Leibis/Lichte: Germany´s last large drinking water dam

Peters, J.; Klaußer, V.; Willmitzer, H.; Kraft, H.
Dam Administration of Thuringia, Germany

The 93.5 m-high Leibis/Lichte dam, now under construction in Germany, will provide much needed improvements to the water supply system of Thuringia when completed in 2004. Studies for the project, with special emphasis on ecological aspects, are described here.

1. Introduction

The Free State of Thuringia has 168 dam plants and belongs, together with the federal states North Rhine-Westphalia and Saxony, to the states of Germany which are the richest in dams.
The Saale cascade with the largest German dam, the Bleiloch dam, (capacity 215 Mio.m³) belongs to these dam plants, too.
Thuringia is one of the regions in Germany which are poorest in water (annual rainfall only just 700 mm). However, the annual rainfall in the Thuringian woods is much higher (1.100 mm).
This unfavourable water availability distribution led to the diversion of water from excess areas to water shortage areas already in the beginning of the last century.
Towns like Nordhausen and Gotha constructed first drinking water dams in Thuringia already in 1901. With the completion of the Leibis/Lichte drinking water dam in 2005 this development will now find its final construction.

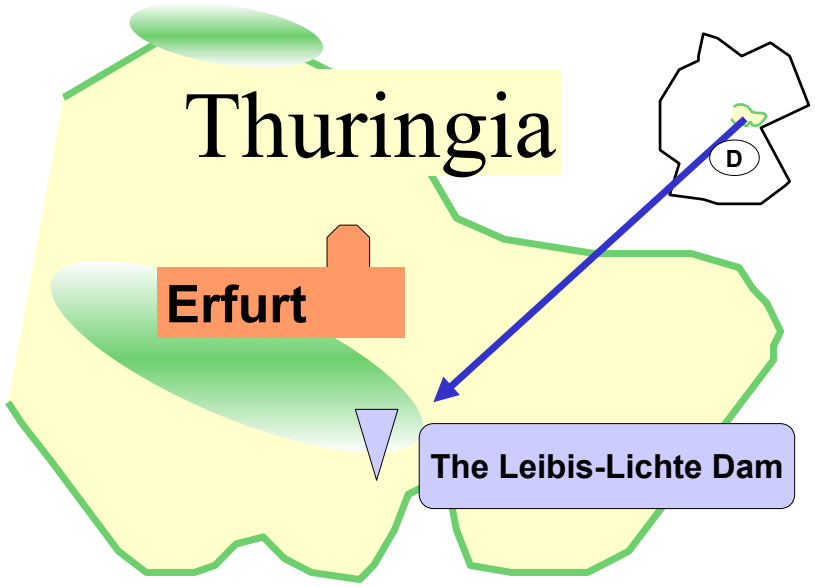


Fig.:1 *The localisation of the Leibis-Lichte-Dam in Thuringia, Germany*

The Dam Administration of Thuringia as an institution of public right having legal capacity took over the whole state-owned dam property as the owner in 1993.
68 dam plants with more than 200 Mio. m³ storage capacity and 42 km diversion tunnels belong to it. The basis of the dam stock is constituted of 12 drinking water dams as well as 10 large flood-control reservoirs.
At present the drinking water supply in Thuringia takes place by 30 % from dams. 2 big long-distance water supply administrative unions consists the dam water and sell it to communal unions.

Fig.:2 *View of the dam site from upstream*

The necessity to build a new dam resulted from the fact, that the production of drinking water in the eastern part of Thuringia suffered from both aspects quality and quantity. The general requirements on raw water quality (WILLMITZER, 1997) are not guaranteed. At this point, the supply is given by managing an eutrophicated reservoir system called "Weida/Zeulenroda/Lössau" and the polytrophic preimpoundment basin Deesbach (WILLMITZER, 2000). The provisional operation of the small preimpoundment basin Deesbach since 1992 means:

- insufficient water quantity
- no water quality management
- permanent quality impairments (bacteria, blue-green algae, toxins, decreasing oxygen, manganese and ammonia) (Fig.: 3)

