

Large scale PV implementation and grid integration with hybrid PV hydro electricity using floating PV devices on water.

Dream or Vision?

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Overview

- How significant is land-use for Switzerland's 53% market share of hydropower?
- How can the energy yield of the existing largest hydropower plant in Switzerland be doubled by using PV? (Case Study)
- How can we integrate such a design into existing hydropower plants?
- What is the dimension of possible future markets? Hydropower and potential for hybrid PV in Spain
- How can we accelerate cost reductions of PV systems beyond cost reductions of the components?
- What are the chances and challenges of «Off shore PV»?



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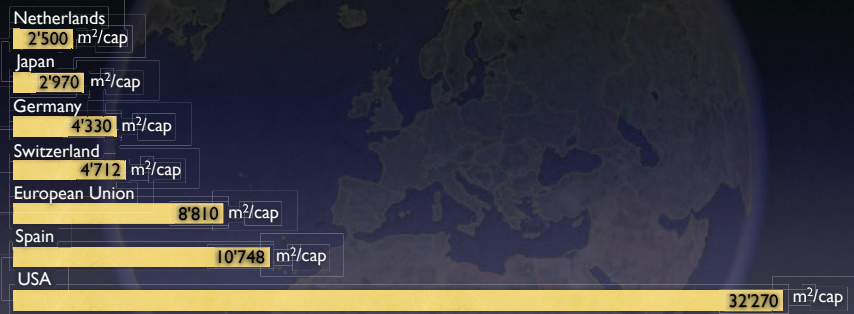


Is PV a land guzzler?

