Regional Workshop on
GIS Energy Planning and RETScreen Training

Organised by

ECOWAS Centre for Renewable Energy and Energy Efficiency & The Energy Centre, KNUST

Developing and Implementing GIS-Based Energy Access Projects

August 23, 2011

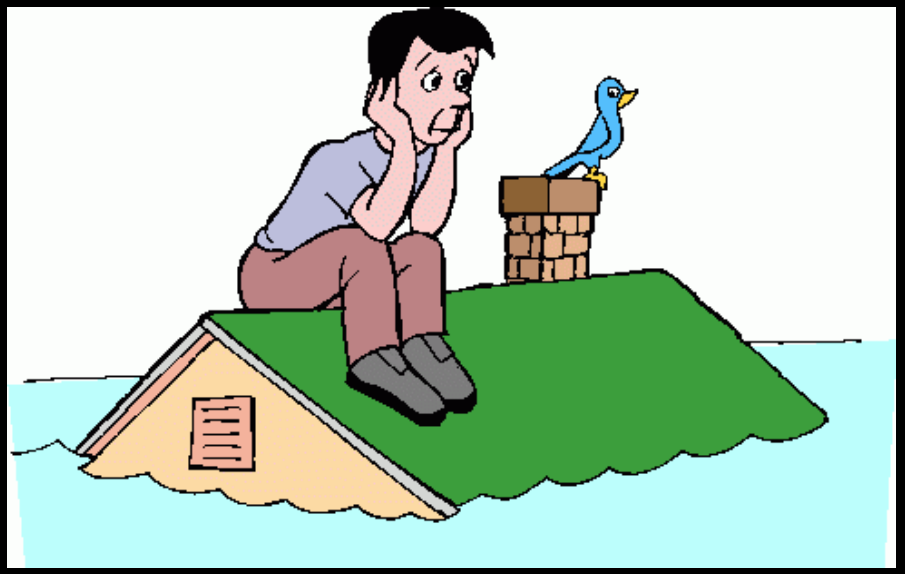
euei
EUROPEAN UNION ENERGY INITIATIVE

CEREEC
ECREEE

Regional Centre for Renewable Energy and Energy Efficiency
Centre Régional pour les Energies Renouvelables et l'Efficacité Energétique
Centro Regional de Energias Renováveis e de Eficiência Energética

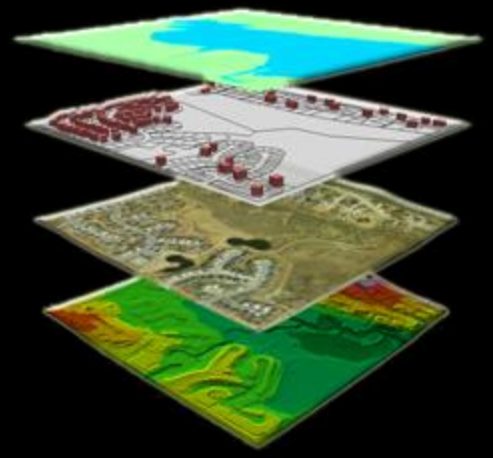
UNIDO

The Energy Center, KNUST



Why a Geographic Information System-Based Energy Access tool?

Needed an energy planning tool (computer program) that was capable of:



- managing, storing, and editing spatial data

- conducting spatial inquiries and analyses

- displaying spatial data (making maps)

- GIS uses the analytical power of the computer to complete complex tasks
- Digital storage power to manage large data sets
- Integration of many different types of data from many different sources e.g.
  - Towns/Communities
  - Demographic (e.g. Pop., landmarks etc)
  - Socio-economic (e.g. Schools, health post, irrigation sites, enterprises etc)
  - Substations, MV lines, LPG stations, Solar, Wind sites, Hydro-dams, Biogas plants etc
- Easily updated and edited

In brief a system that answers the following

Location: Where is it?

e.g. Under SHEP it was a requirement for beneficiary communities to be within 20km radius of an existing 33kV or 11kV electricity grid network

Condition: What is at...?

e.g. Communities on the Volta Lake

Trends: What has changed since...?

Patterns: What spatial patterns exist?

Modeling: What if…?

Project Objectives …1

- contribute towards effective implementation of policies and plans for achieving energy access targets by 2015
- Specifically to
  - review existing energy policies, strategies and plans for increasing energy access (national, ECOWAS & MDG targets)
  - Use GIS to collate and analyze national level data and provide timely information on population distribution, services, economic activities, and status of energy access programs
  - Identify the gaps in energy policies and plans for achieving expected energy access targets by 2020
  - Develop methods and tools to facilitate business models, investment plans and capacity development to complement current planned activities to achieve the energy access targets by 2015

Project Objectives …2

- contribute towards effective implementation of policies and plans for achieving energy access targets by 2015
- Specifically to
  - facilitate project identification, planning implementation and impact assessment for the Energy Commission, the Ministry of Energy and the ECOWAS Commission for timely development, implementation and monitoring of energy access strategies

Audience

- Energy Commission
- Ministry of Energy
- District Assembly
- ECOWAS Commission
- Any more???