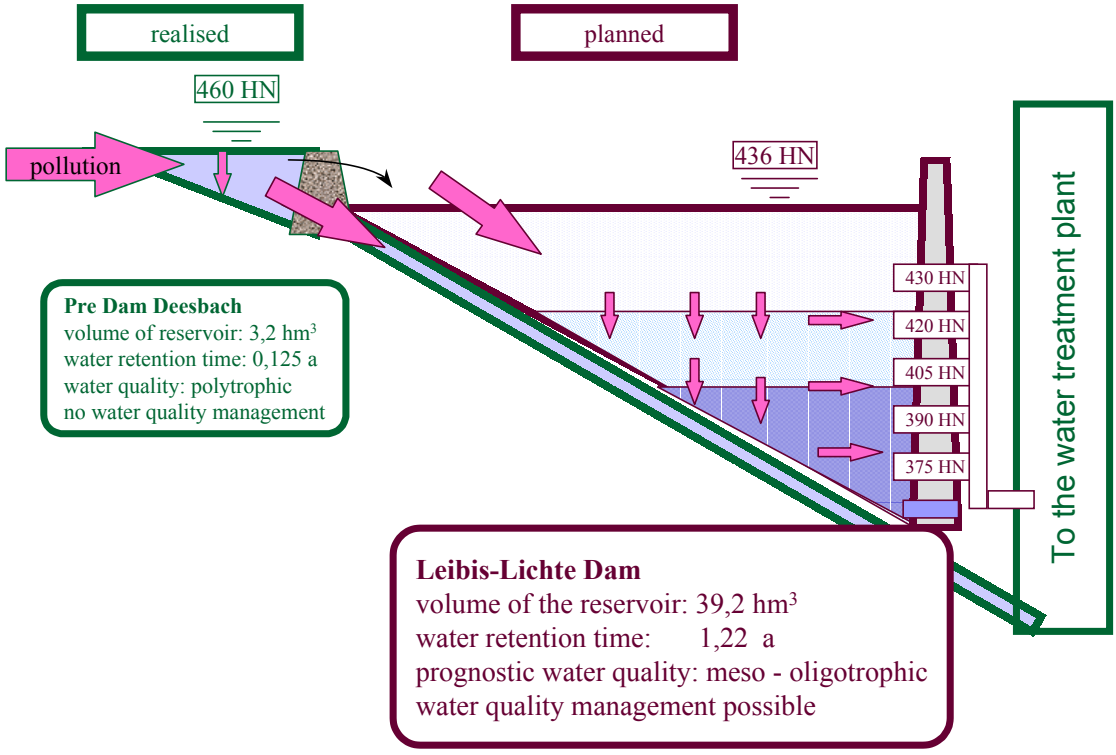


Fig.:3 *The provisional operation of the small preimpoundment basin Deesbach and the planned reservoir Leibis/Lichte*

2. General information

The Leibis/Lichte dam will be constructed above the place Unterweißbach in the district Saalfeld/Rudolstadt at the river Lichte. The seat of the dam keeper is in this place.
The dam, a concrete gravity dam with straight axis, will be erected in the years 2001 - 2004.
The excavation of the dam pit is almost completed. After the test impoundment the dam will be officially put into operation in 2005.
Stabilisation of drinking water supply in eastern Thuringia, flood protection as well as the production of environmentally compatible energy from water power is the function of the dam. This results in the following utilities:

Raw water supply from the storage system:	43.700 m³/d
Flood storage capacity:	5.6 millions. m³
Power generation nominal capacity (2 turbines):	approx.1.0 MW
Wild bed discharge:	ecologically optimized

