Project: *VicInAqua*
Grant agreement: **689427**
Start: 01.06.2016
Duration: 36 months

VicInAqua

Integrated aquaculture based on sustainable water recirculating system for the Victoria Lake Basin

Deliverable D2.1
Specifications & Maintenance Book

Revision: **1.0**
Due date: **30.11.2016**
Submission date: **29.11.2016**
Lead contractor: **BPE**

Dissemination level		*VicInAqua*
PU	Public	X
PP	Restricted to other program participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Deliverable Administration & Summary					*VicInAqua*
Status	**Working**/Final	**Due**	M 6	**Date**	30.11.2016
Author(s)	Dr. Wolfgang Hornig, BPE Ephraim Gukelberger, HSKA Prof. Robert Kinua, JKUAT Julian A. Mamo, ABT Meesuk Lim. OXY				
Editor	Dr. Wolfgang Hornig, BPE				
DoA	**Specifications & Maintenance Book**				
Comments					

Document change history			*VicInAqua*
V	**Date**	**Author**	**Description**
1.	12/07/2016	Dr. Wolfgang Hornig, BPE	First version
	04/08/2016	Dr. Wolfgang Hornig, BPE	Second version
	16/08/2016	Dr. Wolfgang Hornig, BPE	Third version
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Contents

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No **689427**".

1. Abstract

The weather conditions at Kisumu are characterized towards a solar photovoltaic energy system (PV). (Figure 3, 4, 5, 6, 7, Table 1)

It is evident to cool down PV- elements while operating under these conditions. Additional energy harvesting is proposed during cooling using Sogena® (PV+TEG)[1].

To operate/ develop prototype Sogena up to 5 m² surface on running water is needed. Partner in Kenia could propose places to their own needs. 3 m² could be made available (status as of 29.6.16 HSKA)

Tropical convergence zone, rain days, night hours per day forces the use of a battery system for autonomous energy supply.

New development of using biogas reactor heat to transfer into electrical power with TEG-system to be developed by HSKA could overcome autonomous operation to a certain extent using higher volume of biogas-reserve for day and night operation.

Public power net should be used to receive/sell energy. Total energy costs should be zero.

Energy consumption need is set to 14 kW by use of data delivered from partners within this task D2.1.

Intensive use of geophysical and meteorological data at Kisumu area including specification & maintenance aspects lead to a first cost assumption of 2880 € for a conventional photovoltaic energy system including batteries for autonomous energy status.

Partners responsible to put hardware in place at Kisumu are aware of the weather conditions by information on a regular basis.

It is proposed to put in place a conventional photovoltaic energy spending system for intensive measurement of temperature as well as energy data.

These data will be used to come to prototype stage and develop and build TEG system for biogas burning and PV+TEG unit.

Sogena electric energy will undergo testing without spending electric power to the main power circuit.

- Outcome with a larger number of energy consumption
- Calculation of energy not finished but preliminary

  Some data cannot be delivered until the end of November. They will become available during the course of the project.

Maintenance

Specification of equipment shall withstand the environmental conditions at Kisumu.

As discussed during Skype meeting, 4.10.16, QA-documentation of each supply shall include guarantee data for environmental test data as well as other maintenance data.

Newly developed items have to undergo environmental testing.

[1] Solar photovoltaic connected with thermoreactor TEG

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2. Deviation from the work plan

This deliverable is submitted as draft version. Indeed the location of the pilot will greatly influence the need in power consumption. Many aspects need to be clarified during the partner meeting in Kenya at the end of month 8 (end of January 2017). An updated version of this deliverable will be submitted when the pilot plan will be completely defined by the project partners.

3. Results

All figures and tables mentioned in the report are presented in annexe to this report.

3.1. T2.1 Specifications definition

3.1.1. T2.1a Requirements

Renewable energies in an African environment to allow autonomous operation of the system on pilot scale.

The renewable energy sources foreseen in the project are:

- Use of TEG (thermoelectric module) together with a biogas burner as a DC source, to be developed
- Photovoltaic plant (PV)
- Sogena®, PV + TEG, to be developed

Autonomous operation of the system within 24h, including all weather conditions in an equatorial area close to Lake Victoria at Kisumu city.

Duration of the test phase should be determined under these specified conditions.

1. Considerations for PV (photovoltaic) should include for the PV+TEG research module

- Weather data in one local year, global radiation(W/m²) / Temperature (°C) / humidity (Figure 3, Table 1) as well as other atmospheric phenomenon (Figure 5)
- Water temperature Lake Victoria / sanitation & aquaculture
- Conditioning of PV, temperature T (°C) measured at a PV-element in use for pilot energy system and to measure electric power (W) at the same time.

To analyze the expected “Voltage drop” or electric power loss at elevated high temperatures. (Figure 1)

ABT

- Request for 8kW peak and 4 kW constant load with an unknown power consumption for the Solar-thermal system to heat up fish water container (15.11.16)
- Need for warm water (please see temperature values)

  The following information have been given by JKUAT/IEET, Prof. Kinyua:

OXY

- 120W DC, sensor, estimated value because of tbd partners sensors (Table3, page 10, filtration unit/TEG module)

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HSKA

- 5 kW AC, 30.9.16/E.Gukelberger (Figure 8: System flowchart (HSKA))

JKUAT

The power grid in the whole of Kenya is 240V at 50Hz. The current varies with the load applied - many appliances work with 3A - 5A.