Human Resources & Expertise

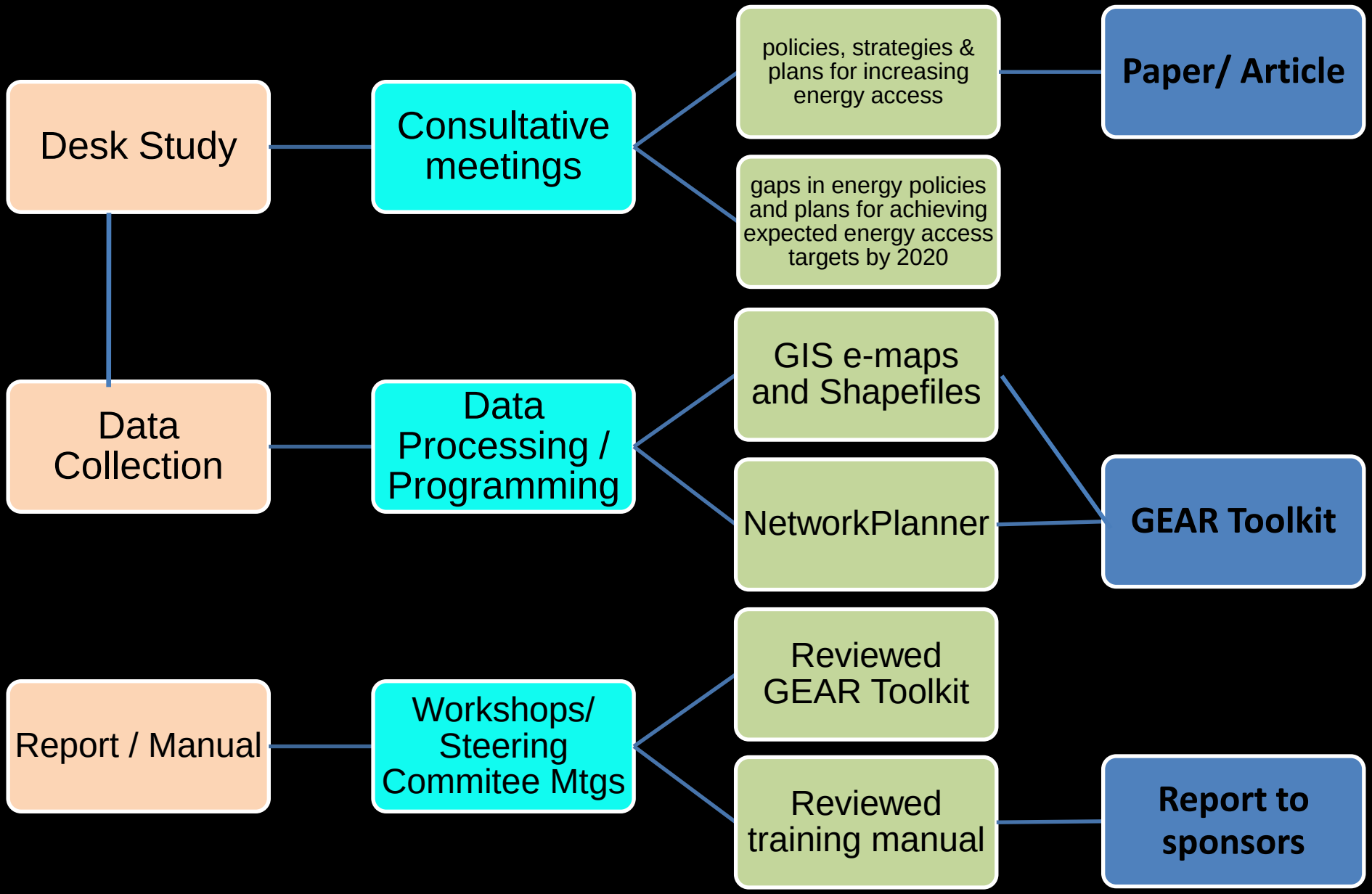
Experts used included:

- Energy Experts (3)
- GIS Experts (3)
- GIS programmer (1)
- Field staff (3)
- Drivers (2)
- Data entry staff (2)
- Administrative staff (2)
- Project Director (1)
- Project Coordinator (1)
- Accountant (1)

Technical Infrastructure

- Working Space
- Computers
- GIS Software (ArcGIS, MapWindow)
- Hand-held GPS Devices
- Printers and Scanners
- Digitising Board
- Vehicles

Project Approach



Project Approach – Desk Study & Meetings

- Review of energy access programmes 1990s – 2009 ; trends, plans and policies for increasing access to energy
- Primary focus on electricity, cooking fuels and renewable energy
- Consultative meetings with relevant agencies:
  - Energy Commission
  - Ministry of Energy
  - Statistical Services Dept.
  - Utility Companies
  - Consultants in the energy sector

Project Approach – Data Acquisition

Consultative meeting to discuss data collection template

SN	Data Type	Description	Source	Format		Contact Person (s)	Contact No.
1	ECG substations	Locations of substations & grid	Energy Commission ECG, Accra	Soft copy Soft copy	Shapefile Autocad (.dwg)	Mr. Out Danquah Ing. Gabriel Gbadogo (Ag. Dir/Op) / Ing. Daniel Teye, Accra	021-813761 / 0277850756 021-676727 / 0244456807
2	Mini Hydro Dams	Locatios & number of mini-hydro dams	Energy Commission	Soft copy	Shapefile	Mr. Otoo Danquah	021-813761 / 0277850756
3	Access to Irrigation Facilities	Towns/communities with access to irrigation facilities	GIDA	Soft copy	Excel	Mr. J. K. Antwi	024-4859962
4	Water Supply	Towns/communities with & without access to potable	GWCL	Soft copy	Excel & Word	Mr. Ebenezer K. Garbrah	0208173649 / 0282345808
			CWSA	Soft copy	pdf	Madam Esi-Nu Abbey / Mr. Salley Samah	021-518401
5	Education	Basic schools with & without access to Electricity	Ministry of Education	Soft copy	Excel	Mr. Thomas Coleman	0241751277 / 0277593767
6	ICT	e-Care	KITE	Soft copy	Excel	Agyeman	021-256801
7	Biogas	Households/Communities/Industries with access to biogas	Biogas Technologies West	Hard copy		Mr. John Afari Idan	022-410638
8	Enterprises with access to modern forms of energy	Rural, micro and small scale enterprises with & without access to electricity	NBSSI	Soft copy	Excel	Mr. Anthony Selomey	021-665693 / 0208197102
9	Census Data (Population)	Total, Male and Female Population of various communities/Towns in	Statistical Services Department	Soft copy	Excel	Mr. Gyebi	020-8134264
10	Health	Health Infrastructure Data	Ghana Health Service	Soft copy	Excel	Mr. Yahya	020-2012469

Project Approach – Fieldwork

- GPS coordinates of
  - LPG stations
  - Communities/Towns
  - Wind sites
  - Substations
  - MV-lines
  - etc