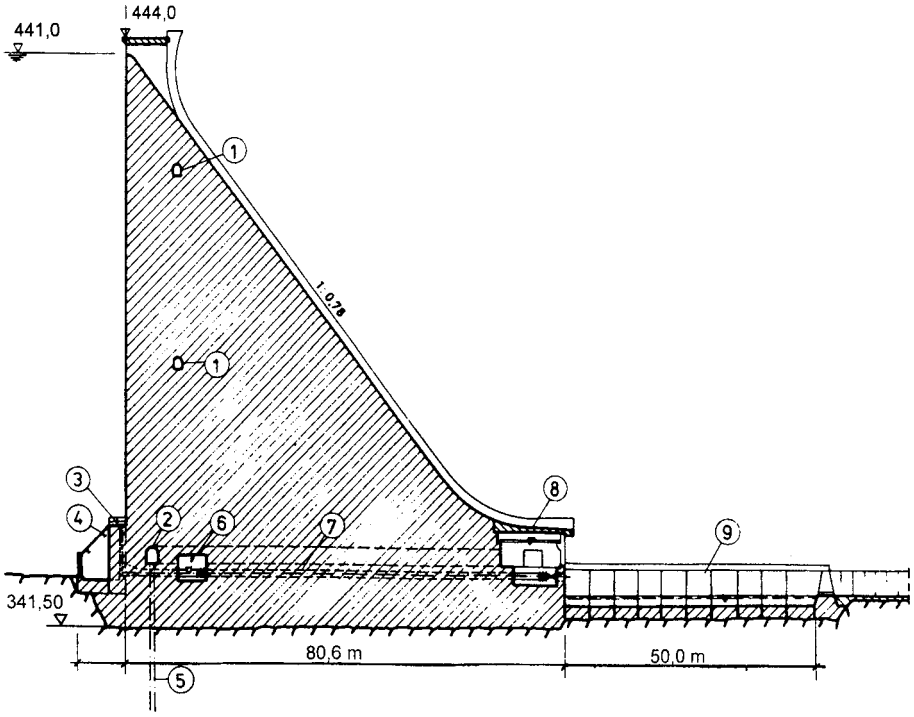


Fig.:4 *Cross section gravity dam*

3. Project development

After the german reunification the decision-making and planning process for the completion of the dam system covered 10 years. The planning and licence right with extensive public participation(planning permission hearings) of the Federal Republic of Germany represented the basis for it.
Conservation and environment associations complained repeatedly against the project, however, these complaints always were rejected. One complaint is still pending. Reviews of alternatives proved that the planning target can be reached best with this dam.
A lot of environmental impact assessments have been carried out throughout several years for the purpose of valuation and forecast of the ecological effects.
The costs of the measures for the minimization and compensation of ecological effects amount to approximately 10 % of the construction costs.

A monitoring program in the lower course of the dam, calculated for 10 years, belongs to it. So the planned dynamic reservoir management can be optimized at any time according to ecological viewpoints.
The place Leibis with 100 inhabitants had to be resettled, a new village had specially been erected.

Last, but not least because of the long and intensive preparation and an offensive public relation work a great acceptance for the project could be reached in the region concerned. A well organized construction site tourism makes the concerned persons (as far as possible) beneficiaries of the project already during the time of construction.
The following chronicle shows the project development:

- 1st planning: in the 1970th
- Start of the construction of the preimpoundment basin Deesbach: 1981
- Construction of the tunnels Lichte I + II : 1981 - 1989
- Provisional operation of the preimpoundment basin Deesbach: since 1992
- Application for the governmental approval: 1993
- Alteration of planning documents: 1995
- Study of environmental impacts: 1995-1997 (see next poster)
- Allowing of the governmental approval: 1998
- Approval for direct execution of selected projects: 1998
- Lawsuit (claim of environmental association) started: 1998
- Start of the construction (single selected projects): 2000
- Court proceeding for the main project: 17. Oct. 2001

4 Secondary dam Deesbach/Lichte - tunnel

The start was made on the construction of Deesbach secondary dam in 1981. Up to the completion of the main dam, with the partially completed system which also includes two altogether 10 km long raw water discharge tunnels (tunnel cross-sectional area 2,70 m), a provisional water supply for 100,000 inhabitants has been provided since 1992.

Fig.: 5 *Deesbach secondary dam*

Rock-fill dam with asphaltic concrete external seal

Height above lowest foundation	42.80	m
Crest length	178.00	m
Crest width	6.00	m
Dam slope		
upstream face	1 : 2	
downstream face	1 : 1.75	
Effective storage at normal water level	3,200	$10^3 m^3$

Flood control: crest spillway on the right-hand slope with collector channel, race and stilling basin

Water intake can be effected infinitely variably via an articulated intake pipe. The bottom outlet and intake pipes are regulated via drop shaft seals. At normal water level, in the main dam the downstream face of the low weir upstream is half impounded.