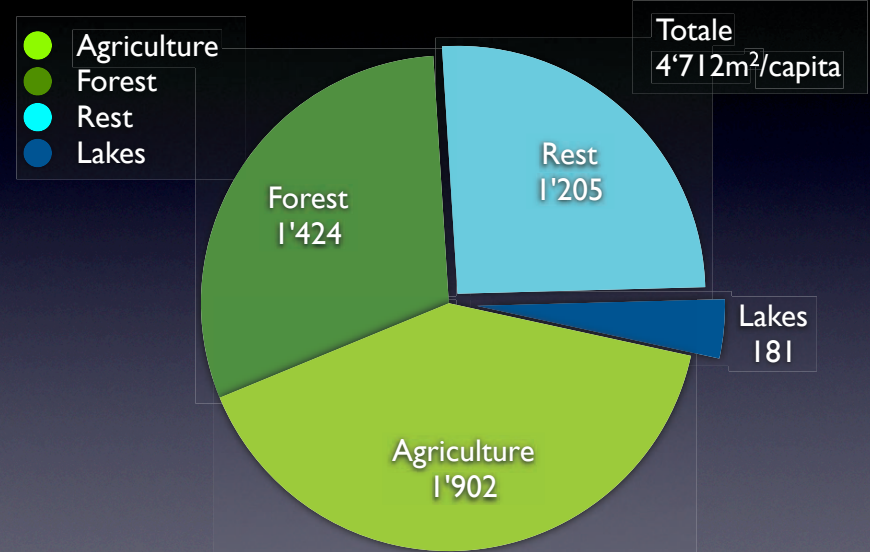


Mühldorf • Bayern 2008 | MW_p

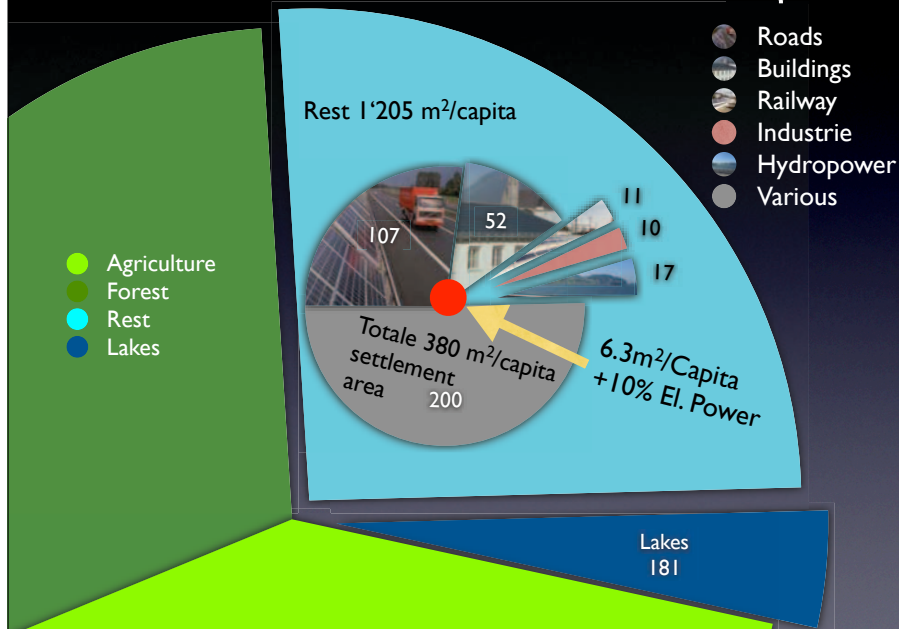
Land available per capita...



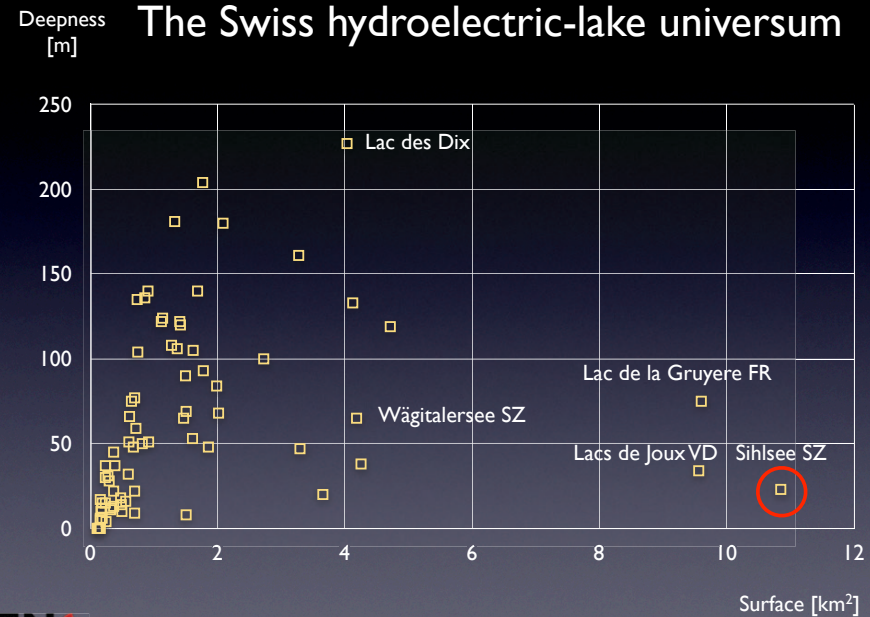
Switzerland Land available ...