Project Approach – Data Processing

- Cleaning the data
- Changing data formats
- Geocoding / Georeferencing
- Linking / joining data
- Editing
- Creating shapefiles
- Spatial Analyses
- Publishing e-maps

Project Approach – Modelling – Network Planner

- Input data
- Output

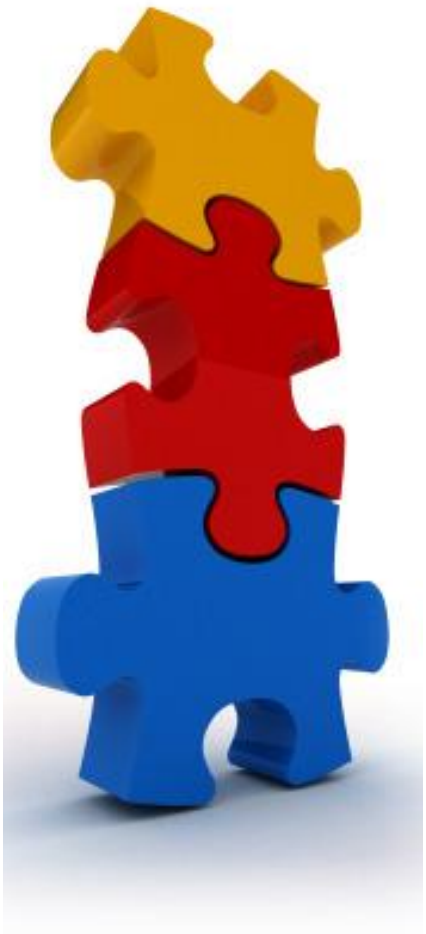
Introduction

- ‘Network Planner’ is an online tool for planning electrification projects at national, regional, and local scales.
- The model combines data on several parameters to compute detailed projection costs of three electrification options and propose the optimal cost-effective option for electrifying a community within a specified time horizon.

Introduction

- Model generates results at any geographical scale (National, regional or local level) based on the availability of data used in the modelling.
- Places more emphasis on electrification expansion rather than intensification.
- Ability to perform sensitivity analysis.

Methodology

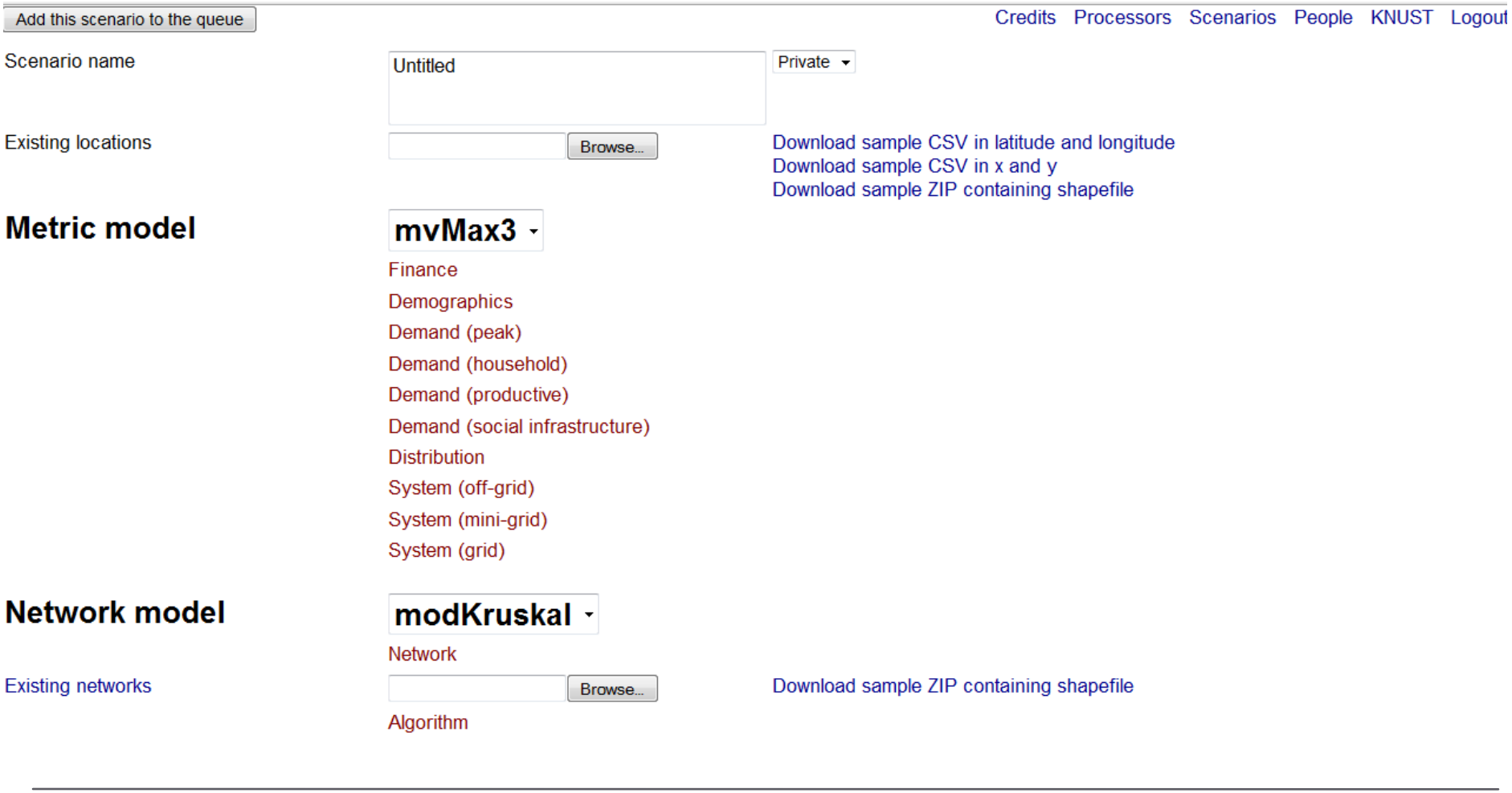


- Population and households count projection
- Modelling projected electricity demands
- Modelling projected cost of each technology
- Selecting the cost-optimized electrification option