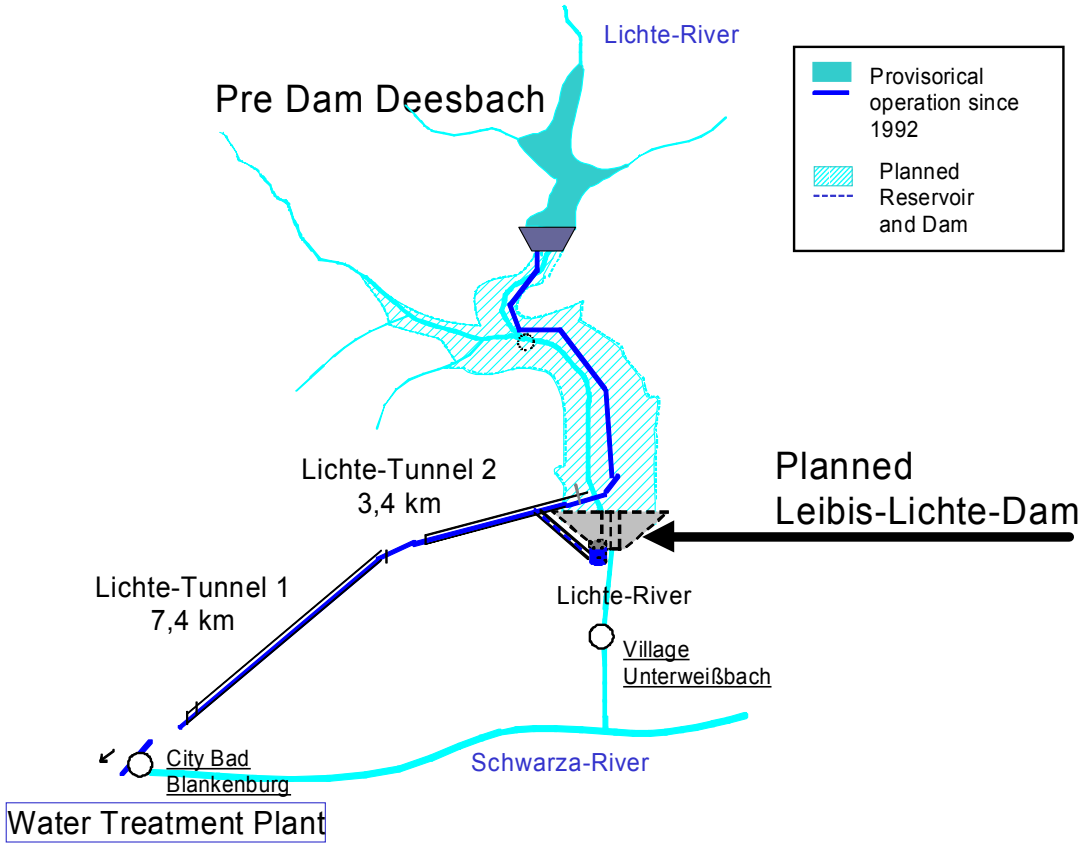


Fig.:6 *Schematic view of the water collection system Leibis-Lichte*

5 General data Leibis/Lichte dam

Catchment area	72.00	km²
Mean annual discharge	31,500	10^3m^3
Maximum water level	442.00	m a sl
Minimum water level	375.00	m a sl
Gross capacity	39,200	10^3m^3
from:		
Surcharge flood storage	1,200	10^3m^3
Flood storage	5,600	10^3m^3
Active storage	29,400	10^3m^3
Inactive storage	2,000	10^3m^3
Dead storage	1,000	10^3m^3
Reservoir surface at max. water level	1,197	10^3m^2
Storage / Mean annual discharge	1.21	
Height above lowest foundation	approx.101.50	m
Height above valley floor	93.50	m
Crest length	370.00	m
Crest width	9.00	m
Maximum dam toe width	81.00	m
Dam volume	620	10^3m^3
Dam volume/Reservoir volume	1 : 63	
Freeboard	2.00 m	
Dam slope		
upstream face	perpendicular	
downstream face	1 : 0.78	