- The daily average insolation in Kenya varies from 4 - 6 kWh/m². The cost of public utility power is about ksh 20/kWh which is equivalent to about 0.20$ per kWh (including taxes and levies). The cost also varies depending on the component of thermal power in generation. In the rainy season when hydro power production drops, the thermal power component is increased and the overall cost of power also increases.

  The biogas reactor-TEG system is estimated at 0,3 kW while the PV-TEG research unit (Sogena) is estimated at 1 kW.

The following input has been given by Prof. Kinyua (D6.1: LITERATURE REVIEW, 2.1.2 Solar Energy)

- Kenya straddles the equator and therefore has over 10 hours of sunshine per day. This means that solar radiation is in abundance throughout the year. On average, Kenya receives solar insolation of between 4 – 6 kWh/m^2 per day. This translates to the average number of hours when solar irradiance averages 1kW/m^2 per day (MEP, 2014). However some areas of Kenya receive extraordinarily higher values of irradiance. Nakuru town situated on the rift valley has recorded daily average insolation of between 4.8kWh/m^2 and 7.8kWh/m^2 within a period of one year (Omwando et al, 2014). Solar energy technologies available include the solar photovoltaic (PV) technology and Solar thermal technologies. In the VicInAqua energy concept, solar PV technology will be used in combination with Thermoelectric generators (TEG).
- The Solar PV business and practice in Kenya is regulated under the Energy Act (Solar PV regulations). Under these regulations, practitioners are required to be licensed by the Energy Regulatory Commission before commencing any business or practice involving Solar Photovoltaic Technology.
- The efficiency of photovoltaic modules is measured under standard conditions of irradiance (1kW/m^2), temperature (25^{0}C) and air mass (1.5).However the nominal operating temperature in many areas of Kenya is higher than 25^{0}C and is a major cause of reduced efficiency and electrical power output. We have estimated that voltage drop with temperature is about 0.05V/^{0}C in Kisumu.

3.1.2. T2.1b Dimensioning

The design of an autonomous standalone electric energy source for the project is characterized by usage of a battery modus.

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The goal of this R&D project is to minimize battery use because of cost reasons and maintenance.

Plan to minimize use of batteries in electric power and size:

- Biogas reserve for 24 hours continuous processing electric power with TEG independent from weather situation
- Design of a biogas burning equipment with maximum use of TEG
- Maximize biogas production
- PV plant, latest generation with an option to retrofit PV modules for higher output in DC-power
- Sogena unit, designed for Kisumu weather, swimming version and 24 h DC power,
- Specific measurement & test program to define operating temperature range for PV/ Sogena
- Analyze weather data over one year at Kisumu (global radiation, temperature, rain)
- TEG use of other sources from “hot spots”

HSKA

Ongoing laboratory tests and research with a prototype biogas+TEG; results in electric power output will be used to a more precise data. Plan is to generate 0,3 kW continual. Advantages of the biogas+TEG module:

- Continual electric power output
- Biogas reserve could assist standalone energy solution
- No limitation so far for the module design as well as power output
- Maintenance not complicated

BPE

The following meteorological data are influencing the electric power generation of a photovoltaic cell/module:

- Global radiation, W/m² , Intensity, hours/day
- Condition of atmosphere, humidity
- Temperature, air, PV-module

Beside a conventional PV power generation as a standalone solution together with batteries and the biogas+TEG source of energy further research will be done for the Sogena module expecting 1kW outcome. Sogena is a combination of one photovoltaic module and 2 TEG modules, one for cooling the backside of PV and second for using direct infrared radiation heat as part of the global radiation. If possible Sogena unit is thought to use surface water of tanks for additional cooling.

Advantages of the Sogena®-module:

- Day & night power
- All season/weather power
- Use of global radiation, visible light & infrared > 80%
- High temperature possible

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- Swimming power module possible

Use of PV module with Si efficiency[2] is reduced to a factor of 0.70 – 0.80 at Kisumu (estimate forecast)

Astronomical data for Kisumu:

- http://www.timeanddate.de/sonne/kenia/kisumu
- http://www.sunearthtools.com/dp/tools/pos_sun.php?lang=de

Conventional PV-energy system dimensioning needs all relevant data and a list of data must be generated, e.g. using the professional data requested by Suncompany PV GmbH, Germany an interested party for Kisumu.

3.1.3. T2.1c - Energy requirement definition

1. Requested energy needed for the total system (HSKA, JKUAT, ABT, OXY, task leaders of WP3, WP5) 14 kW

- Requested data of needed electrical power should include electric power kW / kWh / kWpeak of each subsystem. These data are still to be defined.

To start planning with PV- power plant order:

- 2 weeks planning
- 6 weeks ready for shipment
- 1 week assembly at Kisumu
- Expected 4 PV modules /1kWp, 1module dimension 1 x 1,5 m
- 14 kWp area 112m² requested with brick housing for batteries

ABT data

Data input according contract/WP2, T2.1c from ABT: 8 kW peak and 4kW continuous electric energy. The following data are to be defined.