Data Requirements

1) Initial + Recurring Costs
   - Grid (MV & LV): wire, poles, transformers, maintenance
   - Mini-grid: generators, fuel, maintenance
   - Off-grid/solar: PV panels, batteries & battery replacement
2) Demographic & Financial parameters
   - Population Growth, Demand Growth
   - Interest Rate, Elasticity of Demand
3) Consumption parameters
   - Demand for households
   - Demand for many sectors (productive, health, education)
4) Spatial Data & Parameters:
   - Data: points and populations
   - Mean Inter-household Distance (MID)

Start Page


Add this scenario to the queue
Credits Processors Scenarios People KNUST Logout
Scenario name
Untitled
Private
Existing locations
Browse...
Download sample CSV in latitude and longitude
Download sample CSV in x and y
Download sample ZIP containing shapefile
Metric model
mvMax3
Finance
Demographics
Demand (peak)
Demand (household)
Demand (productive)
Demand (social infrastructure)
Distribution
System (off-grid)
System (mini-grid)
System (grid)
Network model
modKruskal
Network
Existing networks
Browse...
Download sample ZIP containing shapefile
Algorithm

Scenarios page

Create new scenario | Send feedback | Private

Processors | People | Help | KNUST | Logou

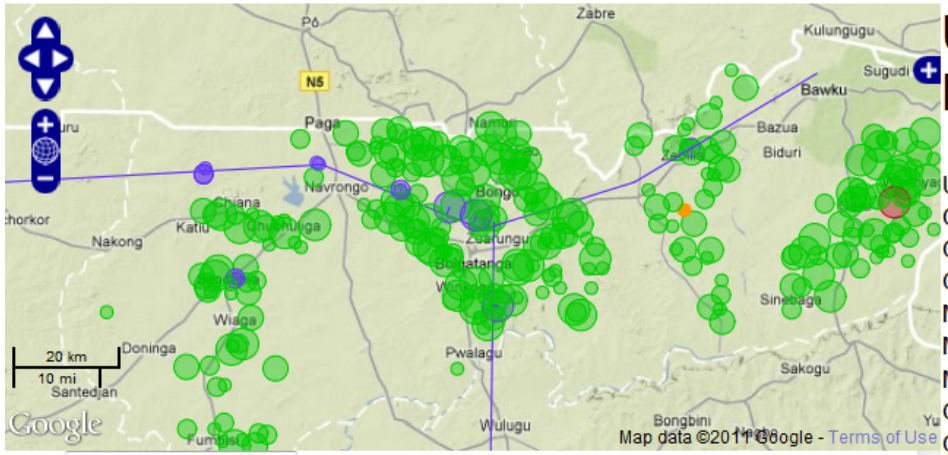
Filter

Owner	Name	Created	Status	Scope	
KNUST	Try clone	07/13/2011 10:05am	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation + Panel cost of 2000	06/07/2011 5:31pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND MID at 100m	06/07/2011 6:51am	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation + Penetration rate of 0.6 clone	06/07/2011 5:57am	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND MID at 40	06/03/2011 3:16pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND MID at 15	06/03/2011 3:15pm	Done	Private	View Download Clone Delete
KNUST	Edited Gr. Accra with a population growth rate of 0.5% + Diesel Generator 12hrs of operation AND MID at 40	06/03/2011 3:15pm	Done	Private	View Download Clone Delete
KNUST	Edited Gr. Accra with a population growth rate of 0.5% + Diesel Generator 12hrs of operation AND MID at 15	06/03/2011 3:14pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND HH demand at 50	06/03/2011 3:13pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND HH demand at 100	06/03/2011 3:12pm	Done	Private	View Download Clone Delete
KNUST	Edited Gr. Accra with a population growth rate of 0.5% + Diesel Generator 12hrs of operation AND HH demand at 50	06/03/2011 3:11pm	Done	Private	View Download Clone Delete
KNUST	Edited Gr. Accra with a population growth rate of 0.5% + Diesel Generator 12hrs of operation AND HH demand at 100	06/03/2011 3:11pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND diesel at $1.50/l	06/03/2011 3:09pm	Done	Private	View Download Clone Delete
KNUST	Edited Northern+ Diesel Generator 12hrs of operation AND diesel at $0.75/l	06/03/2011 3:09pm	Done	Private	View Download Clone

Results Page

Legend Unelectrified Off-grid Mini-grid Grid

Credits Processors Scenarios People KNUST Logout



Filter

Name	Pop	Off-grid	Mini-grid	Grid internal	System
Abilatega	720	$108,022	$127,526	$104,361	off-grid
Abulu	888	$125,667	$151,723	$127,632	off-grid
Adaboya	2,261	$408,935	$445,056	$336,963	off-grid
Adagbirda	804	$116,129	$137,456	$115,378	off-grid
Adasiga	423	$78,932	$88,910	$61,733	off-grid
Agaago Agigi	502	$86,085	$98,840	$72,676	off-grid
Agao	510	$87,039	$99,943	$73,892	off-grid
Akoapelligu	800	$116,129	$137,456	$115,370	off-grid
Akunduo	938	$131,389	$160,590	$134,999	off-grid
Akunkongo	999	$138,066	$171,034	$143,615	off-grid
Amogribisi Taampuro	875	$124,236	$150,212	$126,397	off-grid

UE w MOE Parameters+some Sen defaults HH Dem=50

	Scenario 1276	Comparison	Difference
Unelectrified	0		
Off-grid	284		
Off-grid cost	$34,829,033		
Off-grid cost levelized	$2.36 / kWh		
Mini-grid	1		
Mini-grid cost	$970,937		
Mini-grid cost levelized	$1.21 / kWh		
Grid	13		
Grid cost	$2,136,252		
Grid cost levelized	$1.30 / kWh		
Grid length existing	2,724,180 m		
Grid length proposed	6,208 m		
	Download		