Crest spillway with downstream race and ski jump, cubic stilling basin. Design discharge: HQ_{10000} = 86.5 m³/s

Fig.: 7 *Pit excavation for the concrete dam (right abutment)*

The effective storage capacity of the dam is managed by 5 intakes staggered height-wise. After the shut-off valves, the intake pipes are reduced to two pipes which, via a Francis turbine and/or an annular sleeve valve, lead into the tunnel intake tower. Parallel operation of both lines as well as connection to the bottom outlet unit by means of cross-connections is possible. From the tunnel inlet tower, the raw water flows via the 10 km long Lichte tunnel to the Zeigerheim drinking water conditioning plant.

Three ND 1200 bottom outlets are arranged for a planned discharge capacity of 35 m³/s at normal water level. ND 1000 annular sleeve valves are provided as the regulating devices. The wild bed supply is effected via bypass outlets of the bottom outlets, a small turbine unit with a nominal capacity of 300 kW is interposed. The bottom outlet system contains cross-connections to the raw water line.

The conception of the measuring and control monitoring is primarily oriented to the observation of displacements in the compact joint between the main dam and the abutment, to the detection of deformations in the area close to the foundation as well as to the observation of flow conditions in the foundation area and in the subsoil.

Fig.: 8 *Pit excavation left abutment*

The methods pre-destined for short-term developments such as seepage water and floating sounder measurement are integrated into the process control system as real-time measurement aiming at monitoring trends and limit values. In the case of many other methods which can only be handled with great time consumption and personnel expenditure (e. g. the uplift pressure measurement), the acquisition of measured values is automated with retention of the conventional verifiability.

For the building structures and their operating facilities for the supply of raw water a process control system is provided.

At the barrier location exclusively and, in the storage area, to a large extent argillaceous schist, partly quartzitic can be found.

The greyish blue argillaceous schist's in the subsoil at the barrier location (Ordovician phycode schist) are, for the major part, superposed by slope rubble, in the valley bottom by low bench broken stone, with bottom clay below it.

The argillaceous schist's of the bedrock have a marked fault structure. The water conductivity is exclusively tied to accidents and crevices. Therefore, in addition to the foundation on the solid rock, a grout curtain in two rows is arranged at a depth of 5 to 44 metres.

6 Ecological aspects

The construction of this dam and the management of the new reservoir will implicate serious changes of the environment. This is why an impact study was done in order to estimate all possible environmental changes all round of the planned reservoir. The following objects were estimated:

- Surface waters
- Flora, fauna, habitats
- Landscape
- Soil, contaminated dumps
- Geology
- Hydrogeology
- Socially and humanity aspects
- Climate and air

Appreciable damages would result from flooding and from the "barrier effect" of the dam (Tab.: 1).

Intensity of the impact	**Object of the impact**
Essential prejudice	Wastage of terrestrial ecosystems in the planned reservoir area
Total wastage	Wood Grouse (*Tetrao urogallus*)
Deterioration of the view of the landscape	Dam
Barrier effect	Runnels and little rivers
Moderate ore low effect	Ecosystem downstream of the dam
Local impacts	Climate, ground water, soil

Tab. 1: Prognosticated effects of the new Leibis-Lichte Dam

Beside these effects, the environmental authority was afraid of a negative impact on a protection zone recommended by European Union, located in the downstream of the reservoir. The approval to complete the reservoir system by a dam is connected with compensation measures for all environmental impacts. One project of this compensation plan is the preparation of guidelines for an ecological water management of the reservoir in order to reduce the negative influence on the ecosystem downstream.

The following steps have been done:

- Elaboration of a water management model
- Calculation of hydrological conditions which are necessary to conserve the temporary ecological status of the river downstream of the dam
- Determination of concrete requirements on the water management

Furthermore a monitoring program takes place to investigate all natural components in the river system in the downstream of the planned dam. The aim of this program is the control and estimation of the impact on the environment before, during and after the construction of the new reservoir (Tab. 2).

