

ECOWAS Small-Scale Hydropower Program

2014 - 2020

Program Overview July 2016 for GIS HP Ressource Mapping Training in Dakar

Program Responsible: Mr Hannes Bauer, ECREEE
ECREEE / ECOWAS Centre for Renewable Energy and Energy Efficiency

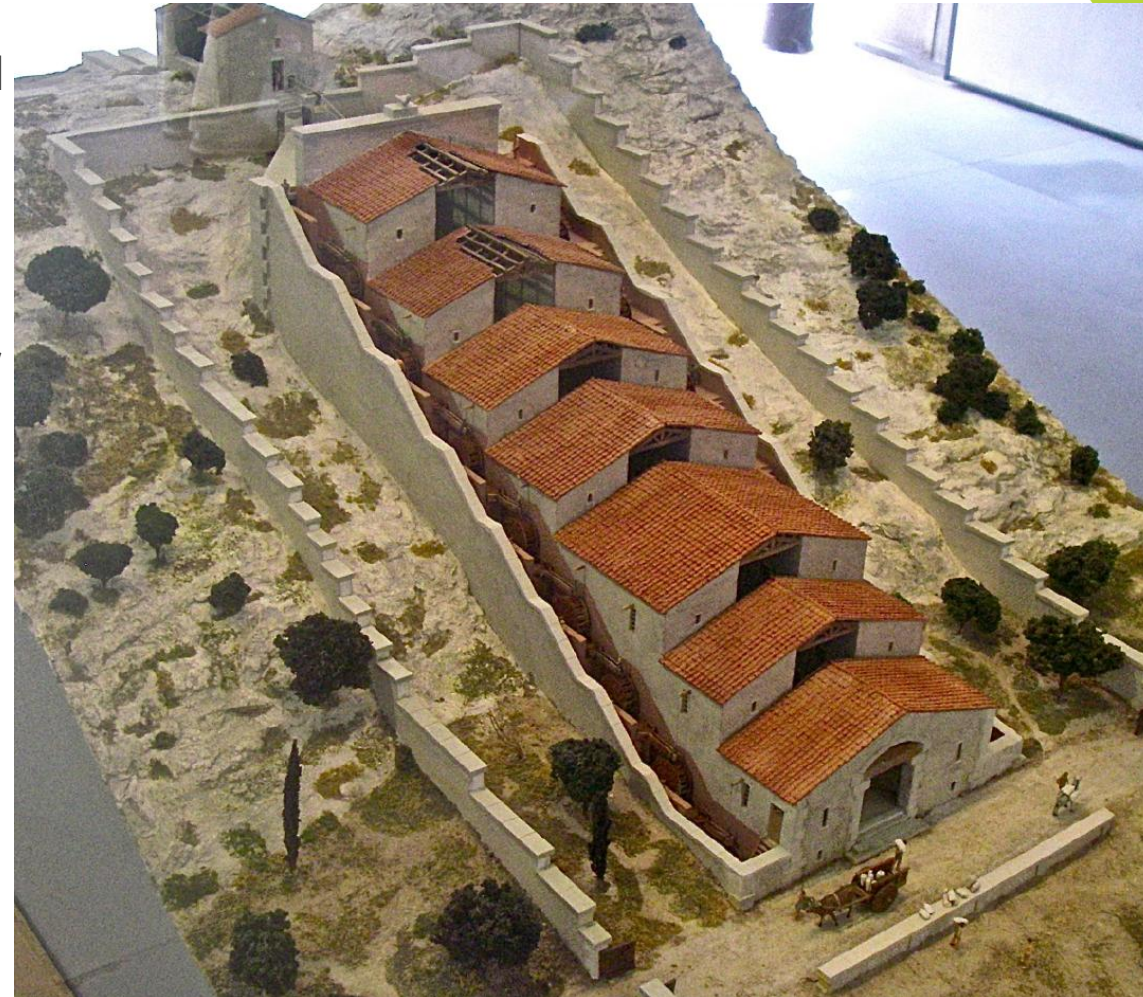


Water wheels (and windmills) since 1000s of years primary source of mechanical power until invention of steam engine

Water power has been available for thousands of years, first exploited through water mills. The Greeks and the Romans used water wheels and windmills for **irrigation** and **flour milling**. Never before had there been an alternative to motive power provided by humans or animals.

The figure on the right shows a model of the **Barbegal mill near Arles in France** that was built in the 2nd century AD and, at about 16 kW, represented the largest source of motive power in the ancient world. It milled about 4.5 metric tons of flour per day and was, almost certainly, the first mechanized factory.

Windmills and water wheels remained the primary source of mechanical power until 1712 when Newcomen developed the first successful steam engine. By modern standards, most of these pioneering plants would be **classified as "small"**.