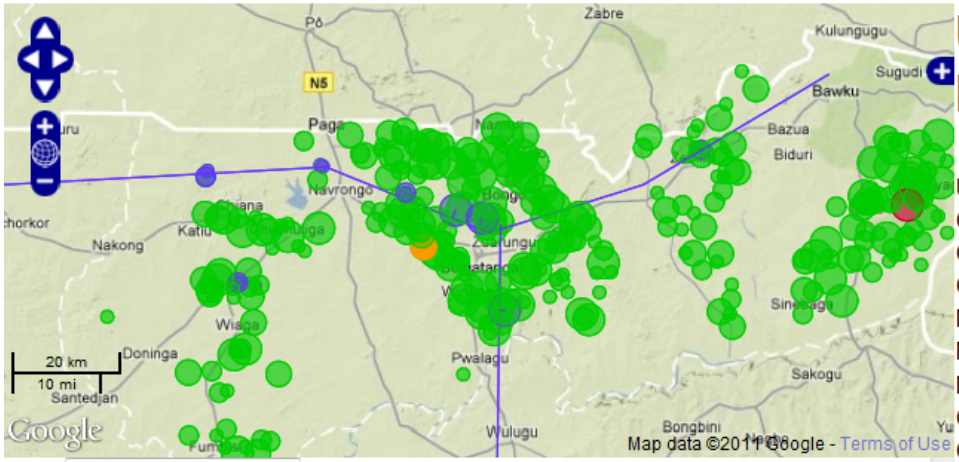
Scenario 1285 - UE w MOE Parameters+some Sen defaults HH Dem=65 clone
Scenario 1284 - UE w MOE Parameters+some Sen defaults HH Dem=75
Scenario 1283 - UE w MOE Parameters+some Sen defaults HH Dem=100 clone+PV cost=4000 clo
Scenario 1282 - UE w MOE Parameters+some Sen defaults HH Dem=100 clone+PV cost=3000
Scenario 1281 - UE w MOE Parameters+some Sen defaults Diesel=1.50 per liter clone
Scenario 1280 - UE w MOE Parameters+some Sen defaults Diesel=0.50 per liter
Scenario 1279 - UE w MOE Parameters+some Sen defaults HH Dem=300 clone clone
Scenario 1278 - UE w MOE Parameters+some Sen defaults HH Dem=200 clone
Scenario 1277 - UE w MOE Parameters+some Sen defaults HH Dem=100
Scenario 1275 - UE w MOE Parameters+some Sen defaults HH Dem=25

Done

Comparing Scenarios

Legend Unelectrified Off-grid Mini-grid Grid

Credits Processors Scenarios People KNUST Logout



Filter

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Amogribisi Taampuro	875	$124,236	$150,212	$126,397	off-grid

UE w MOE Parameters+some Sen defaults HH Dem=50

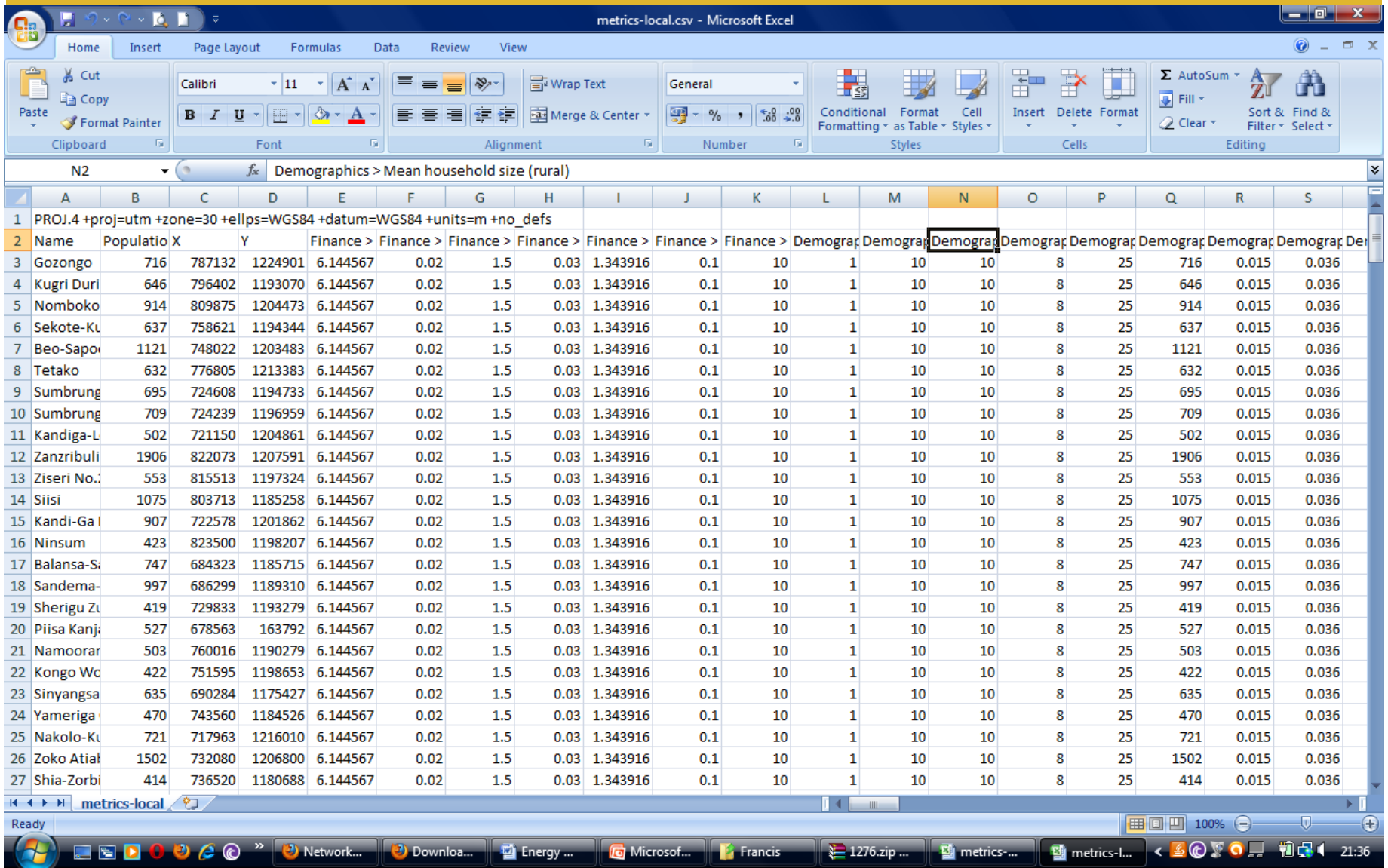
	Scenario 1276	Scenario 1275	Difference
Unelectrified	0	0	0
Off-grid	284	296	12
Off-grid cost	$34,829,033	$25,167,977	$-9,661,056
Off-grid cost levelized	$2.36 / kWh	$2.83 / kWh	$0.47 / kWh
Mini-grid	1	1	0
Mini-grid cost	$970,937	$778,184	$-192,753
Mini-grid cost levelized	$1.21 / kWh	$1.50 / kWh	$0.29 / kWh
Grid	13	1	-12
Grid cost	$2,136,252	$566,874	$-1,569,378
Grid cost levelized	$1.30 / kWh	$1.04 / kWh	$-0.27 / kWh
Grid length existing	2,724,180 m	2,724,180 m	0 m
Grid length proposed	6,208 m	2,122 m	-4,086 m
	Download	Download	