- kWh per day
- kWp peak values per hour
- average demand for kWh
- energy need for water pumps

OXY data

- 120 W DC for extended sensor system

HSKA data reported 30.9.16 power consumption of 5 kW, Table 2

JKUAT data

Data input according contract/WP2, T2.1c from JKUAT: to be defined.

Energy consumption

PV-system + Battery capacity is needed for autonomous energy and the following data of pumps and other equipment is requested:

[2] DE 102016101387.0

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How many hours/days without/with reduced photovoltaic electric power (Figure 6), e.g. 121 days of rain, average value reported by local weather department, reduced global radiation by hours means reduced PV energy. Probably partner JKUAT or others could report average values.

- Energy consumption per day
- Peak values energy consumption
- Switch on/off initial current size

Maintenance data of individual equipment

Environmental data of Kisumu shall specify total equipment; compare with specification of each piece of equipment, e.g. pumps, sensors, electric. Use weather date of this report, request data if needed.

4. Conclusion

The data presented in this report are with preliminary character and should continuously be updated. Especially the weather data are representing long term statistics and do not represent extreme weather data at Kisumu. The data input of partners involved results in 14 kW electric energy. Area needs to be 112 m² for the photovoltaic system with a small (brick) building for the batteries and a roof for string converters.

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5. Annexes Figures 1-8 and Table 1 to 3

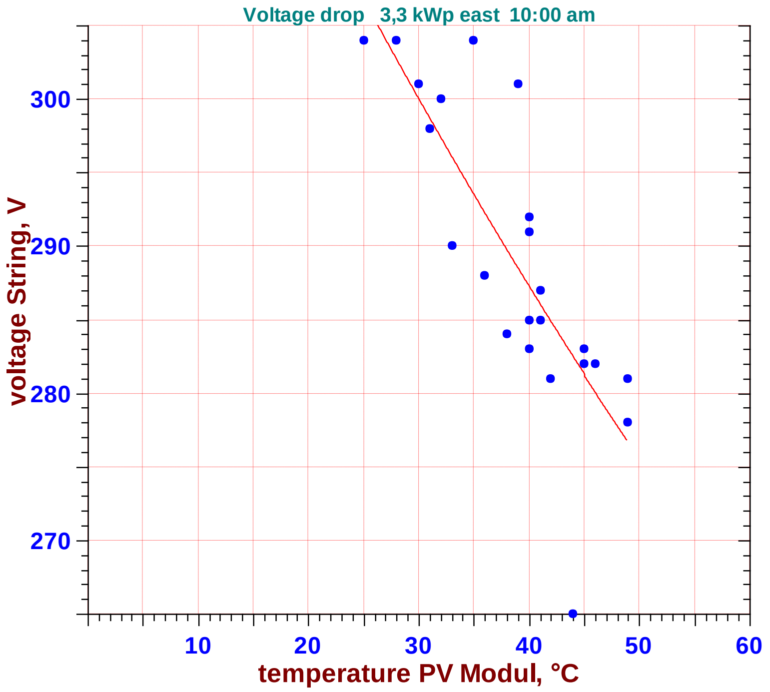

Figure 1: "Voltage drop", V of a running PV-system at different module temperatures, northern Bavaria, Germany, BPE

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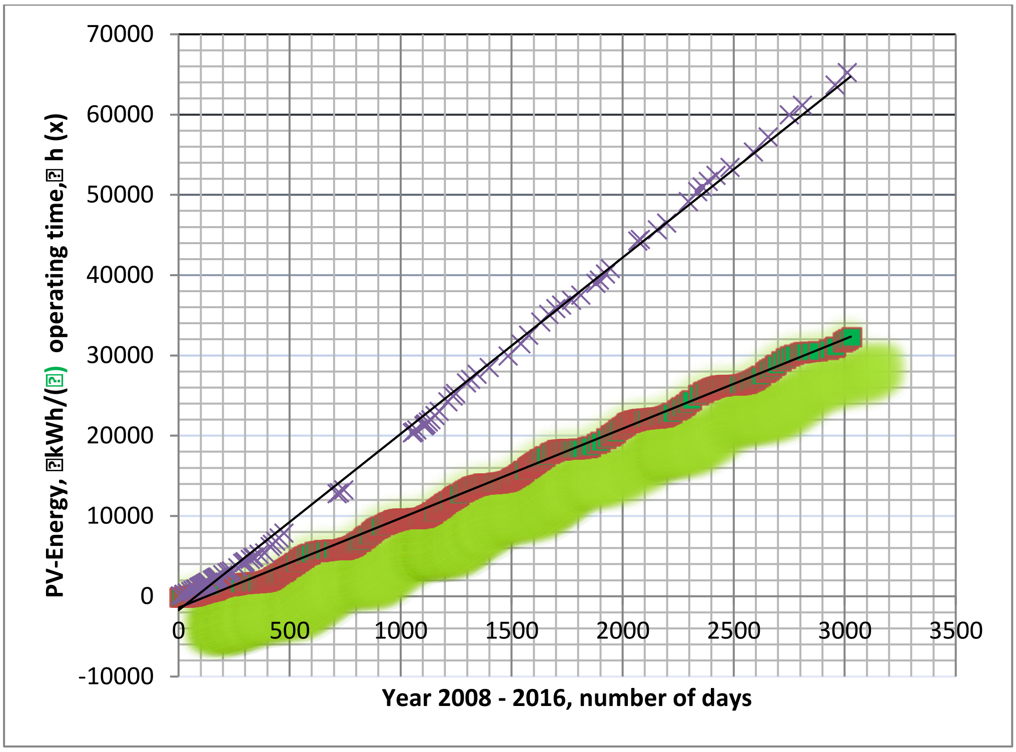

