SCIPEA Kenya Consortium Service Development Team meeting between KenGen, Kenya Meteorological Department (KMD), Institute of Meteorological Training and Research (IMTR) and the Met Office at KenGen Offices, Stima Plaza, Parklands, Kolobot Road, Nairobi 28-29 November 2016

Participants day 1, Front row, left to right: Eng. Francis X. Makhanu (KenGen Assistant Manager – Energy Planning), Peter Chege (KenGen), Zeddy Cherono (KenGen); Back row (left to right): Richard Graham (Met Office), Eric Obeko (KenGen), Paul Mutua (KenGen), James Muhindi (KMD).

Day 2: Left to right James Muhindi (KMD), Richard Graham, Eric Obeko, Richard Muita (IMTR). Right: KenGen Offices, Nairobi.

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Present:
KenGen: Eng. Francis X. Makhanu, Eric Obeko, Paul Mutua, Isaac Maina, Zeddy Cherono, Clement Maiko
KMD: James Muhindi
IMTR: Richard Muita (29 November only)
Met Office: Richard Graham

The meeting agenda is at Annex 1. Participant contact details are at Annex 2

Day 1: 28 November 2016

Opening:
Eng. Francis Makhanu welcomed all to the KenGen offices and expressed wishes for a successful meeting. Richard Graham thanked Eng. Makhanu for hosting the meeting and arranging for attendance by a wide range of experts and thanked Eric Obeko for local organisation.

Richard Graham began proceedings by providing an overview of the WISER-SCIPEA project. The project aims to strengthen climate partnerships on three levels:

1. Enhancing links and data exchanges between global, regional and national climate organisations – strengthening resources and tools for seasonal forecasts;
2. Climate information providers and users – to co-develop prototype tailored services;
3. NMHSs and Universities/Training Centres – strengthening resources for capacity training and climate service development as well as capacity retention.

Strengthened partnerships in these areas are expected to lead to increased capacity for mainstreaming climate services and for national/regional early warning as well as more effective responses to issued warnings.

The SCIPEA structure comprises 5 consortia: 1 Regional consortium and 4 national consortia (Kenya, Uganda, Ethiopia and Tanzania) with ICPAC providing regional coordination. Each consortium includes a climate information provider, a university or training centre partner and two user partners (Fig. 1).

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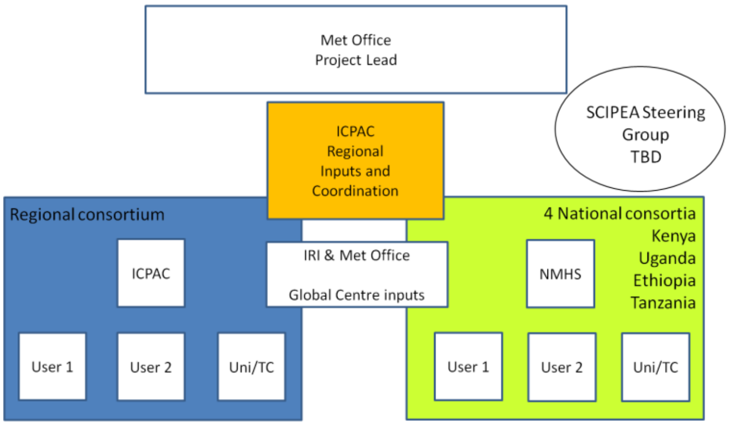

Figure 1: Partners and consortia in SCIPEA

James Muhindi then gave the climate background to the OND 2016 Short Rains season explaining the role of La Niña and the Indian Ocean (specifically a negative phase Indian Ocean Dipole (IOD)) with warm waters in the south east of the basin and cooler waters in the west near the coast of East Africa. These large scale influences tend to set up circulation patterns that divert moisture away from the Greater Horn region and suppress rainfall. Predictions from September had indicated relatively strong probabilities for below normal rainfall on average for the 3-month OND period. The current episodic heavy rainfall being seen in November is not unusual and partly caused by overall dry conditions setting up strong surface heating – which then triggers convective storms. This was later demonstrated by a PowerPoint presentation showing the cumulative rainfall through the season in other La Niña years –generally late October onset, dry conditions in December and episodic rainfall in November (Fig. 2)