Scenario 1285 - UE w MOE Parameters+some Sen defaults HH Dem=65 clone
Scenario 1284 - UE w MOE Parameters+some Sen defaults HH Dem=75
Scenario 1283 - UE w MOE Parameters+some Sen defaults HH Dem=100 clone+PV cost=4000 clo
Scenario 1282 - UE w MOE Parameters+some Sen defaults HH Dem=100 clone+PV cost=3000
Scenario 1281 - UE w MOE Parameters+some Sen defaults Diesel=1.50 per liter clone
Scenario 1280 - UE w MOE Parameters+some Sen defaults Diesel=0.50 per liter
Scenario 1279 - UE w MOE Parameters+some Sen defaults HH Dem=300 clone clone
Scenario 1278 - UE w MOE Parameters+some Sen defaults HH Dem=200 clone
Scenario 1277 - UE w MOE Parameters+some Sen defaults HH Dem=100
Scenario 1275 - UE w MOE Parameters+some Sen defaults HH Dem=25

Done

One active download (26 seconds remaining)

Output in Excel



Challenges

- Data acquisition
  - Data on national, regional and community economic trends
  - Electricity demand for various sectors
  - Cost of various inputs that has to do with grid extension, mini-grid and off-grid systems
  - Etc.
- Data interpretation – data could come in crude forms and should be appropriately interpreted, otherwise results would not be accurate

Project Approach – GEAR Toolkit

- Visual Studio Interface
- Map Interface – ArcExplorer, MapWindow etc
- Input data (shapefiles)
  - Regional & District boundaries
  - Towns/Communities (with/without access to Electricity)
  - Important landmarks
  - LPG Stations
  - etc
- Input data from Network Planner
- Output

Development of GEAR Toolkit

- *Facilitate easy planning and capacity building.*

- The main aim was to develop a user interface which will serve as a tool to manage the energy access data, including results from modeling exercise.

GEAR Toolkit

- Capturing of the geometric and attribute data of electrified and unelectrified communities, etc.
- Updating and modification of information
- Faster and easier retrieval of information for planning, managing
- Performing spatial analysis on energy information.

GIS Energy Access Desktop - [National]

Regional Map View | Query Window | Analysis Window | GeoDatabase | National Statistics | Settings | Help

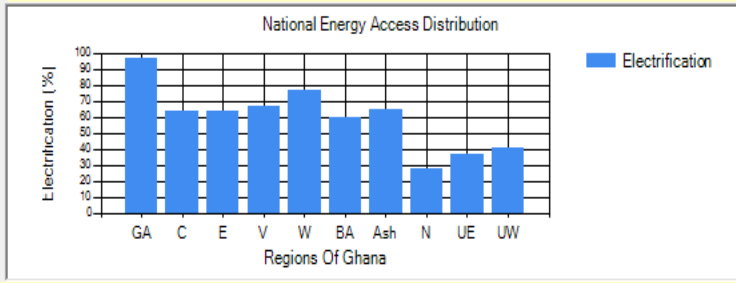
14:38:08
Saturday 25, 2011

File Edit Tools Help

Gird Calculator | Technology Distribution

Greater Accra Region	=	96.88 %	Brong Ahafo Region	=	60.47 %
Central Region	=	64.04 %	Ashanti Region	=	65.41 %
Eastern Region	=	73.37 %	Northern Region	=	28.54 %
Volta Region	=	67.25 %	Upper East Region	=	36.88 %
Western Region	=	77.62 %	Upper West Region	=	41.18 %

Region Name : Greater Accra Region | Name of District : Dangbe West | No. Of Districts :



Regions of Ghana

- Ashanti Region
- Brong Ahafo Region
- Greater Accra Region
- Northern Region
- Eastern Region
- Central Region
- Western Region
- Upper East Region

Get Database | Refresh Data

Districts Under Region

- Dangbe West
- Dangbe East
- Tema
- Ga East
- Adenta
- Ashaiman municipal
- Accra Metropolitan Assembly
- Ledzokuku
- Ga South
- Ga West