Source <http://wbi.worldbank.org/energy/small-hydropower-technology/chapter-1-introduction>

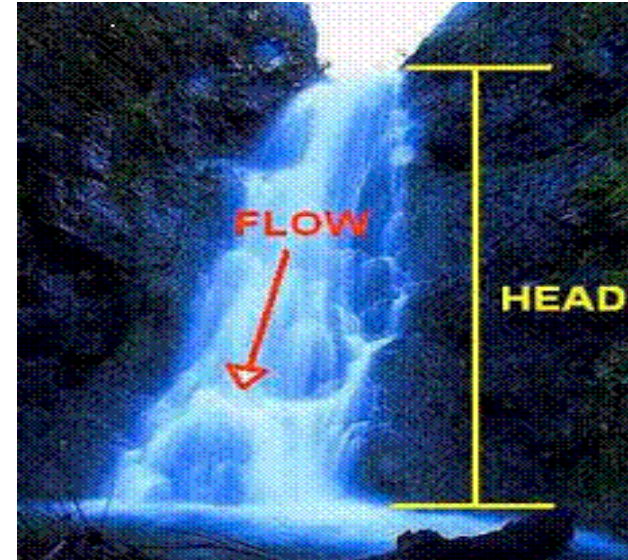
Hydropower Introduction / Terminology

Hydroelectric generation requires a flow of water and a drop of water, or “head”.

flow rate - the quantity of water flowing in a given time

head - the height from which the water falls.

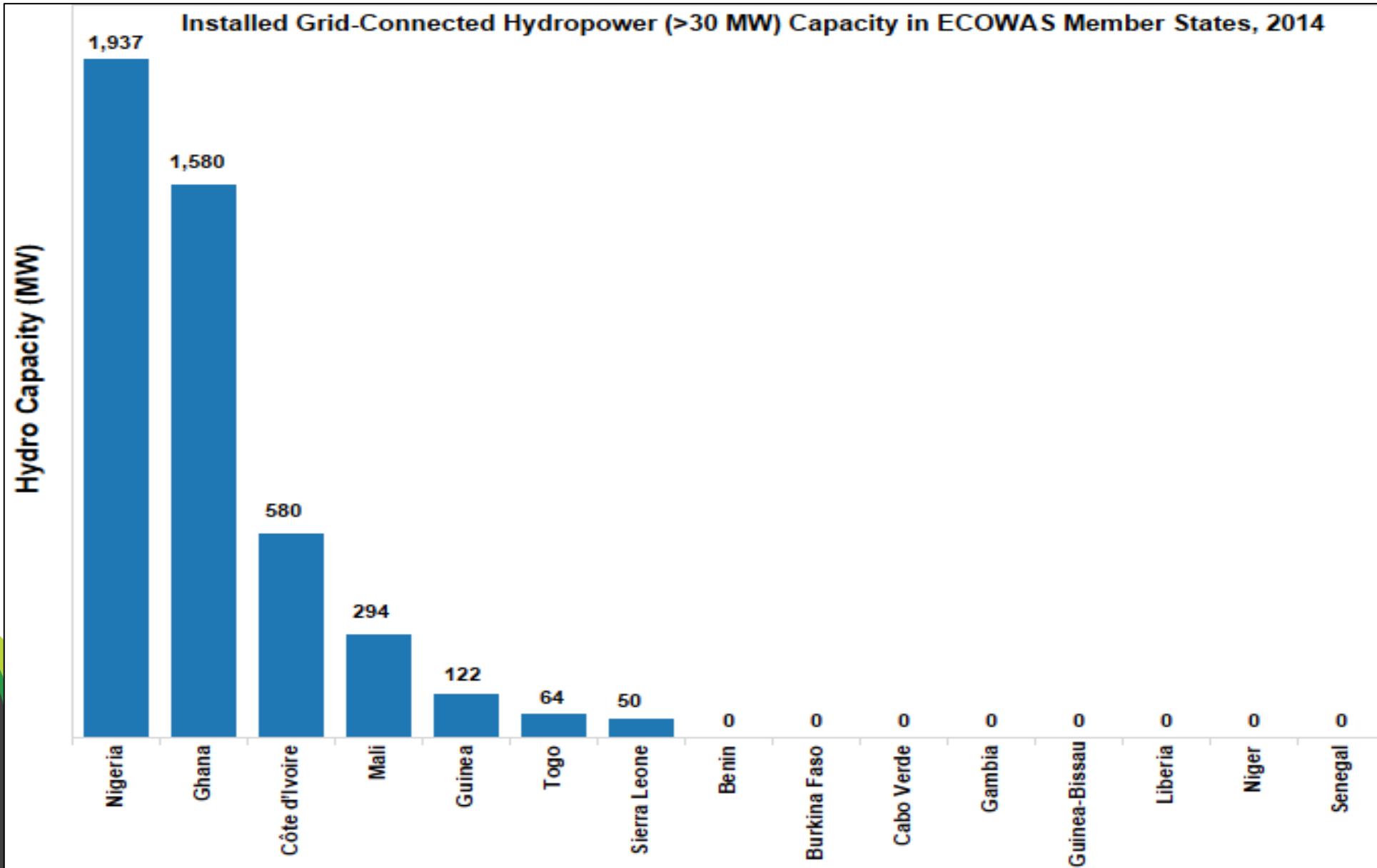
For hydropower plant the head of water is the height difference between reservoir intake and power station outlet.