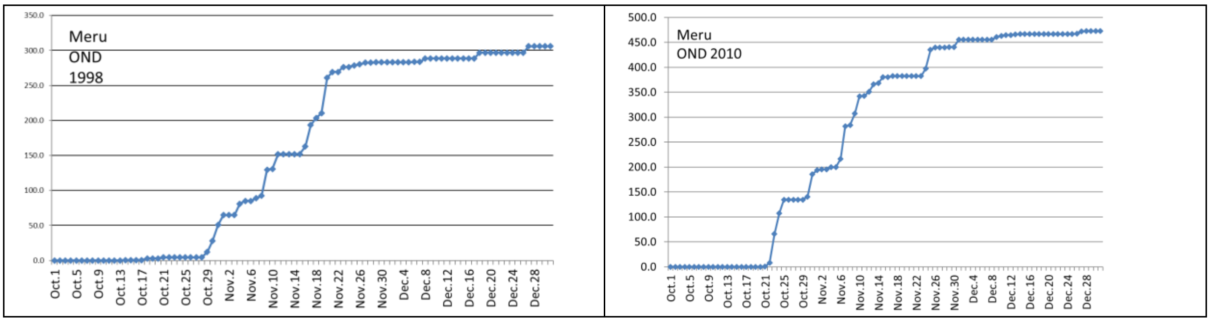

Figure 2: Showing late onset (last week of October) and early cessation (early December) at Meru station in two La Niña years (1998, 2010). In November episodic heavy rain may occur.

Eric Obeko then demonstrated how the water level in the Masinga reservoir (see below and Fig. 3) had steadily declined since September because of water used in generation without replenishment because of the late start to the Short Rains season. Only in mid-November – with occurrence of rains had the water level ceased falling and started to increase. In fact, water levels had dropped more quickly than planned because Kenya Power (the electricity distributer) had generated more than the planned amount because of high demand for cheaper electricity (Hydropower is cheaper than other sources). There is currently a bill going through parliament that will allow more control in this regard (a minimum operating agreement).

Next there was a wide-ranging discussion on Kenya's electricity generation and related complexities. Topics included:

- Generating sources include hydro, thermal, geothermal, wind and solar power. There is a need to harmonise generation across all sources.
- As well as rainfall forecasts, forecasts for wind speed and insolation are thus also required to plan generation. Forecasts are also needed to assist timely construction activities such as pile driving for new installations.
- Hydropower is one of the cleanest and cheapest generation methods and is in great demand.
- Limited knowledge of the detailed hydrology in parts of the country (e.g. run off and flow rates) is a limitation to energy production planning. For example, it is not clear how long it takes for rain falling in Mount Kenya region to reach the seven forks cascade.
- The status of water levels across the whole of the seven forks cascade is monitored using laser measurements fed into a SCADA (Supervisory Control and Data Acquisition) system
- The Eastern hydro system comprises chiefly the Seven Forks cascade of Masinga, Kamburu, Gitaru, Kindaruma, Kiambere and Tana. Of these plants, only Masinga at the top of the cascade and Kamburu (second) have significant reservoir capacity. The Kamburu reservoir also has inflows from the Thiba River (as well as the Tana).
- The western hydro system is comprises chiefly of: Turkwel and Sondu.
- Climate change issues include concern about general declining rainfall (notably in the MAM season) and long-term consequences for hydropower. (Note: this issue of whether climate change will bring increased or decreased rainfall to East Africa is being studied by the HyCRISTAL project). It had also been noted that increased deforestation (around Mount Kenya?) has led to increased rainfall run off.

- There are three key players in providing electricity. 1) The generator (KenGen); 2) The transmitter (KETRACO – Kenya Electricity Transmission Company) and 3) The distributer (Kenya Power and Lighting Company and REA (Rural Electrification Authority).
- Eng. Makhanu noted that there were a number of research activities involving UK-based organisations of relevance to the SCIPEA work, including that by Oxford University Energy and Power Group, Tropical Power of Oxford and the London School of Economics (LSE) as well as the International Hydropower Association (IHA) – based in London. Contact details were kindly provided to Richard Graham
- Planning of water level is also important so that spill away can be avoided as much as possible when inflows are high – spill away can cause flooding of local communities.
- The concept of embedded working between KenGen and KMD – which is part of SCIPEA planning – is supported by KenGen
- Training in meteorology/climatology for KenGen staff is also needed.
- KenGen has Power Purchase Agreements (PPAs) with off takers (e.g. Kenya Power). This is an agreement to make available a certain amount of electricity – if the amount availed is below that agreed there is a penalty on KenGen. The PPAs are used to finance new plants and thus are tied to the productivity of a particular generating plant.
- KenGen is also required to operate hydropower to a certain level because if contribution to the grid falls below certain levels it can cause a trip in the supply with consequent power outages.