Investigated object	Method
Sediments of the waters	Analyse of gravel, evaluation of geological data
Hydrology, Meteorology	Evaluation and measurement of hydrological and meteorological data
Hydrodynamic	Surveying of river profiles, Measurement of flow velocities
River morphology	Registration of gravel islands, Analysis of grains size, total organic carbon
Vegetation	Registration and investigation of vegetation
Fauna	Sampling of imagines, macrozoobenthic organisms, interstitial organisms by surber-sampling and freeze-coring, different depths in the sediment, fish fauna by electric fishing
Water chemistry	Flowing water and interstitial water, On-line data – logging of physical criteria and labor-analysis of nutrients and other components

Tab. 2: Monitoring program downstream of the planned Leibis-Lichte Dam

It can be assumed, that after the completion of the Leibis-Lichte Dam the water supply in eastern Thuringia and the nature in the Leibis-Lichte area will be stabilized.

7. Project realization

That public order is liable to an europe wide call for tenders, the order of which due to award a contract exceeds the threshold value of 5 Mio. EUR for construction orders. The construction order for the Leibis/Lichte dam multiply exceeds this threshold value, so an europe wide order placing procedure according to the regulations of the law for the change of the order placing right had to be implemented beginning with Jan.1st, 1999.

A non-open procedure had been chosen for the placing of the construction order of the Leibis/Lichte dam. The prequalification of the offerers took place through a Point Scoring Model with notification of the point value to be reached for the prequalification.

This model has the advantage, that offerers have to get down intensively to the complexity of the building and that they have to check their own know how which will be necessary for the realization of the order, before tendering an offer.

Out of 30 competitors 8 companies sent those documents back, which fulfilled all conditions of the pre-qualification.
The catalogue of all activities to be realized for the purpose of tendering the offer was sent then to the companies.
The arrived offers have been examined according to formal, calculatory, technical and economical aspects. In case of the economical examination the adequacy of the total offer price has to be taken into consideration. Open questions, e.g. referring technical details,

have been cleared up then during offerer dialogues, in which negotiations about prices are not allowed.
In the end the most economical offer will be found out and the award of contract will be given to it.

Fig.: 9 *Cable crane – installation fixed point*

Considering the high competition in the construction branch projects like the erection of the Leibis/Lichte dam are very tightly calculated referring the offer price.
For this reason the firms try to increase prices respectively to minimize subsequent costs, e.g. by guaranty, through supplement demands, hindrance information's and announcements of doubt.
In order to be able to discuss technical, commercial and legal problems on the same level with the offerer, the building owner has to confront this kind of project management with an own strong organizational structure. For this reason the Dam Administration of Thuringia has decided, referring the project „construction of the Leibis/Lichte dam" for a professional organizational structure and, among another things, a construction-accompanying legal advisory:

To this belongs an insurance, which the building owner effects for all persons concerned with the construction. This insurance contains, among others, project specific regulations, e.g. the exact definition and measurement of a flood during the construction period, which are not part of standard insurance.

The total costs of the project Leibis/Lichte dam will amount to 433.6 Mio EUR. The project initiated during the times of the German Democratic Republic - the total sum for this period is 103,0 Mio EUR. After the reunification 177.2 Mio EUR have been invested in the completion of the project until now. Till 2005 again 153.4 Mio. EUR will be necessary for the project.

Fig.:10 *Cable crane – rail track installation for the counter carriages*

The financing of the completion of the new long-distance water supply system is largely realized through a constructional cost subsidy by the Free State of Thuringia.
The remaining expenditures will be financed according to the planned utilization of the dam.