Switzerland Land available: 4'712 m²/capita



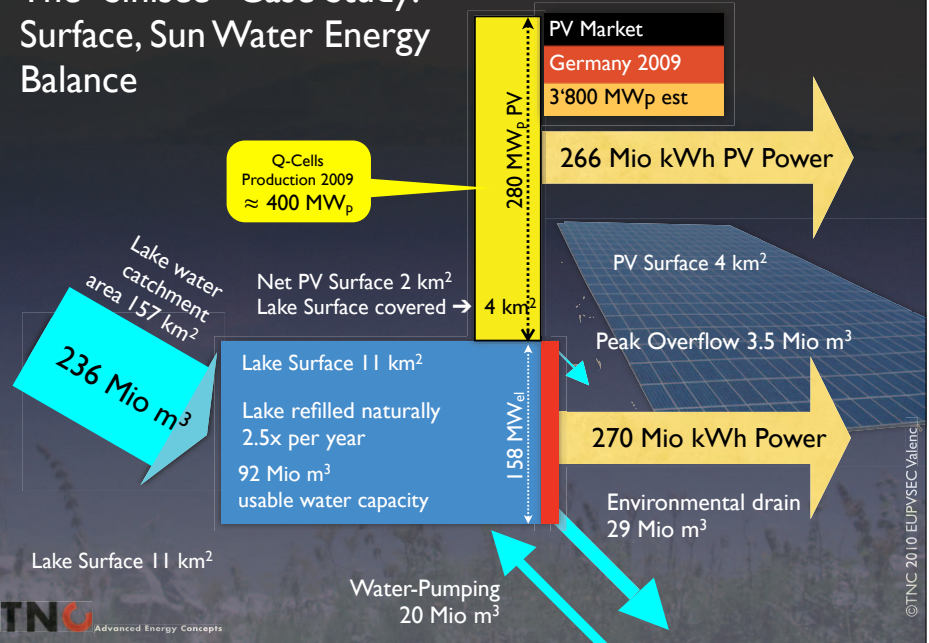
The Swiss hydroelectric-lake universum



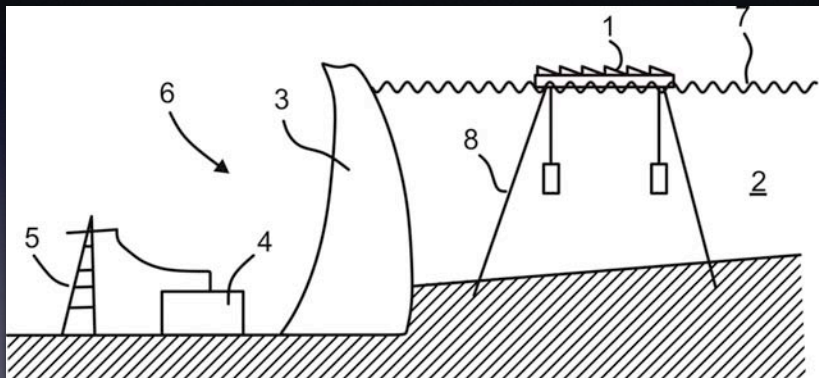
The "Sihlsee" Case Study



The "Sihlsee" Case Study: Surface, Sun Water Energy Balance



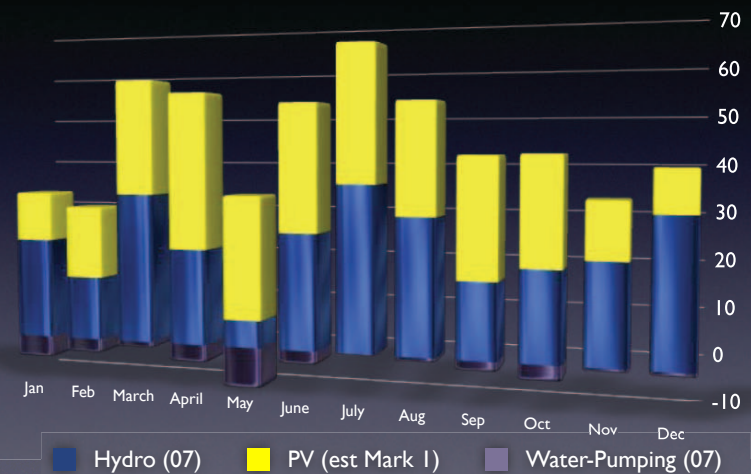
Hybrid PV hydro electricity using floating PV devices on water (Patent pending)