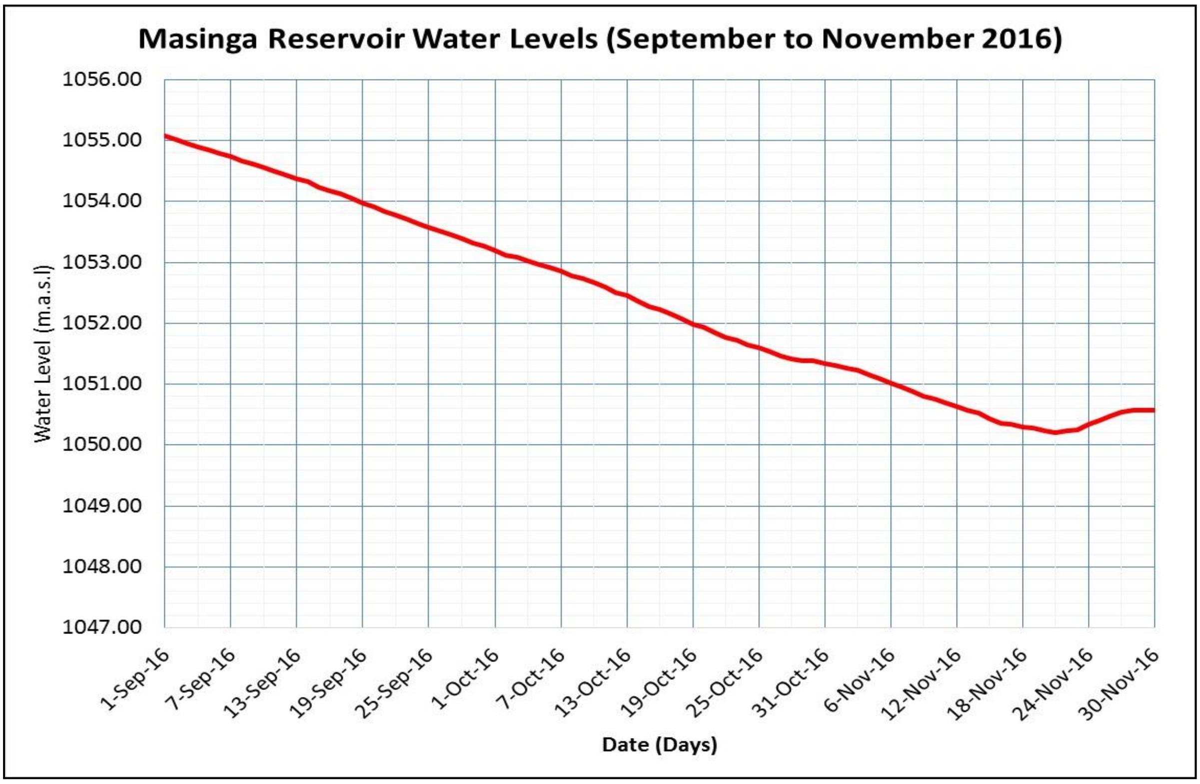

Figure 3: Showing the decrease in water level at Masinga dam due to late onset and low rainfall, plus continued generation. A partial recovery occurs in late November following episodic heavy rain.

Day 2: 29 November 2016 - morning

Eric Obeko went through the planning spreadsheet in some detail (see Fig. 4) focusing on the Masinga dam. In general the steps are as follows (details are provided in KenGen Standard Operating Procedures and Work Instructions (see Annexes 3-7).

See Annex 3

1) Projections of available hydropower energy are made for the KenGen Fiscal Year (FY) energy budget and (for operational purposes) for seasonal and month by month energy projection. Here we focus on the seasonal and 1-month projections.
2) Seasonal projections are started at the end of February for the March to May (MAM) season and the end of September for the October to December (OND) season
3) Monthly projections are made at the end of the preceding month when the KMD monthly forecast becomes available.

See Annex 4

4) For seasonal hydro energy production the reservoir storage is calculated using the Water Balance Equation

   Outflow = Inflow +/- Change in Storage (details are provided in Annex 7)

   The inflows over the season are estimated from the KMD seasonal forecast. If an analogue year is available from KMD, the inflow is estimated as the test flow observed for the same season in the analogue year ("test flow" is the estimated new inflow into a storage reservoir). Since the season being predicted will not have identical rainfall characteristics as that of the analogue season, adjustments for the current season can be made based on advice from KMD. If an analogue year is not available then a percentage of the test flow Long Term Average (LTA) is assumed based on the seasonal forecast. For example, if the forecast is for below normal, 50% of the LTA may be used; if near-normal, 75% may be used; if above normal, 100% may be used (adopting a cautious approach).

   A similar procedure is used for 1-month projections (Annex 5) - however, analogue years are not used for 1-month forecasts.