The greater the flow and head, the more electricity produced.

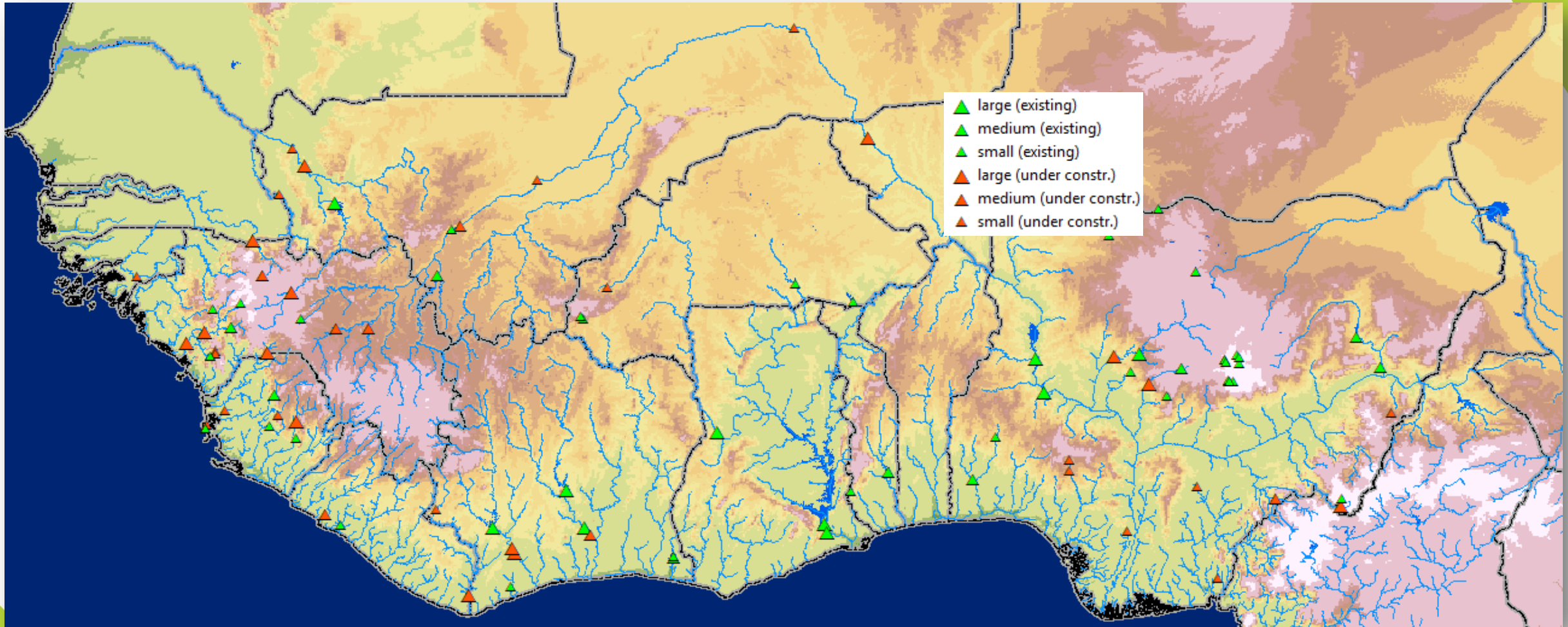
A large drop (high head) with low flow can generate a similar amount of energy as a small drop (low head) and high flow.

Installed Medium/Large HP Capacity > 30 MW in West Africa, 2014



Focus in West Africa in the past on development of medium and large Hydropower, not on small-scale hydropower

91 known Operative Hydropower Plants in West Africa



- **91 HPPs:**

- **24 large HPPs (> 100 MW)**
- **16 medium HPPs (30-100 MW)**
- **51 small HPPs (< 30MW)**

- 21 attributes (installed capacity, start year, reservoir area, etc.)
- Data sources: ECOWREX, GranD, Aquastat, H&D, JICA, SHP News, World Small HPP Development Rep., Int. Water Power & Dam Yearbook, SE4ALL, online search, etc.