10

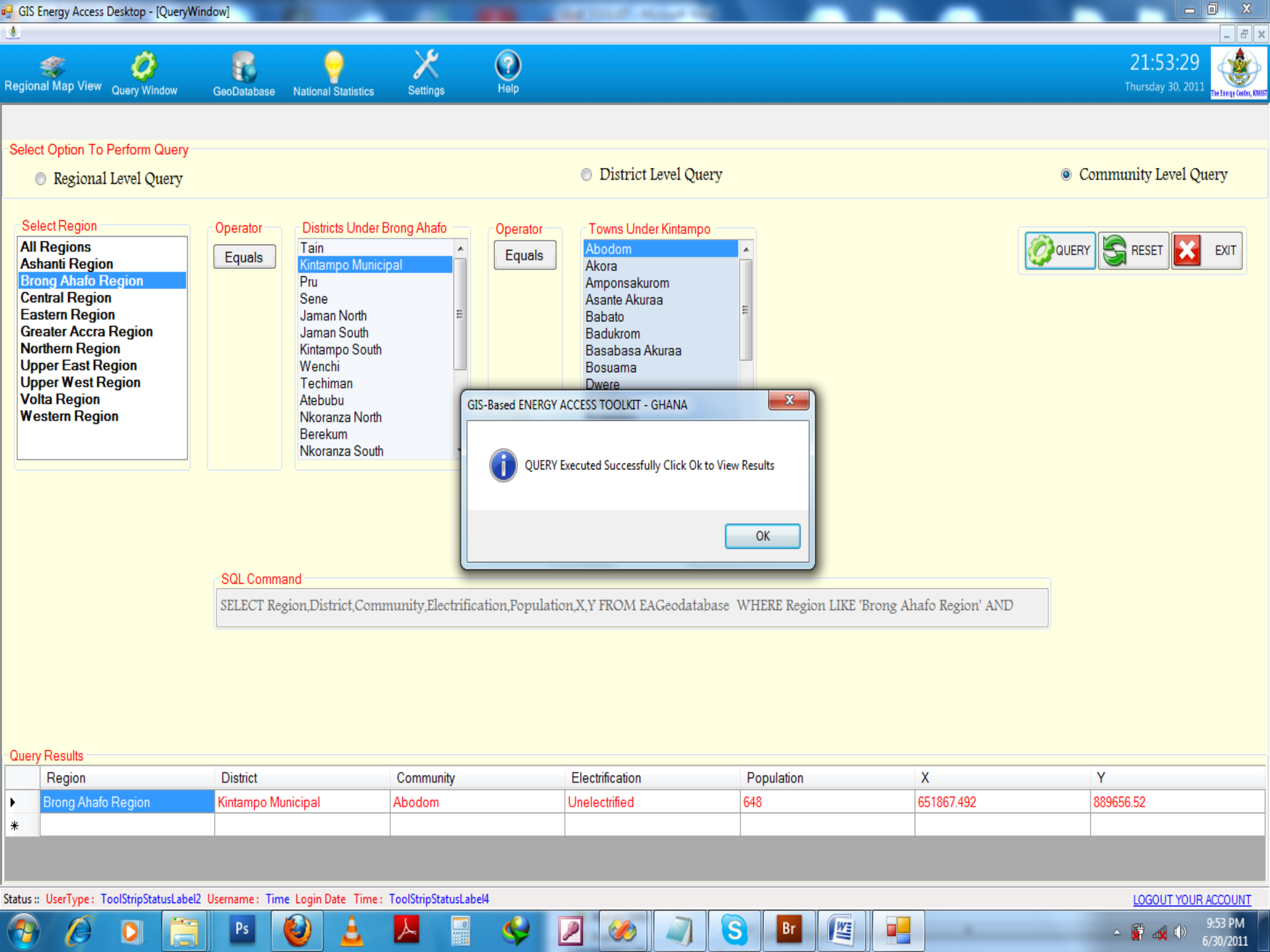
Search By Community Name : | Search By Electrification : | Freeze Column 0

Region	District	Community	Electrification	Population	X	Y	Projected household count at end of planning period	Projected population count at end of planning period	Projected community demand per year (kWh)	Projected household demand per year (kWh)	Projected product demand (kWh)
Greater Accra	Dangbe West	Kakasunanka	Electrified	0	844698	632785	0	0	0	0	0
Greater Accra	Dangbe West	Kotobabi	Electrified	0	848679	635612	0	0	0	0	0
Greater Accra	Dangbe West	Kwashieman	Electrified	0	838820	637793	0	0	0	0	0
Greater Accra	Dangbe West	Lolonya	Electrified	0	862536	639765	0	0	0	0	0
Greater Accra	Dangbe West	Malam	Electrified	0	831122	640702	0	0	0	0	0
Greater Accra	Dangbe West	Michel Camp	Electrified	0	833318	641987	0	0	0	0	0
Greater Accra	Dangbe West	Midie	Electrified	0	856911	642613	0	0	0	0	0
Greater Accra	Dangbe West	New Ningo	Electrified	0	856817	645920	0	0	0	0	0
Greater Accra	Dangbe West	Nima	Electrified	0	820708	648050	0	0	0	0	0
Greater Accra	Dangbe West	Nkuntunse	Electrified	0	820831	648236	0	0	0	0	0
Greater Accra	Dangbe West	Nsakyina	Electrified	0	855056	648257	0	0	0	0	0
Greater Accra	Dangbe West	Nungua	Electrified	0	820568	648537	0	0	0	0	0
Greater Accra	Dangbe West	Nyigbenya	Electrified	0	828205	648773	0	0	0	0	0
Greater Accra	Dangbe West	Oduman	Electrified	0	821317	650579	0	0	0	0	0
Greater Accra	Dangbe West	Okponglo	Electrified	0	836432	651090	0	0	0	0	0
Greater Accra	Dangbe West	Pokuase	Electrified	0	825474	655021	0	0	0	0	0
Greater Accra	Dangbe West	Pute	Electrified	0	834565	656049	0	0	0	0	0
Greater Accra	Dangbe West	Salom	Electrified	0	831357	660295	0	0	0	0	0

Status :: UserType : ToolStripStatusLabel2 Username : Time Login Date Time : ToolStripStatusLabel4