   The forecasts are obtained from KMD through various means: electronic copy and/or telephone or face-to-face consultations. Assistance with interpretation of the forecast is also provided by KMD. The IGAD Climate Prediction and Applications Centre consensus seasonal forecasts, as well as monthly and 10-day forecasts are also used (Annex 6).

As an example planning for October 2016 included the following steps:

1) The measured lake level at the end of September is entered into the planning spreadsheet.
2) The percentage of the long-term average (LTA) inflow expected in October is entered – currently this is estimated using an analogue year. Thus, for October 2016, the percentage of LTA inflow observed in October 2010 (the analogue) was used. This gives via the lookup table, the total water volume that would be available for use by end of October given the geometry of the lake and thus the "live storage".
3) Next, the total required amount of generation over the month is entered (this is determined by the budgeted/planned generation, the seasonal forecast (if poor rains are expected it will be understood that generation will likely need to be lower) as well as the PPA). In the spreadsheet a value of 650 Mwh/day shows the planning for October.
4) Given the planned generation and associated water volume usage, a reverse operation of the look up table gives the end of October lake level given the reservoir geometry. (1052.70 m – Fig. 4)
5) A similar process is then repeated for other plants in the cascade (see rows in Fig. 4). Note that the energy to be generated will depend on the capacity of the generation unit. Masinga and Kamburu are the only reservoirs with significant storage. All water leaving Masinga is used in Kamburu, so the energy generated at Kamburu is approximately twice that at Masinga because its capacity is approximately twice as large.
6) Future months (in this case through to February 2017 are then planned e.g. by using the end-of-month level in October as the input to November and using a predicted inflow for November (percentage of LTA based on analogue for the given Hydro).

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	Oct-16		
	Inflow	Energy	End Month
	%LTA	Mwh/day	Level (m)
Eastern Hydros			
40 MW Masinga	100	650	1052.70
94.2 MW Kamburu	60	1,200	1004.20
225 MW Gitaru		2,400	
72 MW Kindaruma		*550*	
168 MW Kiambere		2,800	694.90
20 MW Tana		150	
Sub total		***7,750***	
Western Hydros			
106 MW Turkwel	100	1,300	1122.55
60 MW Sondu	100	1,200	
Sub Total		***2,500***	
Total		**10,250**	

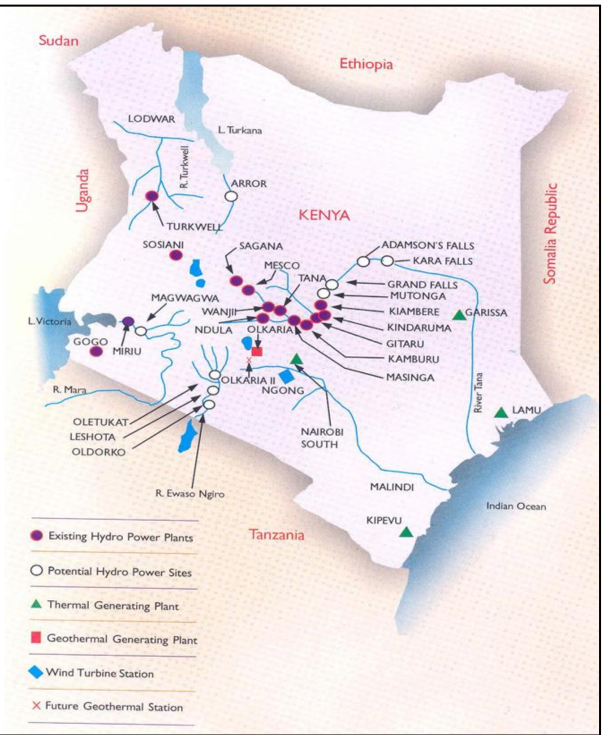

Figure 4: Output from reservoir planning spreadsheet for October. Right: location Hydro stations

Day 2: 29 November – afternoon

Based on the earlier discussions a prototype service from KMD to KenGen was drafted and is outlined with notes and actions in Table1. The services will have 5 components: onset timing; seasonal total rainfall; predicted inflow for the upcoming month and next 3 months; large-scale climate context; and monitoring information on recent climate. For this prototype the service will deal with the Eastern hydros (the Seven Forks cascade). After the service is trialled and refined a similar service could be developed for the Western Hydros.