Figure 2: PV–Energy of a 5.5kWp system within 8 years, northern Bavaria, Germany, BPE

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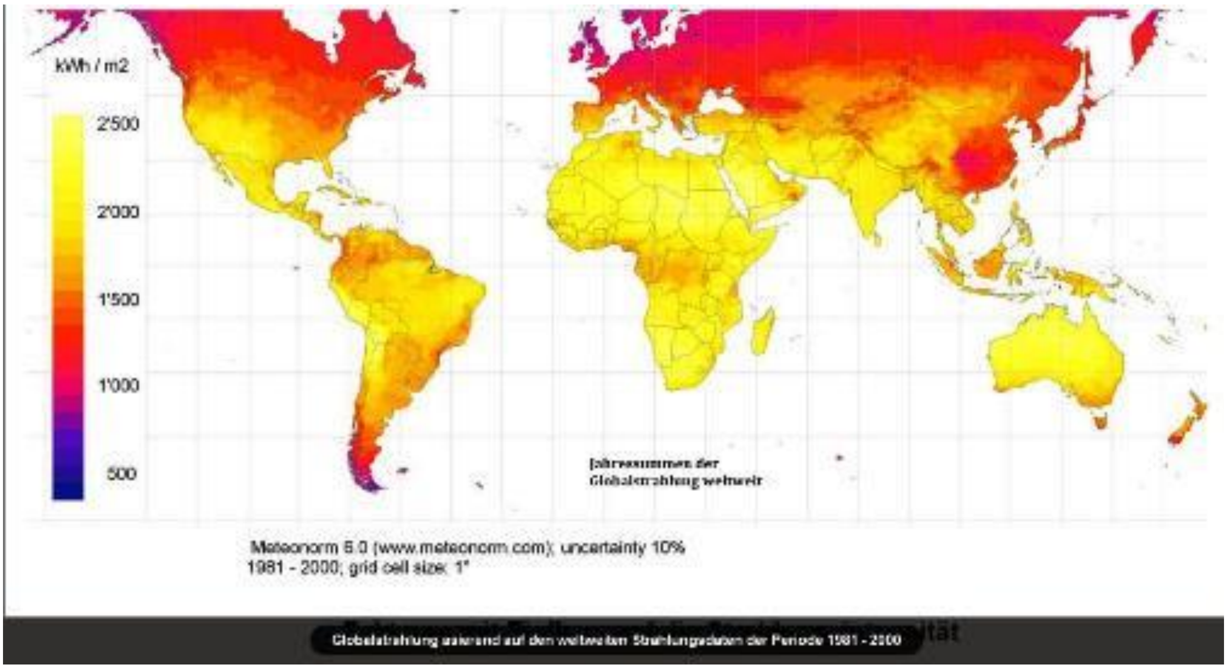