LOGOUT YOUR ACCOUNT

2:38 PM
6/25/2011


GIS Energy Access Desktop - [QueryWindow]
Regional Map View
Query Window
GeoDatabase
National Statistics
Settings
Help
21:53:29
Thursday 30, 2011
Select Option To Perform Query
Regional Level Query
District Level Query
Community Level Query
Select Region
All Regions
Ashanti Region
Brong Ahafo Region
Central Region
Eastern Region
Greater Accra Region
Northern Region
Upper East Region
Upper West Region
Volta Region
Western Region
Operator
Equals
Districts Under Brong Ahafo
Tain
Kintampo Municipal
Pru
Sene
Jaman North
Jaman South
Kintampo South
Wenchi
Techiman
Atebubu
Nkoranza North
Berekum
Nkoranza South
Operator
Equals
Towns Under Kintampo
Abodom
Akora
Amponsakurom
Asante Akuraa
Babato
Badukrom
Basabasa Akuraa
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QUERY
RESET
EXIT
GIS-Based ENERGY ACCESS TOOLKIT - GHANA
QUERY Executed Successfully Click Ok to View Results
OK
SQL Command
SELECT Region,District,Community,Electrification,Population,X,Y FROM EAGeodatabase WHERE Region LIKE 'Brong Ahafo Region' AND
Query Results
Region
District
Community
Electrification
Population
X
Y
Brong Ahafo Region
Kintampo Municipal
Abodom
Unelectrified
648
651867.492
889656.52
Status :: UserType: ToolStripStatusLabel2 Username: Time Login Date Time: ToolStripStatusLabel4
LOGOUT YOUR ACCOUNT
9:53 PM
6/30/2011

GIS Energy Access Desktop - [Analysis Form]

Regional Map View | Query Window | Analysis Window | GeoDatabase | National Statistics | Settings | Help

21:23:09
Friday 24, 2011

File

Save District | Refresh | Update District | Deposit report | Print Analysis | ToolStripButton3 | Graph | Connection | View Log | Get Help

Current Analysis Is Based on : **Connumnity Name**

No of Communities In = 21

No. Of Communities **Electrified** = 17

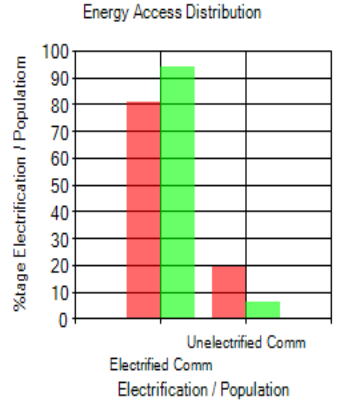
Percentage (%) Of = 80.95 %

Region / District **District Name**

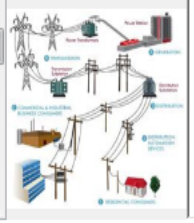
Total Population = 30676

Population Label20 = 28784

Percentage Population a = 93.8 %



OBJECTID	Region	District	Community Name	Electrification	Population
1	Ashanti	Adansi North	Atatam	Unelectrified	509
2	Ashanti	Adansi North	Bena	Unelectrified	453
3	Ashanti	Adansi North	Bukuruwaso	Unelectrified	395
4	Ashanti	Adansi North	Dinkyiea	Unelectrified	535
5	Ashanti	Adansi North	Fumso	Electrified	4409.030978



Further Analysis | Refresh | of 67 | Proposed Technology Analysis | Poposed Technology Cost | Population Analysis | Freeze Column 0

OBJECTID	Region	District	Community Name	Electrification	Population	X	Y	Projected household count at end of planning period	Projected population count at end of planning period	Projected community demand per year (kWh)	Projected household demand per year (kWh)	Projected productive demand (kWh)	Projected commercial facility demand per year (kWh)
5	Ashanti	Adansi North	Fumso	Electrified	4409.030978	670407	675690	0	0	0	0	0	0
6	Ashanti	Adansi North	Tonkoase No.I	Electrified	576.096561	684499	677166	0	0	0	0	0	0
7	Ashanti	Adansi North	Ayokwa	Electrified	590.814356	668242	681766	0	0	0	0	0	0
8	Ashanti	Adansi North	Fumso-Ketewa	Electrified	630.762658	677561	683591	0	0	0	0	0	0
9	Ashanti	Adansi North	Nkonsa	Electrified	497.251229	685527	685077	0	0	0	0	0	0
10	Ashanti	Adansi North	Hweremoase	Electrified	1188.98761	667568	689353	0	0	0	0	0	0
11	Ashanti	Adansi North	Asokwa	Electrified	2982.4561	664853	690092	0	0	0	0	0	0
12	Ashanti	Adansi North	Bodwesango	Electrified	2363.257425	673593	694126	0	0	0	0	0	0
13	Ashanti	Adansi North	Patakro	Electrified	2200.310405	649563	694025	0	0	0	0	0	0
14	Ashanti	Adansi North	Kusa	Electrified	1237.34608	665159	694210	0	0	0	0	0	0
15	Ashanti	Adansi North	Kwapia	Electrified	1991.107457	649148	694957	0	0	0	0	0	0
16	Ashanti	Adansi North	Old Akrofuom	Electrified	418.405896	655866	695779	0	0	0	0	0	0
17	Ashanti	Adansi North	Meduma	Electrified	3740.422561	661531	700915	0	0	0	0	0	0

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Key Deliverables

- Review of energy situation in a country
- GIS maps of energy infrastructure and services
- Toolkit for analysis and data display
- Assessment of Gaps
- Filling the gaps & its' Cost implications
- Training on the use of project output (Sensitisation)
- *Project Outcome*
- *Project Impacts*

Project Communication Strategies

- Meetings
- Online mailing services
- Teleconference
- Text messages (mobile phones)

Challenges

- Data Acquisition
  - Bureaucratic system
  - Need for high motivation to acquire data
  - Formats of data
  - Organisation of data
    - Working with large sets of data
- Accounting systems

Conclusion

- It is doable
- Requires special expertise
- Funding is key
- Useful tool for energy planning and monitoring

Burning Questions

- What can we do from you here in our countries?
- How can ECREE and/or TEC support?
- What resources are available in respective countries for project implementation


Thank You!