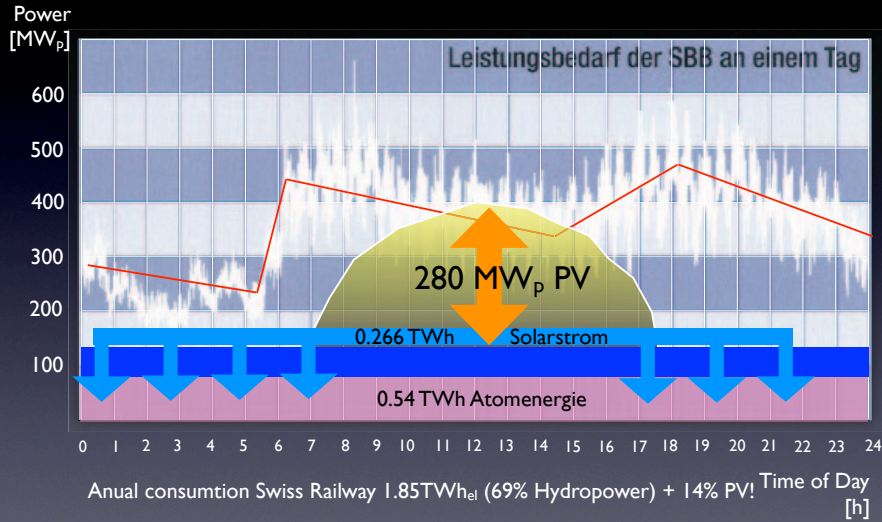
The "Sihlsee" Case Study Power output

158 MW Hydro_{el} plus 280 MW_p PV

yield [mio. kWh/month]

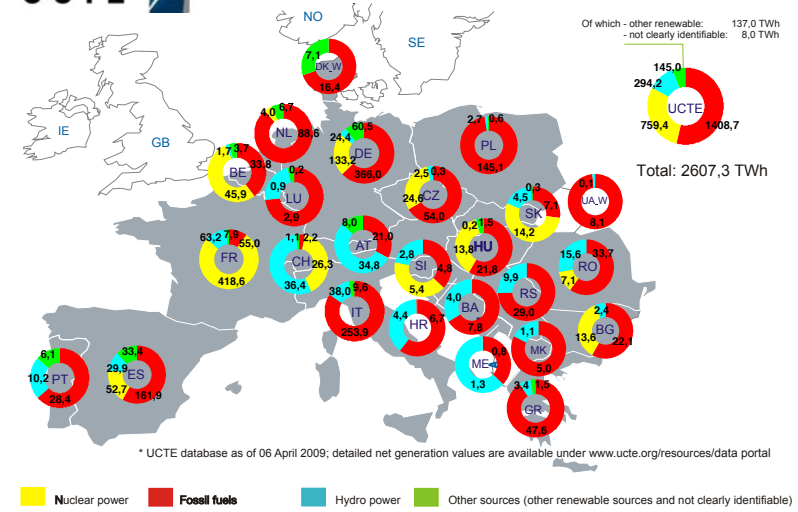


Typical 24h total power load profile of Swiss Federal Railway SBB



Net generation 2007 in TWh *

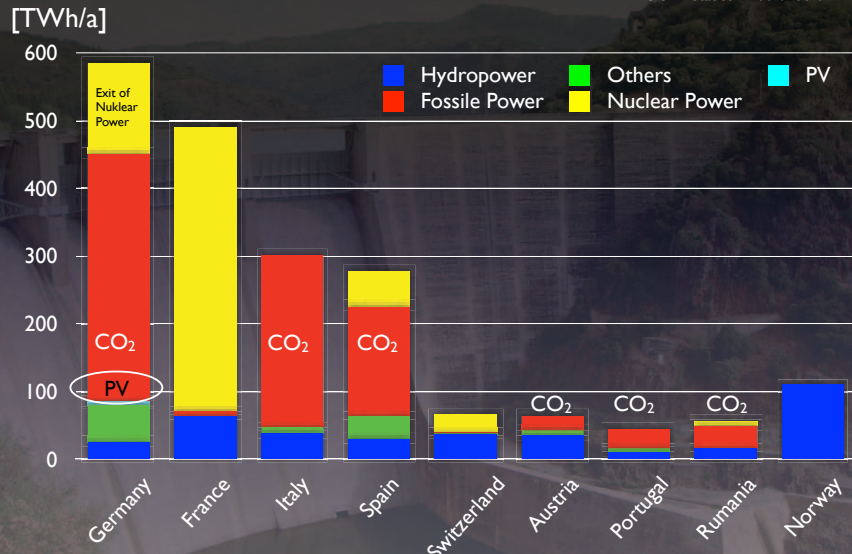
* All values are calculated to represent 100% of the national values *