WISER
Weather and Climate Information Services for Africa

Co-developed Prototype Climate Service: KMD - KenGen

Delivery: On 15th day of each month, by email		**Format:** 2-3 page pdf document		
Section No.	**Content**	**Details**	**Notes**	**Actions**
1	Season onset timing in the Seven Forks catchment	This would be based on rainfall station locations in the catchment near the reservoirs	KMD may not have stations in the catchment There are some KenGen stations. These may need validation/calibration by KMD. They are thought to have long time series.	James to check with Muranga County director to see if there are more stations available than held at HQ. Science visit: predicting onset with CPT and validation.
2	Spatial distribution of rainfall across Kenya	Actual amounts will be given. The Seven Forks catchment to be marked on the map	The precise way in which amounts are presented is to be determined (e.g. value with confidence range, probabilities of threshold exceed etc.)	Richard to ask Willis for GIS shape file for Seven Forks catchment. Science visit: experiment with ways of presenting amounts and GIS software.
3	Predicted inflows for Masinga and Kamburu for first month and first 3-month average		To be used as a complement (alternative?) to the	Science visit: prediction of flows using CPT

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			analogue method	
4	Large scale climate context	E.g. expected status of ENSO and IOD	-	-
5	Historical/analogue information:		Could include: Histograms of previous month's rainfall performance over the catchment; cumulative rainfall graphs showing mean; outer deciles; max and min years etc. (e.g. Fig. 2)	
6	Hydro Power Spillage link with KenGen service			

WISER
Weather and Climate Information Services for Africa

Annex 1:

SCIPEA Service development team meeting and embedded working KenGen, KMD, IMTR and Met Office: 28-29 November 2016, KenGen Offices, Stima Plaza, Parklands, Kolobot Road, Nairobi

Draft Agenda

Day 1	
10:00	Arrivals
10:00-13:00	- Understanding KenGen's operational decisions in the need for seasonal forecast information - If possible – meet some of the operational team
13:00-14:00	lunch
14:00-16:00	Discussion of KMD forecast products used and any gaps from KenGen point of view - Case study for OND 2016 - Use of analogue years
16:00	Close
Day 2	
10:00	Arrivals
10:00-13:00	- List the priority information needed – referring also to Nairobi and Kampala meetings – include new types of information if needed - What would a tailored forecast document for KenGen look like? - Draft the document
13:00-14:00	Lunch
14:00-16:00	- Refine the document - Identify steps to be ready for an experimental trial for the MAM season.
16:00	Close

Annex 2

Participant contact details

No.	Name	Organisation/Position	Contact details
1	Eng. Francis Makhanu	KenGen, Ass. Manager, Energy Planning	fmakhanu@kengen.co.ke
2	Mr Eric Obeko	KenGen	EObeko@kengen.co.ke
3	Mr Paul Mutua	KenGen	PMutua@kengen.co.ke
4	Mr Isaac Maina	KenGen	IMaina@kengen.co.ke
5	Ms Zeddy Cherono	KenGen	ZCherono@kengen.co.ke
6	Mr Peter Chege	KenGen	PChege@kengen.co.ke
7	Mr Clement Maiko	KenGen	CMaiko@kengen.co.ke
8	Mr James Muhindi	KMD, Assistant Director Climate Modelling	muhindi@meteo.go.ke
9	Dr Richard Muita	IMTR	rukwaro2003@yahoo.co.uk
10	Richard Graham	Met Office, SCIPEA Project Lead	richard.graham@metoffice.gov.uk

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Annex 3: Kengen Doc. No. KG/STM/CPS/OP 54-03/02

1. PURPOSE

1.1. To describe the process followed in the projection of hydropower energy for the preparation of the Company's Fiscal Year (FY) energy budget and for the seasonal and month by month energy projection for operational purposes.

2. SCOPE

2.1. For the projection of FY energy budget, it covers the time from the end of December when storage balances are available, through to the review and update of the historic and the test flow databases, the projection of inflows and energy production scenarios and finally to the recommendation of one of the scenarios to be adopted as the FY hydropower energy budget. The budget is expected to be ready by end of January of each year.

2.2. For seasonal projection, it starts at the end of February or September when the weather forecast report for March-May or October-December becomes available, to its interpretation, projection of storage inflows and finally the projection of available energy for 3 to 8 months.

2.3. For month by month projection, it starts at the end of the month when the weather forecast for the following month is available, to the projection of the inflow and energy production for that month.

3. REFERENCES

3.1. ISO 9001:2008 (E) Quality Management Systems - Requirements

3.2. Stima Quality Manual

4. RELATED DOCUMENTATION

4.1 Doc. No. KG/STM/CPS/WI 54-03/01 - Work Instruction for Projection of Fiscal Year Hydro Energy

4.2 Doc. No. KG/STM/CPS/WI 54-03/02 - Work Instruction for Projection of Seasonal Hydro Energy

4.3 Doc. No. KG/STM/CPS/WI 54-03/03 - Work Instruction for Projection of Monthly Hydro Energy

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5. TERMS AND DEFINITIONS

6. RESPONSIBILITY AND AUTHORITY

6.1. Corporate Planning & Strategy Manager or his Appointee is responsible for implementing, maintaining and continual improvement of this procedure.