Installed Small-Scale HP Capacities below 10 MW

West Africa: 69 MW / 40 operative plants

High Potential in about 10 West African Countries for Small Scale Hydropower

But still many barriers for the development of the sector

For Comparison:

Austria: 1.320 MW / 3.100 plants
Europe EU 15: 10.000 MW / 14.000 Plants
World: 37.000 MW

Barriers in the Small-Scale HP Sector in ECOWAS

- Lack of hydrological data and know how of measurement campaigns
- Expertise in hydro resource assessments is quite poor
 - Inventories established decades ago have not been updated
 - Resource assessments in the 1970s to 90s conducted by foreign consultants
- Limited expertise for equipment manufacturing, construction, operation and maintenance.
- Missing institutional capacities and lobbying efforts for SS HP Sector
- Lack of SS HP appropriate policy framework and incentives (such as Feed in tariff in Nigeria)
- Financial barriers include little or no incentives to attract investors

Launch of ECOWAS Small-Scale Hydropower Program

- Formulation of ECOWAS baseline report on Small Hydro Power
- April 2012: Validation WS in Sierra Leone
- October 2012: Adoption of Program Document by ECOWAS Ministers of Energy in Ghana
- Planned budget of 7 year program: 15 Mio EUR
- Launch in 2014 focusing on priority activities
 - Reduced Annual Budget about 300.000 EUR from ADA (Austria) & AECID (Spain)
- Ongoing search for further donors, such as AfDB, EU, USAID, etc.

Definitions Small-Scale Hydropower in ECOWAS Countries

Table 2
Classification of small hydropower in Western Africa

<i>Country</i>	<i>Small (MW)</i>	<i>Mini (MW)</i>	<i>Micro (kW)</i>
Benin ^a	10-30	1-10	10-1000
Ghana ^b	≤ 1		
Mali	1-10	0.1-1	<100
Nigéria	<10	<1	<500
Sierra Leone ^c	1-30	0.1-1	<100
ECOWAS ^b	1-30	0.005-0.1	< 5

Notes:

a. Benin Direction Générale de l'Énergie¹⁰

b. ECREEE Baseline Report⁷

c. Sierra Leone Ministry of Energy and Water Resources⁶

China: up to 25 MW

India: up to 15 MW

Austria: up to 10 MW

Sweden: up to 1,5 MW

Table 1: ECOWAS Hydro Power Definitions

Terms		Power output
Pico hydropower	"Small-scale" Hydro-power "SSHP"	< 5 kW
Micro hydropower		5 - 100 kW
Mini hydropower (MHP)		100 – 1 000 kW (=1 MW)
Small hydropower (normally "SHP")		1 MW - 30 MW (!)
Medium hydropower		30 MW - 100 MW
Large hydropower "LHP"		> 100 MW

Objectives of ECOWAS Small-Scale Hydropower Program

1. Elaborate policies and legal frameworks
2. Capacity development and quality guidelines
3. Knowledge management and access to crucial information
4. Investment and business promotion, build up local industry