* UCTE database as of 06 April 2009; detailed net generation values are available under www.ucte.org/resources/data_portal

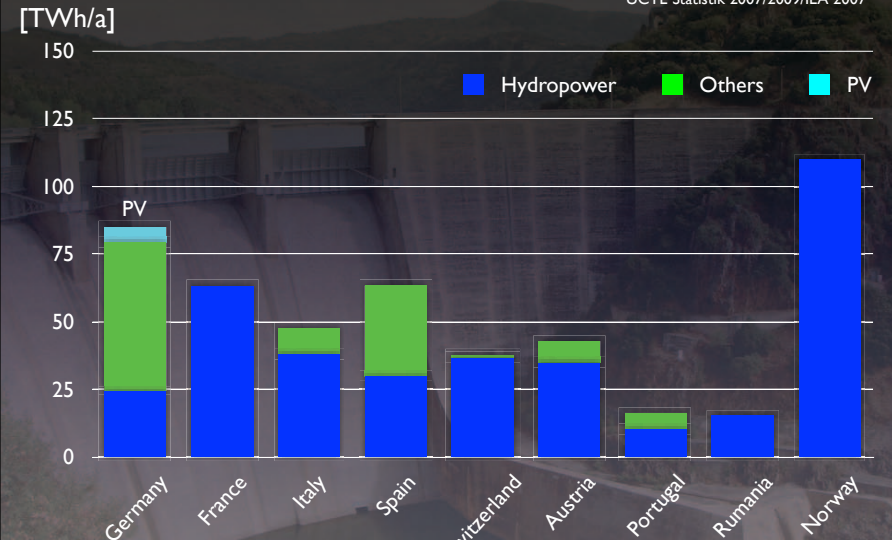
Sources of electric power production in Europe

UCTE Statistik 2007/2009/IEA 2007



Sources of electric power production in Europe

UCTE Statistik 2007/2009/IEA 2007



European Commission
Joint Research Centre

Heinz Ossenbrink,
Thomas Huld, Katalin Bodis

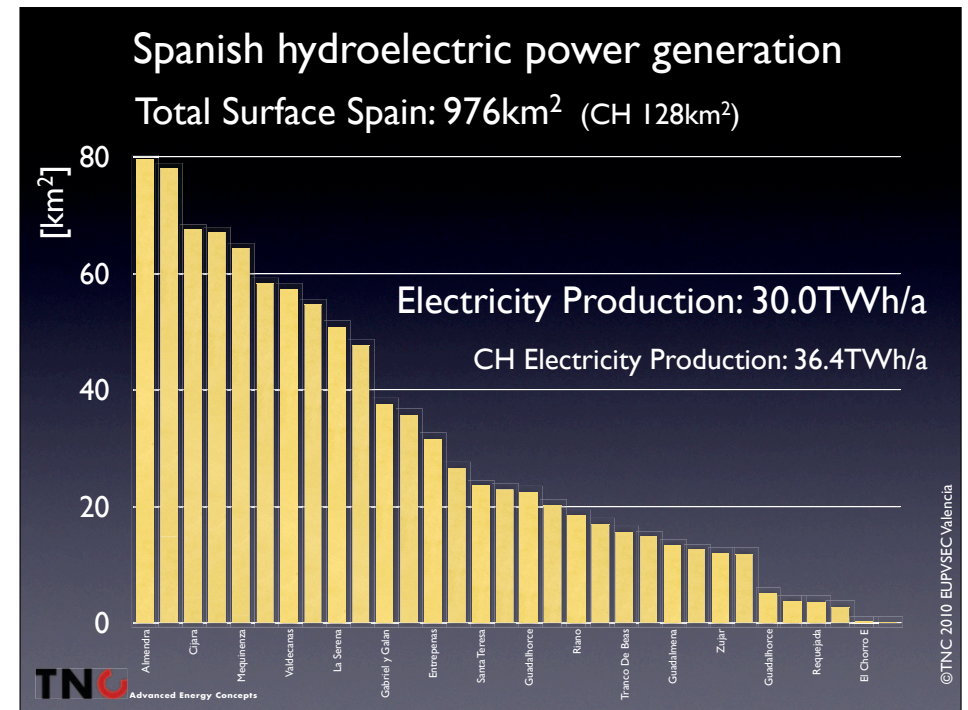
- Evaluation of installable PV capacity on artificial lakes used for hydropower
- Databases containing geographical information
- Simulation of solar radiation on lake surfaces