7. PROCEDURE

The projection of hydro energy shall be carried out according to the following operating procedure;

7.1 For the Projection of the Fiscal Year Hydro Energy, refer to work instruction Doc. No. KG/STM/CPS/WI 54-03/01

7.2 For the Projection of the Seasonal Hydro Energy, refer to work instruction Doc. No. KG/STM/CPS/WI 54-03/02

7.3 For the Projection of the Monthly Hydro Energy, refer to work instruction Doc. No. KG/STM/CPS/WI 54-03/03

8.0 ANNEXES AND RECORDS

None

Annex 4: Kengen Doc. No. KG/STM/CPS/WI 54-03/02

1. PURPOSE

1.1. This work instruction describes the steps followed in the projection of seasonal (3-months) storage hydro production and the reservoir storage balances for operational purposes.

2. SCOPE

2.1. It covers the time from the end of February or September when the seasonal weather forecasts for the long rains (March-May) and the short rains (October-December) become available, to the projection of seasonal inflows and finally to the computation of available energy and the storage balances for the season. The projected energy is provided to Generation Division for information, guidance and necessary action.

3. REFERENCES

3.1. ISO 9001:2008 (E) Quality Management Systems - Requirements

3.2. Stima Quality Manual

4. RELATED DOCUMENTATION

4.1. Kamburu Control Daily Reports

4.2. The Plants Maintenance Programme

4.3. KG/STM/CPS/OP 54-03/04, Procedure for Computation of Test Flows

4.4. KG/STM/CPS/OP 54-03/05, Procedure for Acquisition of Weather Forecast Reports

4.5. KG/STM/CPS/WI 54-03/01, Work Instruction for Projection of Fiscal Year Hydro Energy

4.6. Historic river flows database (April 1947 - March 1995).

4.7. Test flows database (July 1982 to date)

4.8. Verification of previous weather forecasts against recorded inflows.

4.9. Reservoir level storage Tables

5. TERMS AND DEFINITIONS

5.1 Test flow is the estimated net inflow into a storage reservoir, which is employed in hydropower generation.

5.2 KMD is Kenya Meteorological Department

5.3 Mwh is megawatt hours. It is a unit of electric energy.

5.4 LTA is Long Term Average. This is the average monthly inflow from 1982 to date of the test flows database.

5.5 Analogue year is the year whose seasonal weather parameters are similar to the season being forecasted.

6. RESPONSIBILITY AND AUTHORITY

6.1 **Corporate Planning & Strategy Manager or his Appointee is responsible for implementing, maintaining and continual improvement of this Work Instruction.**

8. WORK INSTRUCTION

The computation of seasonal hydro energy shall be carried out according to the following work instruction;

7.1 This process applies the concept of a Water Balance Equation in a Reservoir;

Outflow = Inflow +/- Change in Storage

in accordance with the operating procedure Doc. No. KG/STM/CPS/OP 54-03/04 - Computation of Test Flows

7.2 Get the seasonal weather forecast report in accordance with the operating procedure Doc. No. KG/STM/CPS/OP 54-03/05 - Acquisition of Weather Forecast Report.

7.3 Interpret the forecast in terms of likely inflow magnitudes and liase with KMD for additional information e.g. the provision of the analogue year(s).

7.3.1 If analogue year is available for the season, use the historic inflow data (if the analogue year is before 1982) or the test flows data (if the analogue year is after 1982) to come up with the seasonal inflow magnitudes.

7.3.1.1 Check whether the seasonal inflows require some adjustments, as analogue years are not a replica of each other e.g. Thiba inflow during the dry season is greatly curtailed by indiscriminate water abstractions for irrigation in its catchment area.

7.3.2 If analogue year is not available, assume a reasonable percentage of the test flow LTA based on the weather forecast statement e.g if forecast is "below normal", assume LTA inflow of 50%, if "near normal" assume 75% and "normal to above normal", assume 100% LTA inflow etc.

7.3.3 Follow steps 7.7.1 to 7.7.8 in the work instruction Doc No. KG/STM/CPS/WI 54-03/01 - Projection of Fiscal Year Hydro Energy in the computation of storage energy for the number of months required e.g. from March to June or March to October and from October to December or October to March.

7.3.4 Send the results of 7.3.3 to Generation Division for information, guidance and necessary action

8.0 RECORDS AND ANNEXES

None

Annex 5: Kengen Doc. No. KG/STM/CPS/WI 54-03/03

1. PURPOSE

1.1. This work instruction describes the steps followed in the projection of monthly storage hydro production and the end of month storage balances for operational purposes.

