IWRM-Indonesia Fact Sheet

A Demonstration, Teaching and Research Facility of Innovative Hydropower-Driven Water Supply System

General Data

Plant type:	Demonstration, teaching and research facility of an innovative hydropower-driven water supply system applying “Pumps as Turbine” technology and a wooden penstock
Location:	Gadjah Mada University, Yogyakarta, Province of Yogyakarta Special Region, Indonesia (110.371473° E / -7.763386° S)
Operated since:	March 2014
Operator:	Faculty of Engineering, University of Gadjah Mada (status October 2015)

Technical Data

Technologies:	Wood-stave penstock and Pump as Turbine (PAT)
Penstock:	Wood-stave pipeline 30 m length; 0.5 m inner diameter. Wood type: Teak heartwood (*Tectona grandis)*
Supply system:	Module 1: Direct coupling of “Pump as Turbine” (volute casing pump, type Etanorm ETANORM G-65-160) and “Pump as Pump” (volute casing pump, type Etanorm G-40-250) Module 2: Direct coupling of “Pump as Turbine” (axially split volute casing pump, type Omega 80-210A) and “Pump as Pump” (volute casing pump, type Etanorm G-40-160) via an interposed spur-gear
Module manufacturer:	KSB AG
Hydropower flow rate:	~19 l/s (module 1) and ~23 l/s (module 2)
Hydraulic head:	10 m
Pumping head:	23 m
Supply discharge at full capacity:	14 l/s (2 modules in operation)

1 Objective

According to the United Nations some 1.2 billion people around the world live in areas of physical water scarcity. Beyond this number, another 1.6 billion people face economic water scarcity which is caused by a severe lack of adequate infrastructure in order to sustainably utilize existing water resources. This economic water scarcity is a typical problem in tropical and subtropical karst regions in emerging and developing countries. Here, due to the karstified underground with high infiltration rates and lacking storage possibilities at the surface, water will drain rapidly to the underground and develop deep river networks. However, difficulties arise during exploration and exploitation of these resources out of the poor accessibility associated with high extraction costs. Here, the location deep underground as well as the vulnerability to contamination due to the low filtration rate of carbonate rock have to be mentioned as typical constraints. As a consequence, innovative concepts and adapted technologies are required to sustainably exploit the all-year available underground water resources.

Furthermore, UN-Water reports that the introduction and dissemination of innovative and adapted technologies to developing and emerging countries is a major challenge and needs to be overcome. Therefore, the objective of this work package was to implement a research and teaching facility of an innovative hydropower-driven water supply plant to enable a technology transfer and to enhance the dissemination processes of the applied technologies in Indonesia.

2 Concept and Technology

The main idea of the facility is to demonstrate the supply of water resources to a higher energetic level by means of an efficient utilization of a hydropower potential. The facility comprises three main technological features, namely (I) a wood stave pipeline as penstock, (II) two so-called water conveying modules which contain a reverse driven pump (“Pump as Turbine”, PAT) driving a high-pressure feed pump as well as (III) an innovative and optimized construction method for timber-steel-concrete connections.