Figure 3 : Global radiation worldwide

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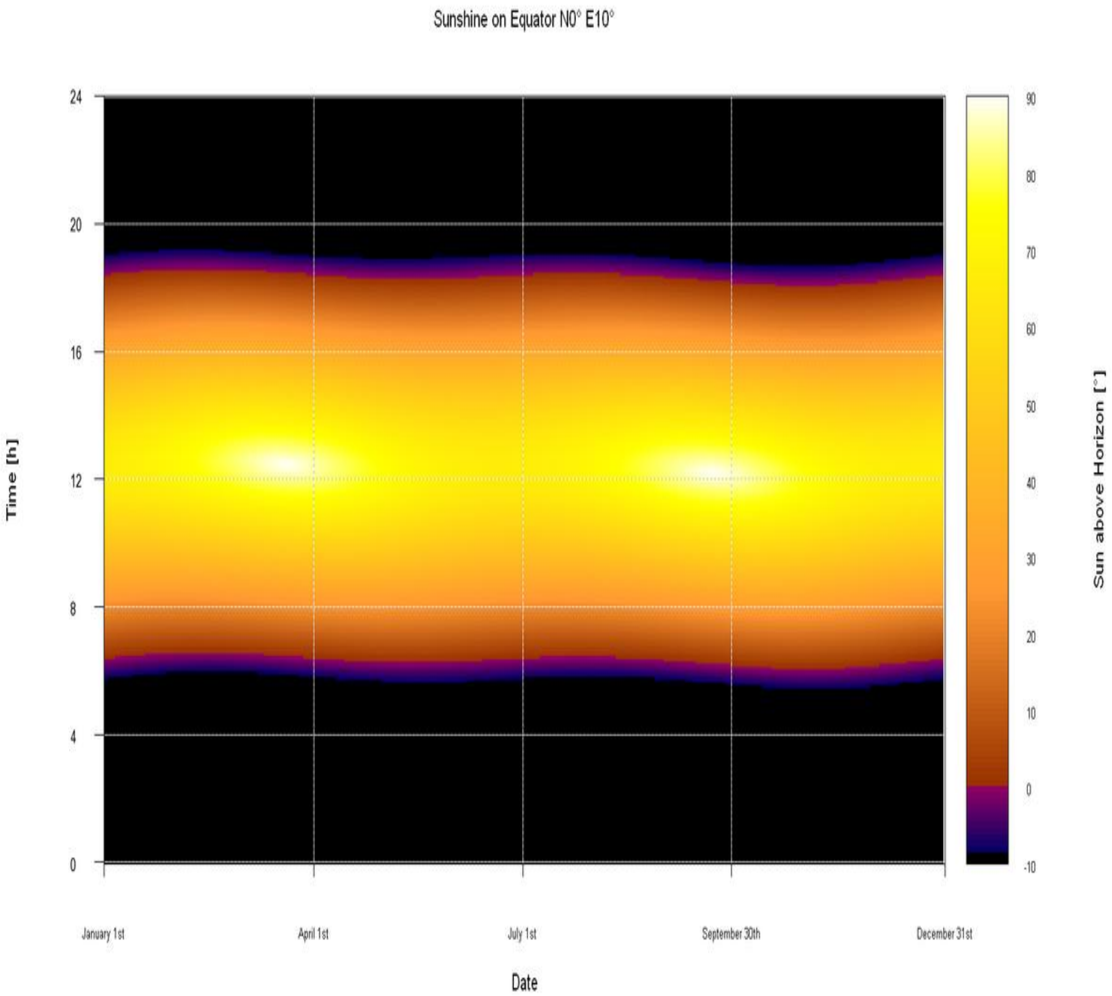

Figure 4: Duration of theoretical sunshine and dusk for No E10

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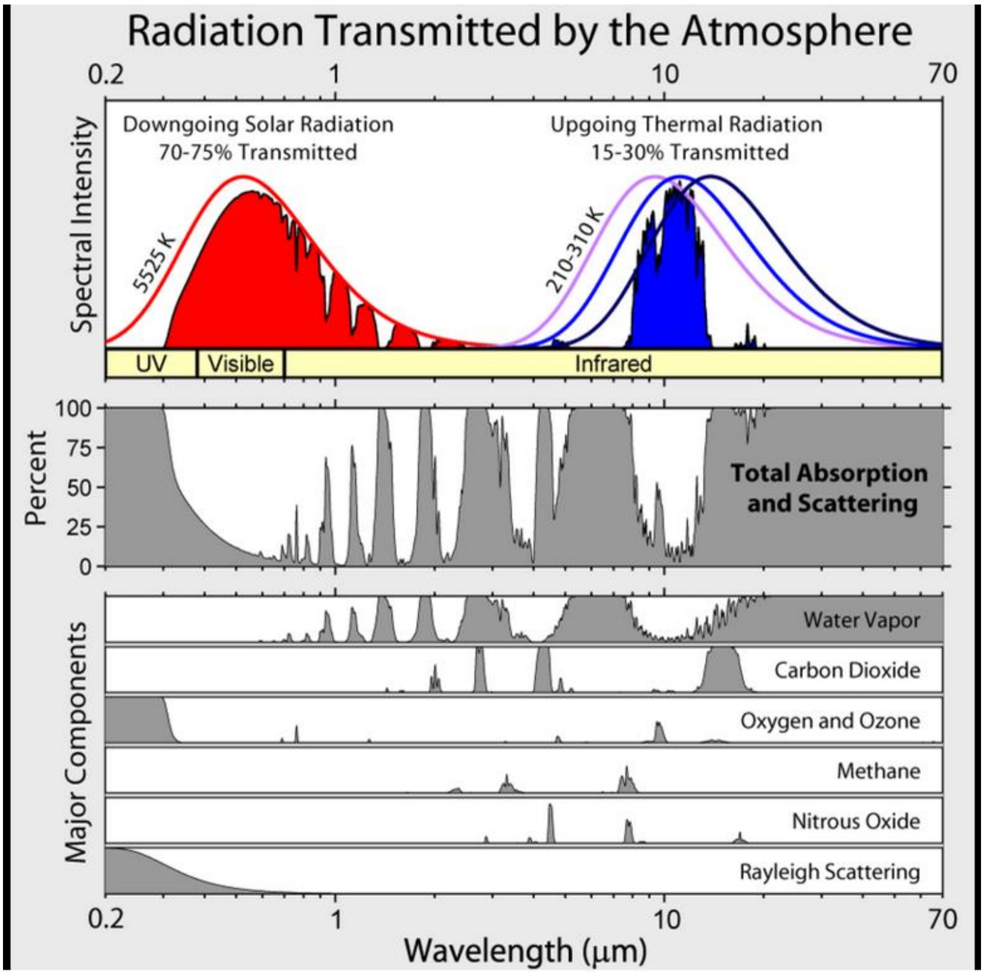

Figure 5: Absorption of gaseous air parts

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Geographie und Klima [Bearbeiten | Quelltext bearbeiten]

Kisumu liegt am *Winamgolf*, einem Teil des Victoriasees, auf einer Höhe von 1131 m über dem Meeresspiegel. Die Tageshöchstwerte liegen im Jahresmittel zwischen 25 °C und 28 °C, die minimalen Werte bei 15 °C bis 16 °C. Das ganze Jahr über fallen starke Niederschläge, im April sind sie mit ca. 360 mm am ergiebigsten.