2. SCOPE

2.1. It covers the time from the end of one month and the availability of end of month storage levels to the receipt of the following month's weather forecast to the projection of inflows and finally the computation of available energy for the month. The projected energy is provided to Generation Division for implementation.

3. REFERENCES

3.1. ISO 9001:2008 (E) Quality Management Systems - Requirements

3.2. Stima Quality Manual

4. RELATED DOCUMENTATION

4.1. Kamburu Control Daily Reports

4.2. The plants maintenance programme

4.3. KG/STM/CPS/OP 54-02H/02, Procedure for Acquisition of Weather Forecast Reports

4.4. KG/STM/CPS/WI 54-02H/02, Work Instruction for Projection of Seasonal Hydro Energy

4.5 Reservoir level storage Tables

5. TERMS AND DEFINITIONS

5.1 Test flow is the estimated net inflow into a storage reservoir, which is employed in hydropower generation.

5.2 LTA stands for the Long Term Average. This is the average monthly inflow from 1982 to date computed from the test flows database.

6. RESPONSIBILITY AND AUTHORITY

6.2 **Corporate Planning & Strategy Manager or his Appointee is responsible for implementing, maintaining and continual improvement of this Work Instruction.**

9. WORK INSTRUCTION

The computation of monthly hydro energy shall be carried out according to the following work instruction;

7.1 From Kamburu Control Daily Report for the last day of the month, get the storage levels and then the storage balances using the level storage tables.

7.2 Obtain the weather forecast for the following month in accordance with operating procedure Doc. No. KG/STM/CPS/OP 54-02H/02

7.3 Interpret the forecast in terms of inflow magnitudes e.g 75% or 100% LTA.

7.4 Compute the available energy and the end of month storage balance in accordance with work instruction Doc. No. KG/STM/CPS/WI 54-02H/02

7.5 Using the Plant Maintenance Programme, ensure that the machines are available to generate the projected energy.

7.6 Send the results in 7.5 to Generation Division for implementation.

Note: Monthly energy projection from the run-of-river plants is not carried out due to their small contribution (4%) compared with storage hydro

8.0 RECORDS AND ANNEXES

None

Annex 6: Kengen Doc. No. KG/STM/CPS/OP 54-03/05

1. PURPOSE

1.1. This procedure describes the process followed in the acquisition of weather forecast reports from Kenya Meteorological Department. The reports are required for the projection of monthly and seasonal storage hydro inflows, reservoir levels and energy production.

2. SCOPE

2.1. It covers the period from when the request for weather forecast report (weekly, monthly or seasonal (3 months)) is made to the Kenya Meteorological Department, to its receipt, interpretation and distribution within KenGen.

3. REFERENCES

3.1. ISO 9001:2008 (E) Quality Management Systems - Requirements

3.2. Stima Quality Manual

4. RELATED DOCUMENTATION

4.1 KenGen and KMD Agreement on the provision of weather forecast reports

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5. TERMS AND DEFINITIONS

5.1 KMD is Kenya Meteorological Department

5.2 Test Flows Data Recipients is a list of management staff who need to be kept informed of the performance of inflows into the storage reservoirs.

5.3 Analogue year is the year whose seasonal weather characteristics are similar to the season being forecasted.

6 RESPONSIBILITY AND AUTHORITY

6.1 **Corporate Planning & Strategy Manager or his Appointee is responsible for implementing, maintaining and continual improvement of this procedure.**

10. PROCEDURE

The acquisition of weather forecast reports shall be carried out according to the following procedure;

7.1 KenGen has a standing Agreement with KMD for the provision of weather forecasts. The forecasts are paid for on an annual basis.

7.2 Call KMD's forecasting office and request for the required weather forecast report (seasonal or monthly or weekly).

7.3 If forecast is available, get an electronic copy and go to 7.5.

7.4 If forecast is not ready but one needs the information quickly, discuss over the phone or drive to KMD for a face to face discussion with the forecasting officer.

7.5 Interpret the forecast in terms of the likely inflow magnitudes to be expected in the hydro catchment areas (below normal, normal or above normal)

7.6 If need be, get additional information/help from KMD on forecast interpretation

7.7 For seasonal forecasts (March-May and October-December), request for the analogue year(s) identified.

7.8 Email the forecast with the inflow interpretation to the "Test Flows Data Recipients" for information and necessary action.

7.9 Because of the dynamic nature of the weather, regular weather update reports are required ranging from daily, weekly, monthly and seasonal.