Running Activities of the ECOWAS SS HP Program

PROJECTS & ACTIVITIES

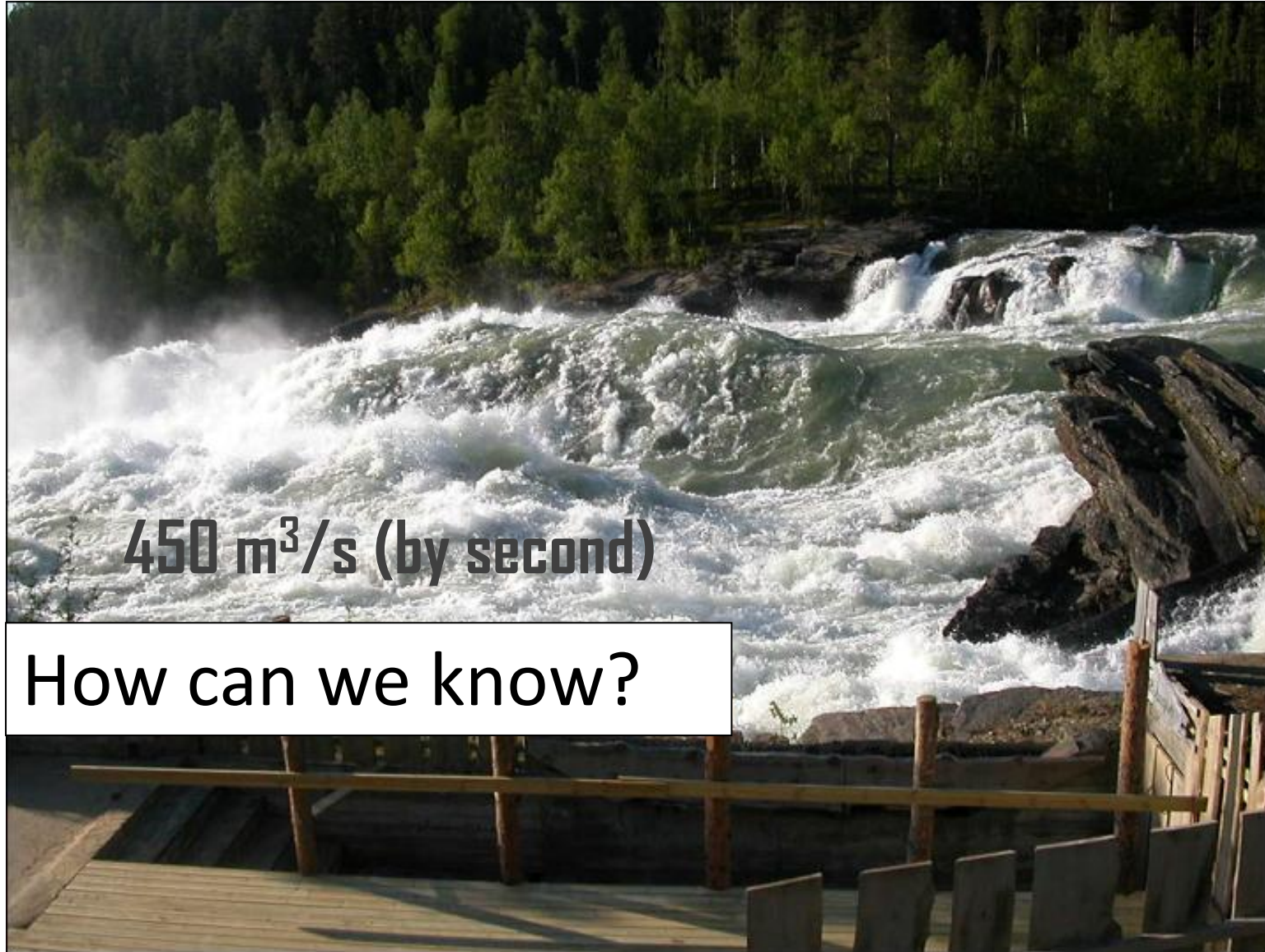
Using the existing limited funds ECREEE focusses on key activities:

- GIS Hydro Power Resource Mapping of all ECOWAS river basins: modelling HP potentials of the basis of discharge, precipitation, climatic and topographical data.
- Open and free data collection on the ECREEE observatory www.ECOWREX.org
- Training of stakeholders on how to use these data for development of the SS HP sector
- Upgrading the hydro-meteorological network and training of hydro-scouts and hydrologists
- Analyses and lessons from the few operative SS HP plants for use in trainings and manuals
- Support countries in accessing financing of selected SS HP plants

Program for hydrologic measurements and training for development of small scale HP in Sierra Leone and Guinea

- Stocktaking missions in Sierra Leone and Guinea in April 2016
- Final draft Program document available July 2016, then Validation
- Fund raising necessary for these 3 year programs in 2 countries:
 - By flow measurement and field training with MoE, MoH and universities:
Start October 2016
 - By Inventory of potential small HP sites based on desk study and field surveys
 - Increasing awareness in countries of data collection and assessment of SS HP
 - Collaboration with experienced Liberian hydrological service, trained 2010-2015 by NVE experts from Norway
 - Establishment of minimum hydrometric network for SS HP development
 - All activities offer practical trainings for the stakeholders in Sierra Leone (English) and Guinea (French), also open to actors from further ECOWAS countries

Flow Rate in Hydropower



$450 \text{ m}^3/\text{s}$ (by second)

How can we know?

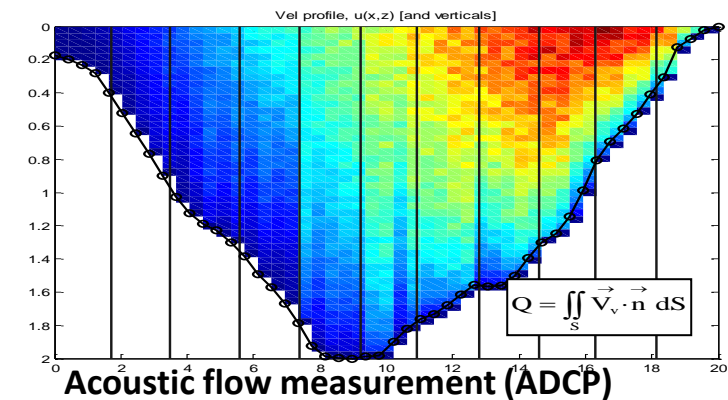
Stream Flow measurements

Hydropower development needs a lot of knowledge and skills and data

- Site location regarding hydrology, access, geology, transmission lines, etc.
- Stand alone system, mini grid or on grid plant
- Estimation of possible head based on topographical conditions
- Stream Flow measurements to get discharge data during many years (dry and humid seasons)
- ECREEE identified a lack of hydrological data and skills as one key barrier for developing small hydro power in West Africa
- ECREEE starts supporting Guinea and Sierra Leone to training and measurements upgrade hydrometric network increase hydrometric data in 2016, using well trained Liberian and international hydrologist experts