Monatliche Durchschnittstemperaturen und -niederschläge für Kisumu

	Jan	Feb	Mär	Apr	Mai	Jun	Jul	Aug	Sep	Okt	Nov	Dez		
Max. Temperatur (°C)	30,6	30,8	30,4	28,8	28,2	27,9	27,7	28,2	29,4	30,5	30,1	29,9	Ø	**29,4**
Min. Temperatur (°C)	23,8	24,1	24,1	23,4	22,8	22,2	21,9	22,2	22,8	23,8	23,7	23,5	Ø	**23,2**
Niederschlag (mm)	79	84	169	213	167	85	85	81	90	95	139	101	Σ	**1.388**
Sonnenstunden (h/d)	8,6	8,7	8,5	7,7	7,8	7,5	6,9	6,9	7,6	7,7	7,3	8,2	Ø	**7,8**
Regentage (d)	7	10	11	17	13	8	7	8	8	10	13	9	Σ	**121**
Luftfeuchtigkeit (%)	64	65	67	75	76	74	71	69	67	65	68	66	Ø	**68,9**

Quelle: Kenya Meteorological Department, Daten: 1938–1990[1]; wetterkontor.de

Basisdaten	
County	Kisumu County
Einwohner	322.734 Einw.
Höhe	1131 m
Koordinaten	0° 5′ S, 34° 46′ O

Geschichte

Figure 6: Climate near Kisumu

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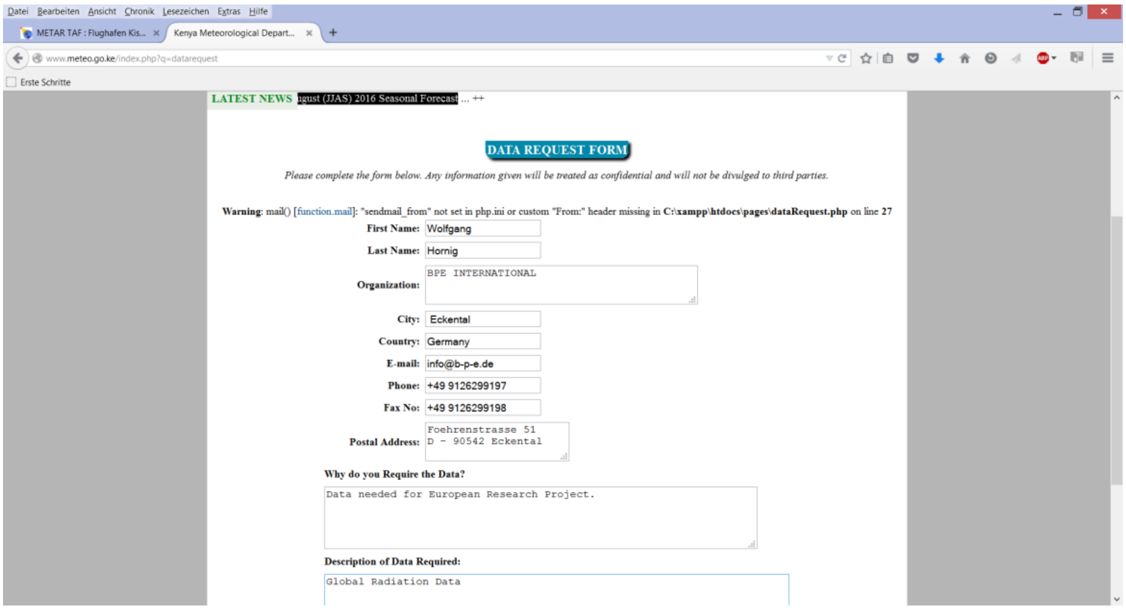
Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe
METAR TAF : Flughafen Kis... Kenya Meteorological Depart...
www.meteo.go.ke/index.php?q=datarequest
Erste Schritte
LATEST NEWS ugust (JJAS) 2016 Seasonal Forecast ... ++

DATA REQUEST FORM

Please complete the form below. Any information given will be treated as confidential and will not be divulged to third parties.

Warning: mail() [function.mail]: "sendmail_from" not set in php.ini or custom "From:" header missing in **C:\xampp\htdocs\pages\dataRequest.php** on line **27**

First Name: Wolfgang
Last Name: Hornig
Organization: BPE INTERNATIONAL
City: Eckental
Country: Germany
E-mail: info@b-p-e.de
Phone: +49 9126299197
Fax No: +49 9126299198
Postal Address: Foehrenstrasse 51 D - 90542 Eckental

Why do you Require the Data?
Data needed for European Research Project.