Note: **The Igad Climate Prediction and Application Centre (ICPAC), is a regional body for the Greater Horn of Africa, which deals with "Climate Information, Prediction Services, Applications and Early Warning for Sustainable Development". It is based at KMD headquarters in Nairobi and provides seasonal, monthly and ten day weather forecasts for the region. Its products are available to all interested parties free of charge and KenGen is a major beneficiary.**

8.0 ANNEXES AND RECORDS

8.1 Sample of monthly and seasonal weather forecast reports

Annex 7: Kengen Doc. No. KG/STM/CPS/OP 54-03/04

1. PURPOSE

1.1. This procedure describes the steps followed in the computation of daily test flows into storage reservoirs. The test flows database is useful in the preparation of the Company's annual hydropower energy budget and in the seasonal and month by month energy projection for operational purposes.

2. SCOPE

2.1. It covers the time from receipt of generation and storage level data from Kamburu Control Daily Report to the computation of test flows and finally storage of the results in a database in the form of an excel worksheet for future use in energy projection.

3. REFERENCES

3.1. ISO 9001:2008 (E) Quality Management Systems - Requirements

3.2. Stima Quality Manual

4. RELATED DOCUMENTATION

4.1. Kamburu Control Daily Reports

4.2. Reservoir Level-Storage Tables

5. TERMS AND DEFINITIONS

5.1 Test flow is the estimated net inflow into a storage reservoir, which is employed in hydropower generation.

5.2 Cumecs denotes cubic metres per second. This is the rate of flow of water.

5.3 Tables: These are the level-storage tables of the storage reservoirs.

5.4 Water utilisation factor is the amount of water required to generate one megawatt at various heads of the reservoir. It is given in cumecs per megawatt.

5.5 Mw or megawatt is a unit of electric power

5.6 MWc or megawatt continuous denotes the electric power flow rate

5.7 Mwh or megawatt hours denotes the unit of electric energy.

5.8 Test Flows Data Recipients is a list of management staff who need to be kept informed of the performance of inflows into the storage reservoirs.

6. RESPONSIBILITY AND AUTHORITY

6.1**Corporate Planning & Strategy Manager or his Appointee is responsible for implementing, maintaining and continual improvement of this procedure.**

11. PROCEDURE

The computation of test flow shall be carried out according to the following procedure;

7.1 Using a Simple Water Balance Equation of a Reservoir;

- **Test flow = Outflow +/- Change in Storage (Mwh)**

where, Outflow = Generation + Spillage + Evaporation + Seepage.

- **Evaporation and seepage losses are not taken into account as they do not play any part in energy generation.**

7.2 The Equation then becomes;

- **Test flow = Generation + Spillage +/- Change in Storage (Mwh)**

7.3 Station generation is provided by the Kamburu Control Daily Report.

7.4 For the free overflow spillways **at Masinga and Kiambere, the spillage amounts are computed as follows;**

7.4.1 From the preceding and the previous days' midnight levels, read the spillage amounts in cumecs from the Tables.

7.4.2 Take an average of the two spillage amounts and get average spillage over 24 hours

7.4.3 Convert the average spillage in cumecs into energy in Mwh

7.4.3.1 Read from the Tables the water utilisation factors (cumecs/Mw) corresponding with the two midnight levels and get an average.

7.4.3.2 Divide average spillage in 7.4.2 by the average factor obtained in 7.4.3.1 (cumecs/Mw) and get spillage flow in MWc.

7.4.3.3 Multiply the result in 7.4.3.2 by 24 hours to get total energy spilled in Mwh.

7.4.4 Use the result in 7.4.3.3 in the storage Equation 7.2.

7.5 For gated spillways **(Kamburu, Gitaru and Kindaruma), the Control staff at the stations work out the spillage amounts from gate openings and provide the data in cubic metres (M3).**

7.5.1 Use the appropriate water utilisation factors from the Tables to convert spillage in M3 into Mwh and insert the result in Equation 7.2.

7.6 For Change in Storage, use the two storage levels in 7.4.1 and find out from the Tables, by how much the storage has increased (+) or decreased (-) and put that amount in Mwh in Equation 7.2.

7.7 Add the Right Hand Side of the Equation and get total inflow in Mwh.

7.7.1 Divide the result in 7.7 by 24 hours and get the average daily inflow in MWc. This is the test flow in MWc.

7.7.2 Multiply the result in 7.7.1 by the average water utilisation factor computed in 7.4.3.1 and get average daily inflow in cumecs. This is the test flow in cumecs.

7.8 Store the results in 7.7.1 and 7.7.2 in an excel worksheet database for future use in energy projection.

7.9 Send out the results in 7.8 to the "Test Flow Data Recipients" for information.

8.0 RECORDS AND ANNEXES

8.1 Test flows database (July 1982 to date)

8.2 Sample worksheet of test flow computation