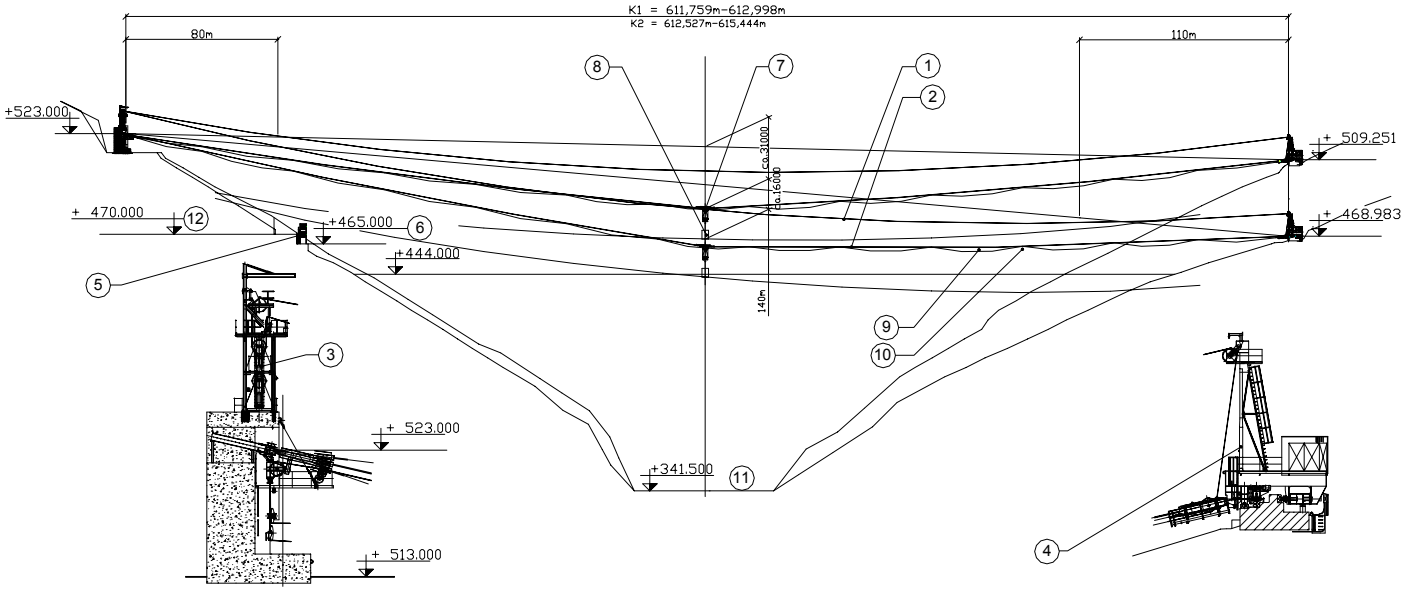
So, another investment cost subsidy of the Free State will be granted, which corresponds to the share of the storage capacity to be kept free for the active flood protection in relation to the total storage capacity. This subsidy is not a subsidy without equivalent, but the taking over of the proportional flood protection dam costs, because flood protection is duty of the state.
The state again refinances this subsidy from its tax receipts, to which the dam operators and the supplied water supply firms as well as their customers contribute to. The rest will be financed by own means of the Dam Administration of Thuringia respectively through credits.
The credit respectively the interest debits resulting from it will be part of the raw water price calculation.

The barrage corpus will be made of a mass concrete (core concrete), covered by a facing concrete. According to special mixture ratios and special barrage areas bottom concrete, bottom fine concrete, joint concrete and reinforced concrete will be produced.

Purchase from outside is necessary for the concrete aggregates, because the local phycode schists are not suitable for the concrete production.

Already during the erection of the pre-dam, thus before the procedure of plan establishing for the barrage, preparatory measures for the erection of the barrage have been done. At present the excavation pit is under realization, the double cable crane plant with radial guideway (spread 615 m) will be erected and the concrete batching and mixing plant with ice plant will be erected until the end of September 2001. In October 2001 the concreting of the barrage will begin.
The completion of the 100 m high Leibis/Lichte dam is planned for the end of the year 2004.

Because of the water problems in Eastern Thuringia it is planned to provide water for the drinking water supply by the Leibis/Lichte dam already during the 2-year-lasting test impoundment.



Cable crane of the Leibis/Lichte Dam

1 Running Cable 1 (Diameter: 78 mm; Span: 614 m)
2 Running Cable 2 (Diameter: 78 mm; Span: 614 m)
3 Head Mast for 1 + 2
4 Head Mast Rail Track
5 Control Cabin
6 Concrete Ramp
7 Travelling Crane (Load: 20 t)
8 Concrete Bucket (Contents: 6 m³)
9 Winding Cable (Diameter: 28 mm)
10 Lifting Cable (Diameter: 26 mm, Lifting Height: 140 m)
11 Dam Foundation Level
12 Road

Fig.: 11 *Cable crane – general arrangement plan*

8 Summary

First time in November 2000 principles for the valuation, planning and realization of large dam projects were presented by the World Commission on Dams(WCD) in London.