Direct Normal Irradiation Spain and Portugal

TNC Advanced Energy Concepts

GeoModel | solarGIS

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Potential for hybrid PV hydro power plants in Spain

- Hydropower storage lakes: 976km² surface area, little shading
- PV: 12.5% Module efficiency, 20° tilt, south oriented
- Simulation of DC PV power output was done with PVGIS at JRC Ispra for spanish hydro power lakes (1'400...1'700 kWh/kW_pm²a)
- Assumptions: 1%, 5%, 10%, 25% of surface area used for PV (active Module area)

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Potential for hybrid PV hydro power plants in Spain

	1% PV area of total lake surface	5% PV area of total lake surface	10% PV area of total lake surface	25% PV area of total lake surface
Nominal PV power [GW _p]	1.22	6.1	12.2	30.5
PV power output AC [TWh/a]	1.56	7.8	15.6	39.0

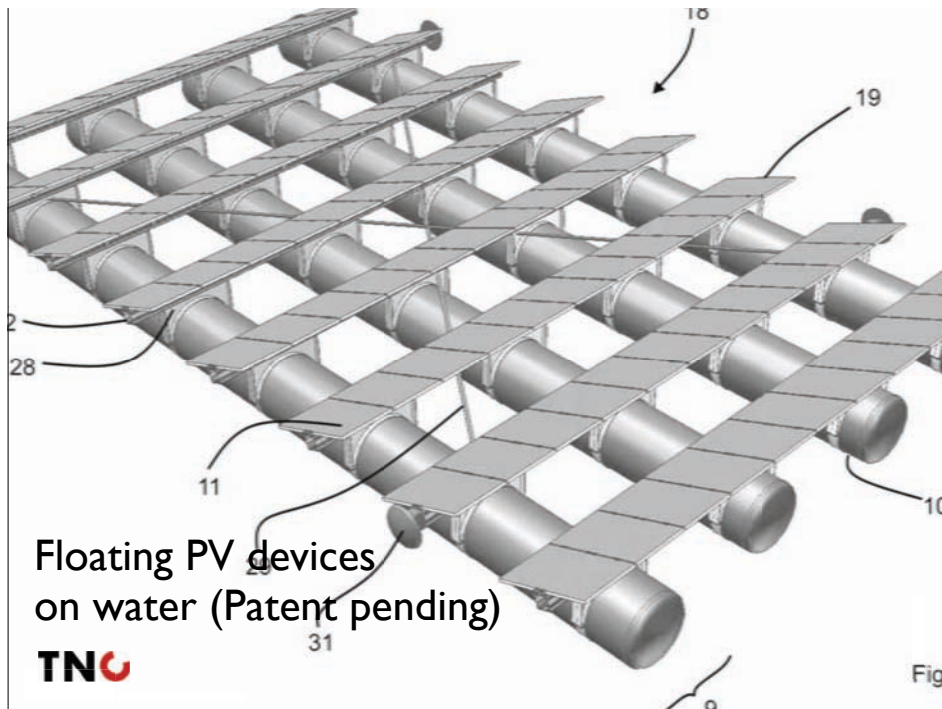
Total Spain Production 278 TWh/a UCTE 2007