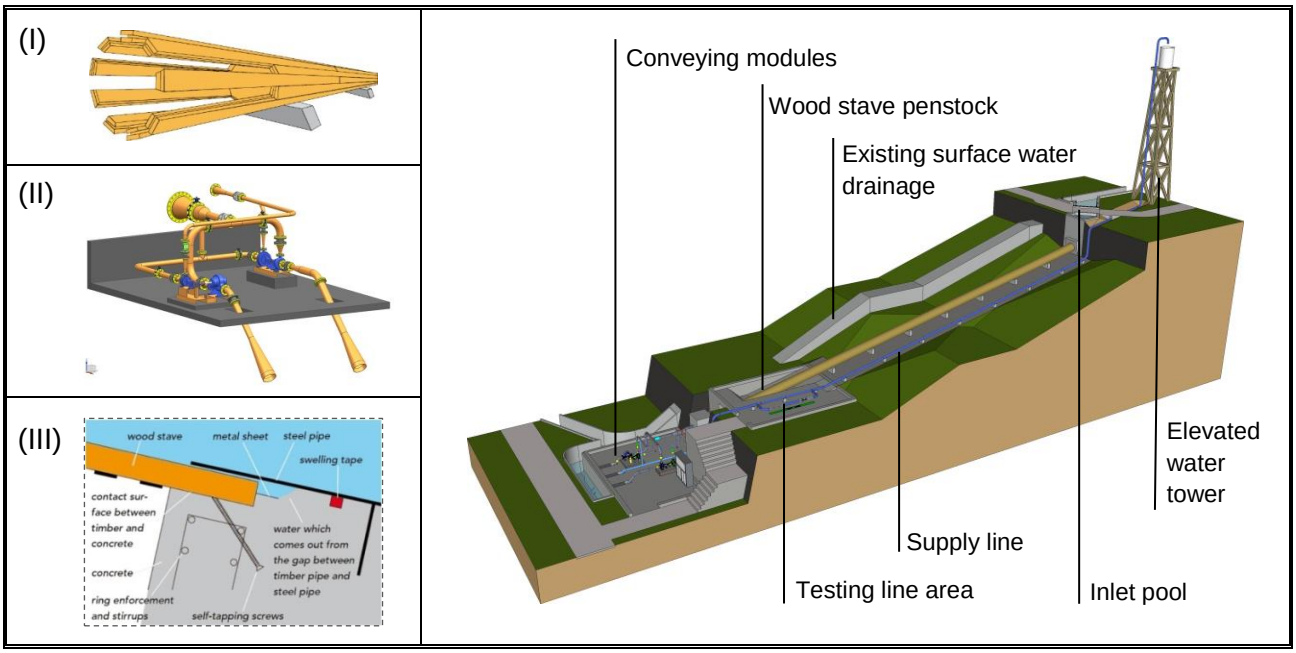

Fig.1. Design and implementation of the plant, with three main features: (I) Application of the wood stave penstock, (II) direct coupling of “Pump as Turbine” (PAT) and feed pump and (III) optimized timber – steel – concrete connections

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Advantages of applying a wood stave pipeline instead of steel or concrete pipe refer to the flexible construction in difficult-to-access areas since the pipes consist of small discrete parts and can be assembled on-site. Furthermore, they do not suffer from roughening since they form a bio-film which lowers the hydraulic roughness through time. In addition wooden pipelines are low-cost applications as well as an ecologically sustainable technology.

The application of the PAT technology is considered to be a suitable approach for utilizing hydropower potentials in remote areas due to the high availability, high robustness, low-maintenance of the associated machinery compared to conventional water turbines. By coupling a PAT mechanically with a feed pump, water can be conveyed without the need for electricity or other external energy sources.

3 Implementation and Results

The here described facility was built on the campus of Gadjah Mada University (UGM). The chosen site is part of an existing surface water drainage system which also drains the residual irrigation water from close-by agricultural areas. At the selected site, a geodetic height difference of approx. 11 meters over a length of approx. 30 m associated with a discharge range of 25 (dry seasons) to 60 (rain seasons) liters per second was identified.

As a demonstration facility, this plant has been utilized intensively by UGM during guest visits, workshops, conferences etc. Regarding the plant's function as teaching facility, the plant is used for mandatory practical courses of UGM bachelor and master students. Here it is possible for the students to gain practical experiences with two types of conveying modules under different operating conditions by varying the hydraulic head (at the inlet pool) or the pumping head (by implementing hydraulic resistances at the test line area). For further assessment of the plant's performance a monitoring system which measures the inflow of the PATs as well as the supply discharge and rotation speed of the feed pumps was developed. From research point of view, among others the investigation of the wood-stave pipeline's long-term behavior in a tropical environment, the application of locally manufactured pumps used as PAT or feed pump, the assessment of technology adaptation to the needs and knowhow of local users within multiplications projects etc. can be carried out.

(a) Construction of wood-stave pipeline

(b) Implementation of wood-steel-concrete connections

(c) Monitoring of stress distribution at clamping rings

(d) Commissioning of the facility

(e) Control panel of the monitoring system inside the powerhouse

(f) Students carrying out measurements during practical courses

Fig. 3. Pictures impression of the implementation

4 Hydraulic Machinery

Parameter			Module 1 ("robustness")		Module 2 ("efficiency")	
Hydraulic Machines	Manufacturer	[-]	KSB AG	KSB AG	KSB AG	KSB AG
	Type	[-]	ETANORM G-65-160	ETANORM G-40-250	OMEGA 80-210A	ETANORM G-40-160
	Function	[-]	PAT	Feed pump	PAT	Feed pump
	Hydraulic head	[m]	8-10	-	8-10	-
	Pressure head	[m]	-	13	-	13
	Discharge	[l/s]	16.7-19.4	4.6-6.8	16.7-22.5	4.7-7.5
	Rotation speed	[min^{-1}]	1,180	1,180	1,100	1,700
	Max. efficiency	[%]	75	58.5	76.9	66.3
	At conditions	[min^{-1}]	1,515	1,450	1,515	1,450
Gearbox	Manufacturer	[-]	-		Walther Flender GmbH	
	Type	[-]	-		BG24AX	
	Transmission	[-]	-		1.55	
	Efficiency	[%]	-		91	
Coupling	Manufacturer	[-]	Walther Flender GmbH		Walther Flender GmbH	
	Type	[-]	WK-EG 28		WK-EG 42	WK-EG 28
	Function	[-]	PAT – feed pump		PAT – gearbox	Gearbox – feed pump
	Efficiency	[%]	99.9		99.8	99.9
System efficiency		[%]	42		45	

5 Project Partners

- Research Centre for Steel, Timber and Masonry – Timber Structure and Building Construction
- Institute for Water and River Basin Management
- Institute of Concrete Structure and Building Materials

- Faculty of Engineering
- Magister of Technical System
- Department of Civil and Environmental Engineering
- Department of Mechanical Engineering
- Department of Electrical Engineering

KSB AG

Ministry of Public Works and Public Housing

Province of Yogyakarta Special Region

National Nuclear Energy Agency

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