Description of Data Required:
Global Radiation Data

Figure 7: Data request by BPE to weather service in Kisumu

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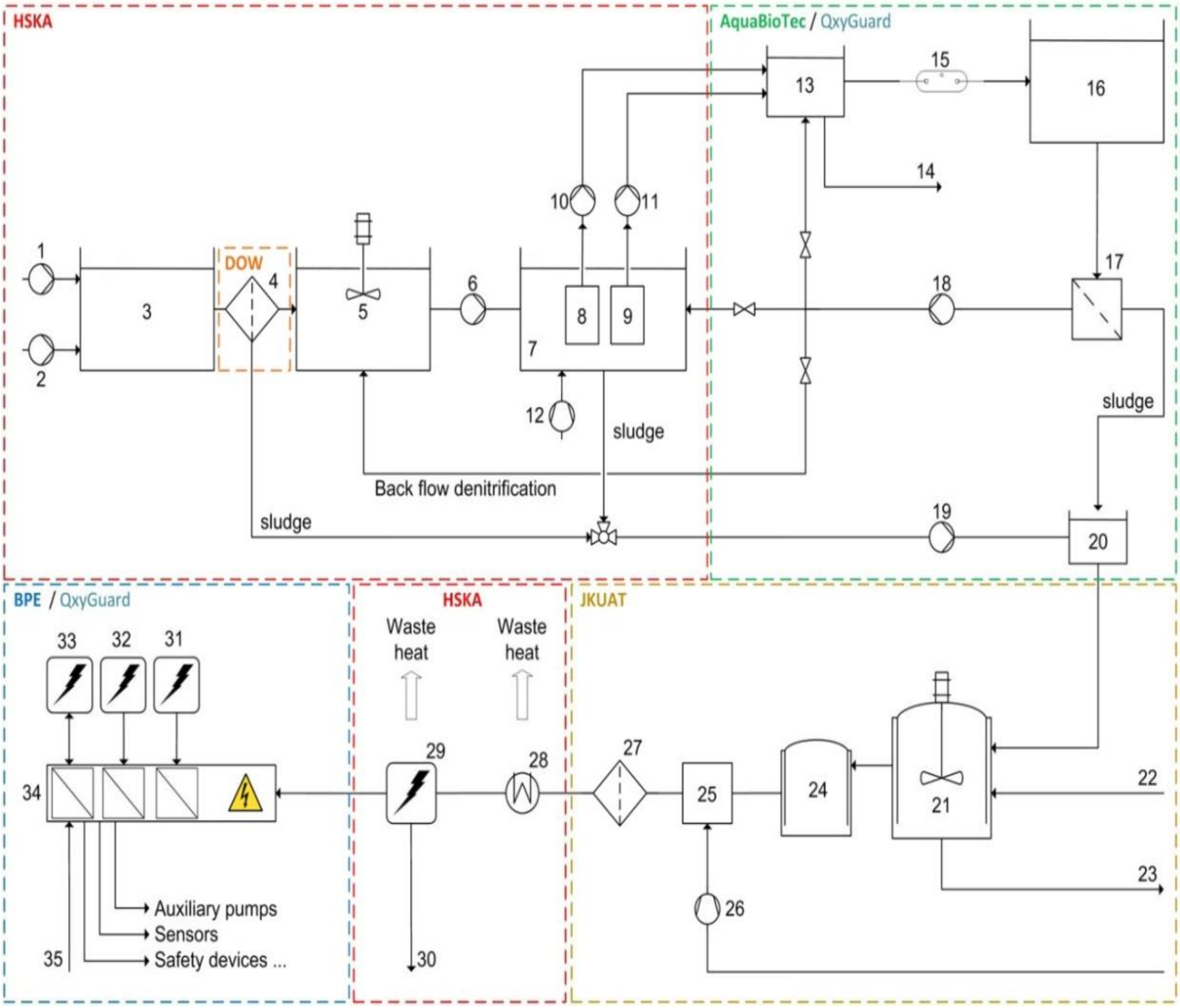

Figure 8: System flow chart

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Sources:	https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=skip@larc.nasa.gov													
	https://eosweb.larc.nasa.gov/sse/													
	https://eosweb.larc.nasa.gov/sse/temp/DLY740.txt													
Comparison		**Monthly Averaged (22 Years) Direct Normal Radiation (kWh/m2/day)**												
	Description	Amount of electromagnetic energy (solar radiation) incident on the surface of the earth. Also referred to as total or global solar radiation.												
		kWh/m²/day	**Jan.**	**Feb.**	**March**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Eckental	N 49.59 E 11.24		1.51	2.44	2.77	3.54	4.19	4.04	4.19	4.08	3.05	2.20	1.33	1.19
Kisumu	N - 0.09 E 34.76	kWh/m²/day	7.10	7.25	6.63	6.16	6.51	6.61	6.32	6.60	6.57	6.04	6.09	1.19

Table 1: Comparison Monthly Averaged (22 Years) Direct Normal radiation (kWh/m²/day)

