 3.9 2.5 4.2 2.5 3.3 2.7 2.6 4.2 3.7 3.0 3.0**
After a shortlisting process, three companies were assessed to be a potential contributor to manufacturing wind turbines

- Mesfin Engineering (Mesfin) – mostly a fabricator, has the potential to engineer, fabricate, ship to site and install foundations, and towers. Outside the scope of this note, but through its corporate ownership, Mesfin management expressed it might be able to provide finance and invest in additional manufacturing skills like a foundry or a machining center. Having Mesfin undertake the work package for foundations and towers would be technically medium to low risk. There is sufficient factory space on the premises in the city of Mekele to also undertake assembly (although the hub would have to be done elsewhere in a precision environment).

- Akaki Spare Parts Factory (Akaki) - a vertically integrated metal processing job shop, could undertake casting of the hub (technically medium to high risk), small part machining (low risk), nacelle assembly (low risk) and hub machining and assembly (medium to high risk). The site has considerable potential but will require significant investment (of expertise, culture change and money) to enable it to realize this potential.

- Maru Manufacturing (Maru) - a fabricator and assembler, is an impressive small private business, where a shrewd investment in machinery for automation (very bold step in an environment where labour is low cost), demonstrates a clear recognition of the benefits of automation above that of pure cost reduction. Could produce foundations and tower components, and could assemble nacelles. The management of the business itself is a valuable aspect to the business.
View of ASPF Manufacturing building today
View of a wind turbine assembly operation which was designed and built by the manufacturing engineer who evaluated ASPF
How to finance wind energy on a large scale in Ethiopia?

As a financing vehicle a ppp-structured fund is recommended

Source: Frankfurt School of Finance and Management, Prof Dr Sebastian Fritz
Next steps ecbp: facilitate university support and deepen the Ethiopian supply chain structure in the metal sector

Status October 08:
- 0% local value added
- 3 m$ per 1 MW rated power
- Wind power considered a luxury to be funded externally, donor driven

Status May 09:
- 60% local value added
- 1.6 m$ per 1 MW rated power
- Wind power considered a strategic opportunity for an export-led energy sector

Further ecbp support:
- To entice/support universities to build a research and training agenda with muscle
- To capacitate suppliers so that a renewables cluster can develop and entrench

Source: Dr. Peer Ederer; Stephan Willms
An Ethiopian Renewable Energy Institute (EREI) would bundle research, focus attention and leverage knowledge.

**How can universities support the process?**

- **University staff**
- **PhD students**
- **Students and Ethiopian population**
- **Foreign experts, institutes and universities**
- **Private sector**

**EREI**

- **Publications + studies**
- **Professional training**
- **Community involvement**
- **Global exchange of ideas**
- **Research with private sector**
- **Promotion of Ethiopian energy development**

Source: Stephan Willms
### How can universities support the process?

#### Examples for global institutes

<table>
<thead>
<tr>
<th>Institute</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Jülich Research Centre</strong></td>
<td>Fuel cells; plasma physics; material science; photovoltaics; safety research; technology Evaluation; offshore wind (…)</td>
</tr>
<tr>
<td><strong>Helmholtz Association</strong></td>
<td>To solve the grand challenges that face society in energy and other areas</td>
</tr>
<tr>
<td><strong>Institute for wind energy and energy System technology (IWES)</strong></td>
<td>PhD courses in a multitude of topics</td>
</tr>
<tr>
<td><strong>ForWind</strong></td>
<td>Wind, solar, geothermics, biomass</td>
</tr>
<tr>
<td><strong>Research Group Wind Energy</strong></td>
<td>Fraunhofer: expand Germany’s leadership in wind energy; Energy system technology</td>
</tr>
<tr>
<td><strong>ForWind</strong></td>
<td>Wind research; scientific cooperation in industry oriented projects; further education</td>
</tr>
<tr>
<td><strong>Risoe Institut</strong></td>
<td>Result oriented research focussed on Danish Society; large projects, training, business orientation</td>
</tr>
<tr>
<td></td>
<td>Measurement, modelling, aerodynamics, Loads, fatigue assessment</td>
</tr>
<tr>
<td></td>
<td>12MW turbines, blade manufacturing, Vanadium batteries, materials, (…)</td>
</tr>
</tbody>
</table>
Ethiopia would need to develop its own solution

Exemplary structure of an Ethiopian REI

Ethiopian Universities
(Adama, Addis Ababa, Mekelle, Awasa, others)

Supervisory Board

Management structure

EREI

Partnerships / Twins (tbc)
- TU Berlin
- TU Aachen
- Cambridge
- FH Köln
- MIT (US)
- Harvard Univ.
- Univ. Oldenburg
- Univ. Kassel
- Univ. Rostock
- (…)

Source: Stephan Willms
Possible scenarios for EREI

**Scenario 1: Connecting existing activities**
Within a build up phase of 3 years Ethiopian universities have joined forces and put together their existing activities into an EREI. Twinning arrangements with partner universities have been established. Even though activities are still happening at their original universities, the EREI managed to make Professors join forces e.g. when it comes to obtaining funds. Through communication campaigns on renewable energy the EREI has become well known in Ethiopia and in neighboring countries. It focuses mainly on teaching.

