Sustainable Energy for Africa

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Hydroelectric Energy

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(With CIGB-ICOLD
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Hydro Generation

A clean renewable energy using the power of water to produce electricity.

Resource is the product of rainfall, catchments area, and vertical head.

A power resource that has evolved with technology for centuries.

Simple, well understood conversion of potential energy into mechanical and then electrical power.
World Energy Consumption by 2050
(P. Boisson, ENERGIE 2010-2020, CGP 1998)

Developing Countries population from 4.6 billions in 1995 to 8.1 in 2050
Industrialized Countries: from 1.15 to 1.14 Billion
Renewable energy has dominated the history of humanity.

Before 19th century: wood, water, wind, animal traction, slaves.
19th century: coal, steam.
20th century: oil, gas, hydropower, nuclear, renewables.

Can we go back to renewable energy?
And have power when you need it, and not when it is available.
Annual Solar Energy
And Hydro comes from solar
Hydroelectricity Worldwide

- **69%** in America, with 1,000,000 GWh/y and 12,143 MW.
- **75%** in Asia, with 3,600,000 GWh/y and 154,000 MW.
- **33%** in Africa, with 1,600,000 GWh/y and 75,000 MW.
- **7%** in Australia, with 1,100,000 GWh/y and 93 MW.
- **22%** in Europe, with 783,000 GWh/y and 8,343 MW.
- **49%** in North America, with 107,000 GWh/y and 61 MW.
World Hydro Potential
Dams in the World

LARGE DAMS %

GEOGRAPHICAL REGION

ASIA; 59,7
NORTH AMERICA; 21,1
EUROPE; 12,6
AFRICA; 3,3
SOUTH AMERICA; 2
AUSTRALIA-ASIA; 1,3

NORTH AMERICA; 21,1
ASIA; 59,7
Dams in the World

LEADER’S COUNTRIES IN NUMBER OF LARGE DAMS

- China: 26,278
- USA: 9,265
- India: 4,636
- Spain: 1,267
- Korea (ROK): 1,205
- Japan: 1,121
- South Africa: 915
- Canada: 793
- Brazil: 635
- Turkey: 625
- France: 597
- Italy: 549
- Mexico: 536
- United Kingdom: 517
- Australia: 507
Dams in the World

- 60,000 Large Dams
- 1 Million Little Dams
- Total Capacity: 9,000 km³
Large dams

Types of dams

Gravity dams,  
Arch dams  
Arc –gravity dam,  
multiple-arch buttress dam.

Embankments dams,  
Rock-fill dams  
Earth Fill dams  
Concrete-face rock-fill dams
Arch dams

- The arch dams are generally concrete dams whose curved shape allows a transfer of the thrust forces of the water on the rocky banks of the valley.

Barrage de Punt dal Gall (Suisse/Italie)
Homogeneous earth dams

Homogeneous earth dams are embankment dikes made up of a single loose material sufficiently impermeable to ensure both waterproofness and resistance.

Dam of MATEMALE
Hydropower and dams

- Three Gorges Dam in China
- Itaipu,
- Great Inga in DRC Congo
- The micropower plant of Toubkal Morroco

Hydropower: Another great potential for competitive RE
Advantages disadvantages,
Adaptation to each site and innovation
Very capital-intensive
Environmental and social acceptability
Three Gorges dam
China The new Xiluodu Dam,

The new Xiluodu Dam, a 278-meter-high arch dam, has been linked to a 13,860 MW hydroelectric power plant since 2014,

second largest hydro dam in China after the Three Gorges Dam  180,000 people were displaced

China has, by far, the largest hydroelectric potential in the world.
The Itaipu Dam on the Parana River generates 14 GW and supplied 93% of the energy consumed by Paraguay and 20% of that consumed by Brazil as of 2005.
Egypt Aswan
Temple of Abou Simbel
Inga (Congo River)  
the biggest potential in the world

A summary of the potentials and difficulties of major African projects: INGA, 44000 MW, study of HV-DC transmission to Egypt and RSA, at a relatively low cost, competitive with nuclear and gas, even including long-distance transport.
Hydroelectric Resources of DRC

2. RESSOURCES HYDRO-ELECTRIQUES

<table>
<thead>
<tr>
<th>Site</th>
<th>Potentiel (MW)</th>
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<tbody>
<tr>
<td>01 Grand Inga</td>
<td>43.800</td>
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<tr>
<td>02 Inga IX</td>
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<td>03 Meladi</td>
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<td>04 Ploka</td>
<td>22.000</td>
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<td>05 Zongo II</td>
<td>150</td>
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<td>06 Kitoba</td>
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<td>07 Bambra</td>
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<td>10.5</td>
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<td>09 Ruki</td>
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<td>10 Mobayi II</td>
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<td>45 Mambilima II</td>
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Légende
- Chutes ou rapides
- Centrales hydroélectr. SNEL existantes
- Centrales hydroélectr. privées existantes
- Sites hydroélectriques étudiés
- Villes principales
- Autres centres
Grand Ethiopian Renaissance Dam

The Grand Ethiopian Renaissance Dam on the Blue Nile river in Ethiopia, currently under construction.

At 6,450 MW, the dam will be the largest hydroelectric power plant in Africa when completed, as well as the 7th largest in the world.

The gravity dam will be 175 m tall.
Cameroon Nachtigal Dam

420 MW, 1.1 Billion € of total project cost

On the Sanaga river
Nachtigal Hydro Power Company

Cameroonian limited company established in July 2016; 40% EDFI–30% International Finance Corporation – 30% Cameroonian State; total cost of 1.1 billion euros; non-recourse project finance

420 MW, 1.1 Billion € of total project, O&M during 35 years, located 65 km north-east of Yaoundé, including 15 meter high roller-compacted concrete dams over a total length of 2,000 meters, a 3.3 km long headrace channel, a power plant with seven generating units (420 MW), a 50 km long 225 kV transmission line;
Small Hydro
The Toubkal Micro hydro plant
Cameraman of Moroccan TV Dounya

Pelton Turbine 5 KW
The debate: the benefits and drawbacks of dams

Irrigation for food production, by irrigating land that would otherwise be desert.

Dams for a cheap and sustainable energy

Hydroelectric energy production generate electricity from a renewable source with very few CO2 emissions.

Unlike wind or solar energy, hydro energy can be stored (in reservoirs) in order to generate electricity when needed, simply by opening the gates. It is the most competitive form of power storage,
The difficult process of gaining acceptance for dams today

Dams also have downsides: conflicts of use, risk of breach, Social aspects, the displacement of local populations, arousing opposition.

Impacts on environment biodiversity, Strong oppositions in democratic countries, Controversy, NGO opposing dams since the 1990s, World Bank and World Commission on Dams, Complexity in the decision making process

A multidiciplinary approach is necessary
Acceptance must be found at every level, global and local

The local level is now more important than it used to be, with less central government control, and more local power devolved to “civil society”.

A Multicriteria environmental assessment is necessary. In addition to the three classic criteria of technical, economic and financial feasibility, dam projects must now meet a fourth, very demanding, criterion: that of their acceptance by the public and by elected representatives.

Dam promoters must act as mediators and educators in order to win acceptance. Special care must be taken with vulnerable ethnic groups.
Thank you for your attention

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