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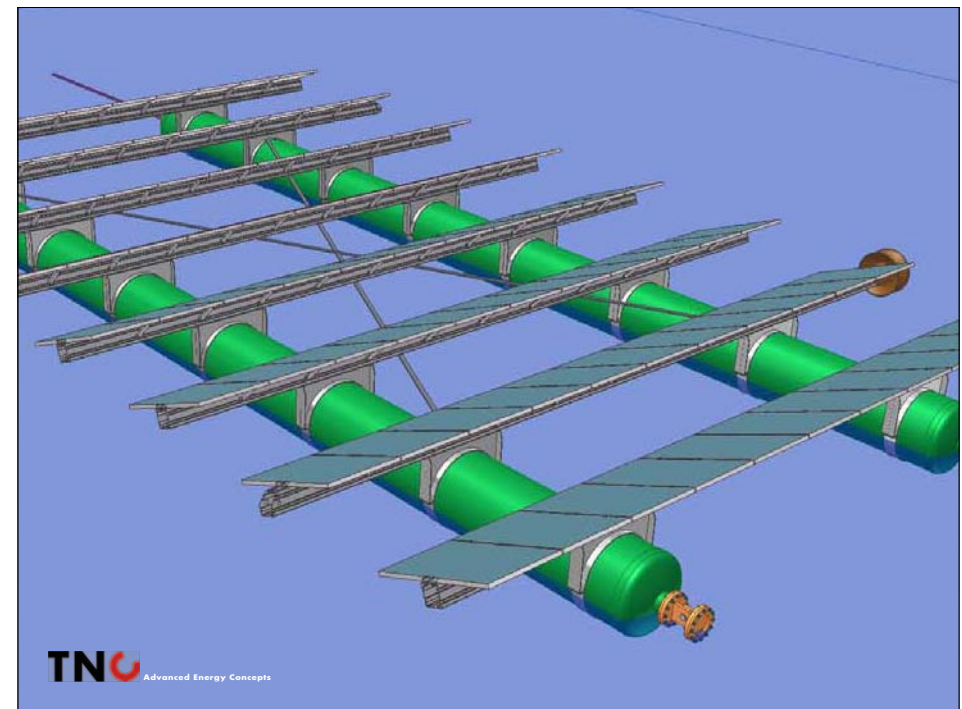
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







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



Chances ...

-  Innovative approach to optimize and expand energy production of existing hydro power plants
-  Easy multiplication on different sites with little changes in blue print possible
-  Modularity allows easy scaling of plants from 10kW_p to multi MW_p
-  Hybrid Day and Night power production and storage possible
-  Third way for fast PV deployment and market development
-  (Surprisingly) high energy density of PV compared with hydro power production

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and Challenges ...

-  How is the political, legal and social acceptance for hybrid use of artificial hydro power storage lakes?
-  How can maintenance costs be kept low?
-  What is the impact of snow and ice during winter?
-  How can we control the impact of barnacles and algae on the floating devices during summer?
-  What are the best solutions to adapt to the large changes of fill level in hydro power storage lakes?
-  How can the benchmark costs of a conventional PV power plant be reached?

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PV TAKING OFF: LARGE-SCALE DEPLOYMENT

New Markets for large-scale PV applications

- PV markets for grid-connected applications focused so far on roofs, facades and large, free-standing plants
- These projects need large efforts for project-individual components during planning, legal issues, financial engineering, permits, etc.
- For free-standing large plants there are (justified) concerns about land-use, social acceptance, etc.
- In order to keep up fast dissemination of PV new large-scale projects have to be found
- Hybrid PV hydropower plants offer a possibility for large-scale PV plants with little adjustments needed to the original blueprint!