Mechanical Flow Measurement by Current meter for small and medium rivers



First Regional Rural HP Civil Engineering Training implemented in West Africa

- One of the barriers of developing micro and mini Hydropower plants, up to 500 kW, in West Africa are missing technical skills on civil engineering.
- ECREEE responded to this capacity gap by inviting and selecting trainers from 6 ECOWAS countries for participation in a 3 week practical training on mini hydropower civil engineering in April/May 2016 in cooperation the Federal University of Technology in Akure (FUTA) in Nigeria.
- Training planned to be repeated in French for Francophone countries
- Funded by ADA, AECID, EU and GIZ



Prof Lafe of CRET, vice chancellor of FUTA, Manager manufacturing of cross flow turbines, H. Bauer

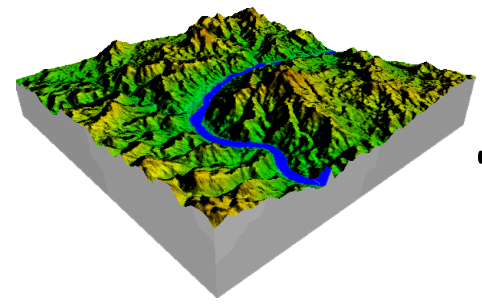


Participants and trainers of first rural HP civil engineering training at FUTA in Nigeria

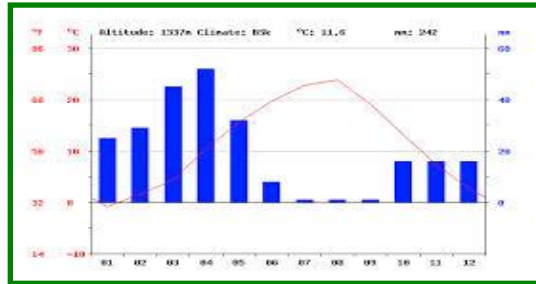
Questions for Hydropower Development in West Africa

- Where are attractive areas and river reaches for hydropower potentials in 14 West African countries?
- Which river reaches are suitable for which Plant Sizes (micro/mini, small, medium, large)?
- In which areas and locations shall the countries or private actors start field inventory for development of small scale hydropower plants?
- How will discharge (and consequently hydropower potentials) change in future in West Africa due to climate change?
- Will there be negative impacts on hydropower in West Africa?
- How can we increase the interest of investors, promoters and banks in hydropower in West Africa?

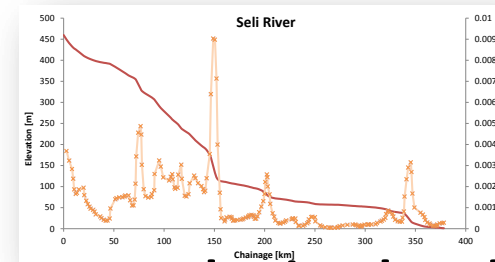
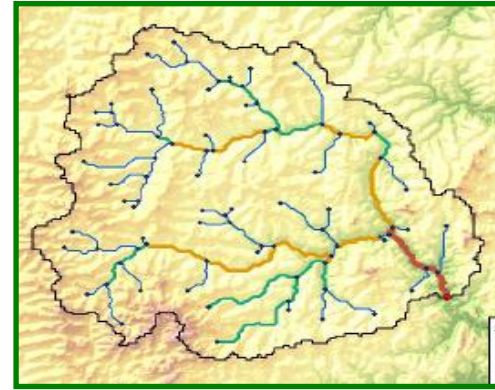
Overview GIS Hydropower Resource Mapping



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**River Reaches with sexy
Hydropower Potentials:**

**Screen River for
potential HP sites
&**

**Start field inventory and
hydrometric
measurements**

- River network, simulated flows
- Longitudinal Profiles
- Estimate Discharge conditions & evapotranspiration losses
- Compute Hydropower Potential