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Nr.	**Assembly group**	**Component name**	**Actuator**	**Energy supply**	**Current**	2		Domestic waste water pump	on-off switch	400VAC		?
1	Membrane filtration	Fish processing waste water pump	on-off switch	400 VAC		3		TEQUATEC® filter series skid	frequency drive	230VAC	6A	1,50
2		Domestic waste water pump	on-off switch	400 VAC		4		Stirrer (denitrification)	on-off switch	230VAC		0,25
3.1°		TEQUATEC® feed pump	frequency drive	400 VAC	8.4* A	5		Feed water pump	on-off switch	230VAC	3.9A	0,83
3.2°		TEQUATEC® recirculating pump	frequency drive	400 VAC	3.8* A	6		Fan feed tank aeration	on-off switch	230VAC	5.2A	1,10
4		Stirrer (denitrification)	on-off switch	230 VAC		6		Fan membrane aeration	on-off switch	230VAC	1A	0,22
5		Feed water pump	on-off switch	230 VAC	3.9 A	7		Permeate pump commercial modul	frequency drive	400VAC	1A	0,26

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								e				
6		Recirculation pump	on-off switch	230 VAC	3.9 A	8		Permeate pump coated module	frequency drive	400 VAC	1 A	0,26
7		Fan feed tank aeration	on-off switch	230 VAC	5.2 A	1.10						
8		Fan membrane aeration	on-off switch	230 VAC	1 A	0.215						
9		Permeate pump commercial module	frequency drive	230 VAC	1.75* A	0.26						
10		Permeate pump coated module	frequency drive	230 VAC	1.75* A	0.26						
11	TEG module (biogas)	Cooling unit pump	frequency drive	230 VAC		0.25*						
12	Biogas system	Compressor gas storage	on-off switch	230* VAC		1.00*						
°	TEQUATEC®-filter unit disconnected with RAS to save PV aperture surface		*	estimated								

Table 2: HSKA/JKUAT energy consumption listed as of 1.8.16

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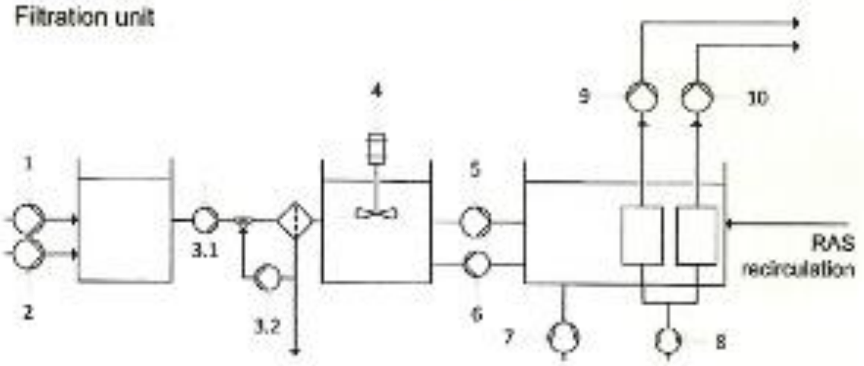
VicInAqua

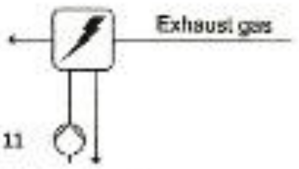
Energy supply: University Karlsruhe / JKUAT

Wasser °C ?

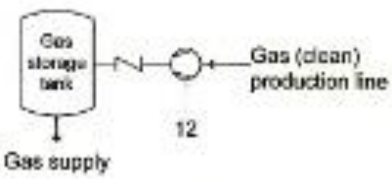
Filtration unit



TEG Module



Biogas production
JKUAT



Nr.	Assembly group	Component name	Actuator	Energy supply	Current	Power [kW]
1	Membrane filtration	Fish processing waste water pump	on-off switch	400 VAC		?
2		Domestic waste water pump	on-off switch	400 VAC		?
3.1*		TEQUATEC® feed pump	frequency drive	400 VAC	8.4* A	5.50
3.2*		TEQUATEC® recirculating pump	frequency drive	400 VAC	3.8* A	2.50*
4		Stirrer (denitrification)	on-off switch	230 VAC		0.25*
5		Feed water pump	on-off switch	230 VAC	3.9 A	0.83
6		Recirculation pump	on-off switch	230 VAC	3.9 A	0.83
7		Fan feed tank aeration	on-off switch	230 VAC	5.2 A	1.10
8		Fan membrane aeration	on-off switch	230 VAC	1 A	0.215
9		Permeate pump commercial module	frequency drive	230 VAC	1.75* A	0.25
10		Permeate pump coated module	frequency drive	230 VAC	1.75* A	0.25
11	TEG module (biogas)	Cooling unit pump	frequency drive	230 VAC		0.25*
12	Biogas system	Compressor gas storage	on-off switch	230* VAC		1.00*

* TEQUATEC® - [illegible] * estimated

+ Sensors / Denmark DC current

Sulzberger, E.; University Karlsruhe of Applied Sciences

Hochschule Karlsruhe Technik und Wirtschaft

Table 3: HSKA component list

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