**Budget: 80,000€ annually**

**Scenario 2: Real research but small**
Just as in Scenario one but with a stronger focus on proprietary research and a more international exposure. Twin partnerships with European institutes and universities have been set up and several project groups are working on the development of new and better energy applications for the Ethiopian and African context. Several PhDs can travel to foreign countries on a regular basis. Likewise there are 2-3 foreign PhDs working in Ethiopia. **Budget: 155,000€ annually**

**Scenario 3: Creating an internationally renowned institute**
After a build up phase of 5-7 years the EREI is the best reputed institute in Africa with strong links to twin partner institutions in Europe, US and Asia. It has a regular exchange of 10 PhD students with foreign students working in the institute on one year contracts. The EREI manages to attract top researchers and teachers to come to Ethiopia for seminars, summer schools and for medium to long term research. The institute has along the lines of different renewable energies: hydro, wind, geothermal, bagasse and solar and works in a matrix organization with faculties of several local universities.

**Budget: 525,000€ annually**
Within 3-5 years EREI could have itself established

**Founding Phase**
- Acquisition of twinning partners
- Planning and structuring
- 1st call for papers
- 1st Summer Academy

**ecbp support:**
- Start up funding
- Twinning support
- Changing curricula

**Build up phase**
- Deep development of research themes
- Staff development
- Ountry-wide communication
- Participation in international conferences

**Sustainability phase**
- First successes in publications
- Sufficient external funding gathered
- First doctoral theses finished
- Twin partners intensify cooperation

Source: Dr. Peer Ederer; Stephan Willms
## Potential role of ecbp

<table>
<thead>
<tr>
<th>Component I (University)</th>
<th>Component II (TVET)</th>
<th>Component III (Qual.Infra.)</th>
<th>Component IV (Private Sector)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EREI</td>
<td>TVET to include skill sets for a RE industry</td>
<td>Institute for national technical certification?</td>
<td>Feed-in Tariffs</td>
</tr>
<tr>
<td>Curriculum Adaptation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Training</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introduction of global standards</td>
<td></td>
</tr>
</tbody>
</table>

**Macro**

**Meso**

**Micro**

- Certify the industry companies
- BPR in metal companies
- 5xCIM experts for Akaki transformation

Source: Dr. Peer Ederer; Stephan Willms
What can be the role of ecbp?

Ecbp can play a major role in further assisting the process of establishing a renewables industry in the country

1. Development of the EREI in cooperation with Adama and Mekelle Universities
   - Financial and technical assistance of the EREI
   - Development of internship opportunities for EREI students
   - Further curricula development at universities to include the area of renewable energy
   - Development of university twinning partners globally

2. Support of the upcoming renewable energy industry in the transformation process:
   - Technical support through 5 experts in the areas of foundry, welding, forging, manufacturing and supply chain management
   - Support in management skill upgrading,
   - Support in certification procedures

3. Establishment of an Ethiopian manufacturing incubation centre (EIC)
   - CIM expert as Manager of the centre
   - Support of micro companies to access finance + technical capacity development (CEE?)

4. Financial support for further studies potentially needed in the future

Source: Stephan Willms
Thank You
Additional Information
Wind Power fills Gap

instead of thermal power plants, EEPCO decided to use Wind Power

Source: EEPCO/ACRES 2003, Figure 10.7
Technical University of Denmark – MSc in Wind Energy – I/II

**General Competence Courses**
- Design of Wind Turbine
- Wind Turbine Measurement Technique
- Wind Turbine Technology and Aerodynamics (mandatory)
- Technology, Economics, Management and Organization (TEMO)
- Planning and development of wind farms

**Technological Specialization Courses**
- High Power Electronics
- Power System Networks
- Stability and Control in Electric Power Systems
- Connection of Wind Turbines to the Grid
- Electric Machines in Wind Turbine Systems
- Computational Electric Energy Systems

**Structural Mechanics:**
- Risk and Decision Analysis
- Dynamics of Structures: Theory and Analysis
- Plate and Shell Structures
- Strength of Materials
- Composite Lightweight Structures
- Non-Linear Modelling and Analysis of Structures and Solids
- Experimental Mechanics
- FEM-Light
- CAD/CAM

**Wind Turbine Construction and Materials:**
- Advanced Acoustics
- Sound and Vibration
- Machine Elements
- Dynamics of Machinery
- Plasticity and Fracture Mechanics
- FEM-Heavy
- Advanced Vibration and Stability Analysis
- Tribology of Machine Elements
- Applied Mechatronics

**Elective courses:**
- Turbulence Theory
- Wind Resources and Loads on Wind Turbines
- Theoretical Ship Hydrodynamics
- Computational Fluid Dynamics
- Projects in Wind Turbine Aeroelasticity

Source: Stephan Willms
### Exemplary Curriculum

**Technical University of Denmark – MSc in Wind Energy – II/II**

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**Electrical Design, Grid Connection and Power System Integration**

- Power Electronics 1
- High Power Electronics
- Electric Power Engineering, Fundamentals
- Power System Networks
- Stability and Control in Electric Power Systems
- High Voltage Engineering
- Power apparatus design and diagnosis
- Power engineering project
- Connection of Wind Turbines to the Grid
- Electric Machines in wind turbine systems
- Basic Electric Circuit Theory

**Wind Energy Prognosis and Optimization:**

- Time Series Analysis
- Advanced Time Series Analysis
- Static and Dynamic Optimization

*Source: Stephan Willms*
View on Akaki from space

Source: Google maps
According to the International Energy Agency and the OECD, wind energy will be the second largest growth sector in renewable power generation.

Source: Energy Technology Perspectives 2008, IEA and OECD