**Digital elevation
model**

Precipitation data

Enhance ECOWREX by Hydropower Resource Mapping



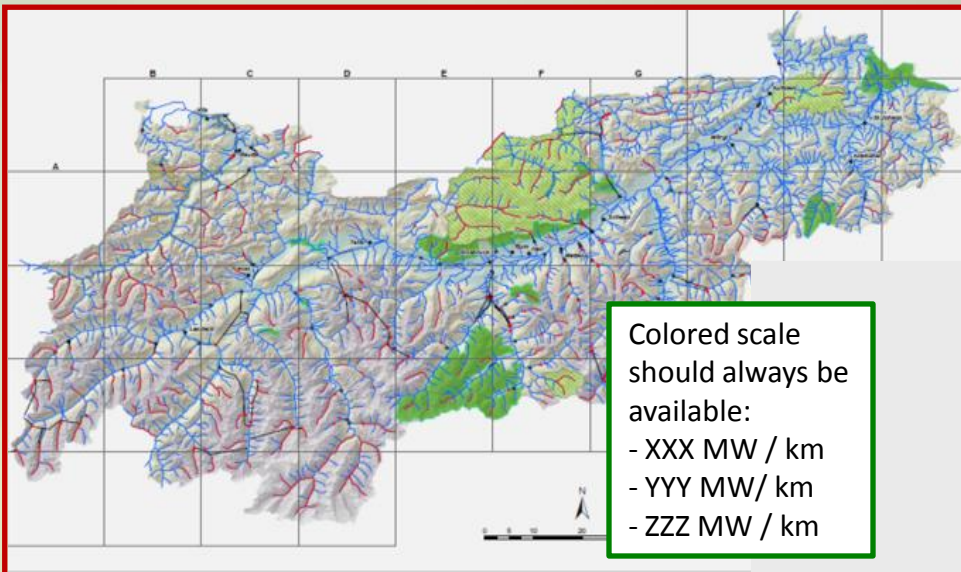
to be delivered

- Base Map
- Country Info
- Infrastructures
- Renewable Energy Potential
- Resources
 - Solar DNI Energy Resource
 - Solar GHI Energy Resource
 - Wind Energy Resource
 - Hydropower Resources
 - Precipitations & Climatic Zones
 - Rivers & Resources
 - Volta Basin
 - Niger Basin
 - XYZ Basin
 - Single River Channels
 - Power Generation Potentials
 - Suitability for Plant Sizes
 - Suitability for High/ Low Pressure Machines
 - Suitability for Plant Types
 - Suitability for Any Other Combination of Above Criteria

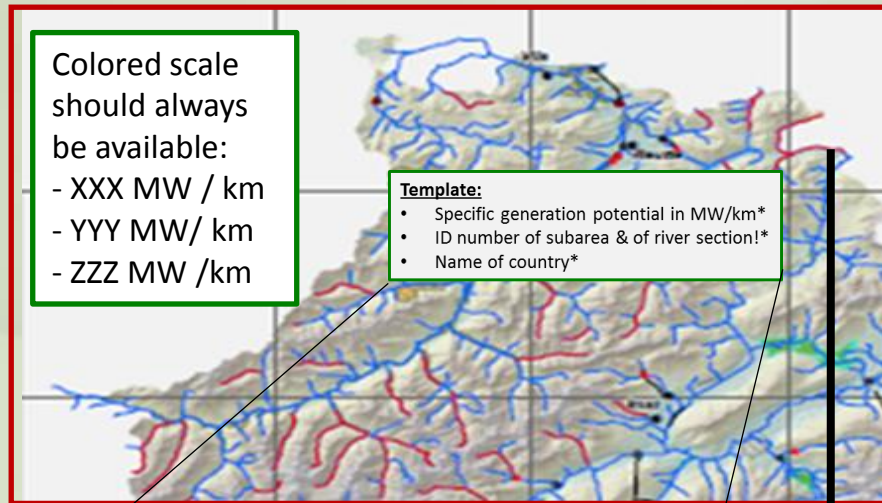
existing

Layer River Basins with Single River Channels

- Hydropower Resources
 - Precipitations & Climatic Zones
 - Rivers & Resources
 - Volta Basin
 - Niger Basin
 - XYZ Basin**
 - Single River Channels**
 - Power Generation Potentials
 - Suitability for Plant Sizes
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Data about Single River Channels



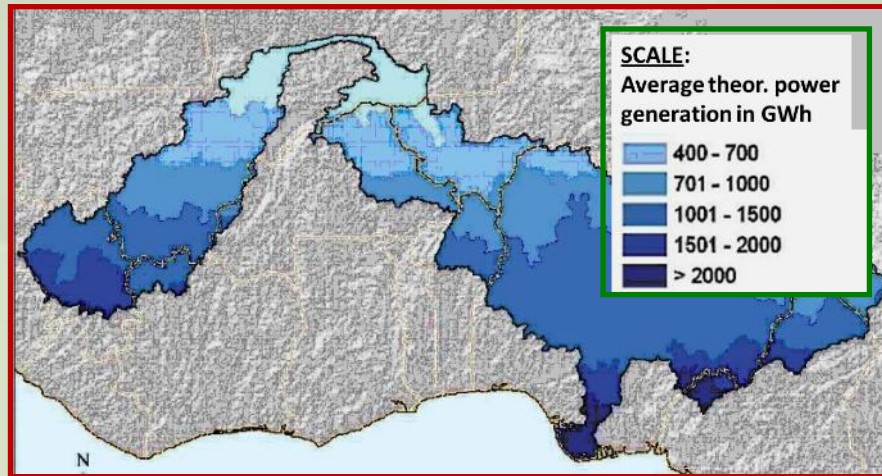
Template:

- Specific generation potential in MW/km*
- ID number of subarea & of river section!*
- Name of country*

← After click on a specific river section a template with the following data of the river section will be displayed.