To begin with the WCD formulates a general standard with regard to an efficient project purpose. It consists of a significant improvement of the human development on a economically working, socially fair and lasting ecologically harmless basis. The WCD has the opinion, that the construction of a large dam deserves support only than, when this aim can be reached best with a large dam. In this connection the WCD demands the consistent consideration of all possible options (e.g. reducing of the water consumption and the

pipe system losses, utilization of alternative resources like rain water) during the decision making.

With respect to the construction of the Leibis/Lichte dam the guarantee of an always orderly water supply (regarding water quantity and -quality) is an efficient project purpose. This aim will be reached best through the construction of the Leibis/Lichte dam, because system alternatives did not lead to an efficient result.

The Dam Administration of Thuringia thoroughly examined, with respect to the WCD-criteria, the project Leibis/Lichte dam - not only with respect to technical/financial aspects, but especially with respect to the ecological/social compatibility.

The Leibis/Lichte dam can nearly be seen exemplary with regard to the WCD-criteria , especially concerning the consideration of social and ecological interests.

Because the criteria for the decision making and planning process have been observed too, the Leibis/Lichte dam as one of the last large dam projects in the Green Heart of Germany - Thuringia - fulfils without reservation the principles of the WCD.

Fig.:12 *Leibis/Lichte dam – model (2004)*

9 Engineering, construction, management

Owner: Thüringer Talsperrenverwaltung
Talsperrenstraße 25 - 27
99897 Tambach - Dietharz
Germany

Telefon ++49(0)3 6163 33-0
Fax ++49(0)3 61 63 33-1
E-Mail thueringer-talsperren@t-online.de

Engineering/ Site Supervision: Hydroprojekt Ingenieurgesellschaft mbh, Erfurt
Lahmeyer International, Bad Vilbel

Project Management/Building: Salveter GmbHh, Netphen

Project Management/Ecology: emc GmbH, Erfurt

Legal Counsellingor: Anwaltskanzlei Langer, Walter & Collegen, Erfurt

Inspection Authority: Staatliche Umweltamt Suhl, Suhl

Inspection Statics: Ingenieurbüro Dr. Linse, München

Construction contractors: Leibis/Lichte dam joint venture

Bilfinger + Berger Bauaktiengesellschaft, Köln

Max Bögl Bauunternehmen GmbH & Co. KG, Neumarkt

Bickhardt Bau AG, Kirchheim

Oevermann Hoch- und Tiefbau GmbH & Co., Münster

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More published and non-published publications referring the project Leibis/Lichte dam can be demanded from the Thuringian dam-archives with its extensive library under the following address:

Thüringer Talsperrenverwaltung /Thüringer Talsperrenarchiv
Talsperrenstraße 25 – 27, 99897 Tambach-Dietharz,Germany
Telefon: ++49(0) 3 6252 33 152
Fax: ++49(0) 3 6252 33 111
E-Mail: talsperrenarchiv.ttv@t-online.de

Information: Schneider, H.-Jürgen (58), Dipl.Ing., Leiter Talsperrenmarketing,
Scholz, Evelyne (37), Archivarin

11 Authors

Peters, Jens (56) - Dipl.-Ing.
Main Managing Director of the Dam Administration of Thuringia
Member of Deutsches Talsperrenkomitee - Technischer Beirat

Arbeitsgemeinschaft Trinwassertalsperren e.V. – Vice Chairman

Klaußer, Volkmar (37) – Economist (Dipl.)
Economic Managing Director of the Dam Administration of Thuringia

Kraft, Heiko (40) - Dipl.-Ing. (FH)
Head of Dam Maintenance Works Unterweißbach, Responsible Head of the Leibis/Lichte Dam

Willmitzer, Hartmut (40) – Biologist, (Dipl.)
Head of the Department of Dam- and Reservoir Controlling and Head of the Department of Water Quality of the Thuringian Dam Administration
Member of ICOLD Committee of the Role of Dams in the Development of River Basins