- Hydropower Resources
- Precipitations & Climatic Zones
- Rivers & Resources
 - Volta Basin
 - Niger Basin
 - XYZ Basin
 - Single River Channels**
 - Power Generation Potentials
 - Suitability for Plant Sizes
 - Suitability for High/ Low Pressure Machines
 - Suitability for Plant Types
 - Suitability for Any Other Combination of Above Criteria

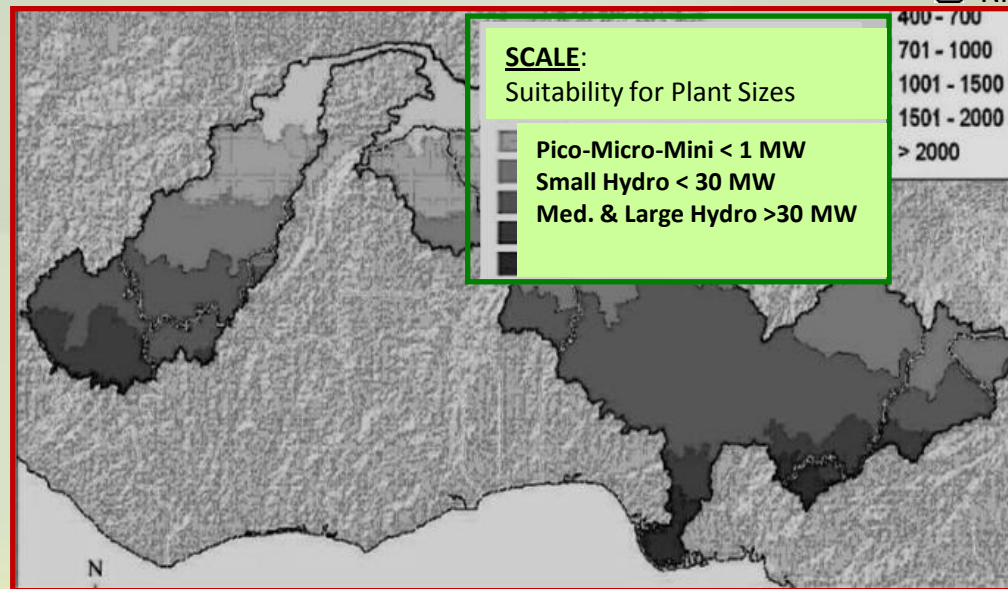
Identify attractive regions for Power Generation Potentials in the River Basin



- Hydropower Resources
 - Precipitations & Climatic Zones
 - Rivers & Resources
 - Volta Basin
 - Niger Basin
 - XYZ Basin**
 - Single River Channels
 - Power Generation Potentials**
 - Suitability for Plant Sizes
 - Suitability for High/ Low Pressure Machines
 - Suitability for Plant Types
 - Suitability for Any Other Combination of Above Criteria

- No further mouse click options. Visualization of attractiveness of subareas only by colors of the scale.

Suitability for Plant Sizes: Pico-Micro/ Mini/ Small H.



- Hydropower Resources
 - Precipitations & Climatic Zones
 - Rivers & Resources
- Volta Basin
- Niger Basin
- XYZ Basin**
 - Single River Channels
 - Power Generation Potentials
 - Suitability for Plant Sizes**
 - Suitability for High/ Low Pressure Machines
 - Suitability for Plant Types
 - Suitability for Any Other Combination of Above Criteria

- No further mouse click options. Visualization of attractiveness of subareas only by colors of the scale.

Power Generation Potential by Countries



- Hydropower Resources
 - Precipitations & Climatic Zones
 - Rivers & Resources
 - Volta Basin
 - Niger Basin
 - XYZ Basin
 - Single River Channels
 - Power Generation Potentials
 - Suitability for Plant Sizes
 - Suitability for Low/ High Pressure Machines
 - Suitability for Plant Types
 - Suitability for Any Other Combination of Above Criteria
- Countries & Resources**

- After mouse click on adequate country a template with at least three categories of theoretical power generation capacity appears (see picture above).
- The Technical Consultant is asked to suggest any other evaluation criteria for displaying various degrees of attractiveness of the defined subareas.

ECOWAS Small-Scale Hydropower Program

EOCWAS Centre for Renewable Energy
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