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Damming China's and India's Periphery: An Overview over the Region's Rapid Hydropower Development

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1. Introduction

To sustain their impressive economic growth and to provide electricity for the two most populated states, PR China and India are aggressively developing their energy sector. Regenerative energy, mainly hydropower, plays a key role in their present and future energy sector strategy. The speed of hydropower development shows a dimension which is unique worldwide. This extreme rapid development is mainly based on controversial large dams, but also on the fast development of small scaled hydropower projects.

The following chapter uses a geographical perspective to compare and to analyse the two states in their past, present and future hydropower development. Based on a political-ecological approach the chapter studies the institutional, spatial, environmental and socio-economic challenges and problems related to hydropower development in China and India. Although the focus is on large hydro schemes, and often they are so large that they can even referred to as mega-projects, the chapter includes also the development of the small hydropower sector.

The chapter compares and discusses similarities and discrepancies of the hydropower development in China and India. First it studies the relevance of the hydropower sector in the wider field of power development and power mix and further it discusses spatial as well as institutional challenges related to the fast developing hydropower sector. Second the chapter analyses in a more detailed scale the massive hydropower development in Asia's water tower, which is the transition area between Northeast-India and Southwest-China. This region has worldwide the highest potential in hydropower development and is therefore tagged as one of the world's future power houses or batteries. It shows the spatial consequences from that development and discusses it in its institutional, environmental and socio-economic implications. The last paragraph goes beyond that region and studies the conflicts and trends of internationalising hydropower business in Asia, mainly in the adjacent transboundary watersheds.

The chapter is based on extensive field work in China, mainly in Yunnan and on minor field work in India. The author visited many existing hydropower stations and potential hydropower locations and conducted semi-structured interviews during several field visits between 2009 and 2011 with researchers, members of hydropower companies, government

officials, and policy advisors. Further interviews were conducted with representatives of foreign non-governmental organisations and consultants doing services in China and India as well as with other researchers working on the topic in China. Given the delicate political nature of the issue, all interviewees from China were anonymity assured.

2. Overview of China’s and India’s power sector

2.1 Present state of the power sector in the two countries

China and India are the two most populated countries in the world. Additionally the economic growth rate of both countries belongs to the highest in the world and the GDP-growth has also maintained high over a long period. The national economic growth in both nations is inevitably accompanied with an increasing demand for energy in general and electric power in particular. To sustain their impressive economic growth both states have been developing aggressively their energy sector. The challenge of their rapidly growing energy and power sector in the 21st century is unparalleled in the world. Finding a proper solution for this energy bottleneck will determine the economic, social and sustainable future of China as well as of India.

A key issue within the present and future energy sector strategy is to solve the generation and supply of electrical energy. On one side the power sector has to grow slightly faster than the GDP-growth and on the other side is the present need for power for an average Chinese and Indian merely 1 kW/person, which is far inadequate compared to 11 kW/person for an average US person and ~ 3.5 to 5.5 kW/person for a Western European (Cahen & Lubimorsky, 2008, as cited in Chang et al. 2010).

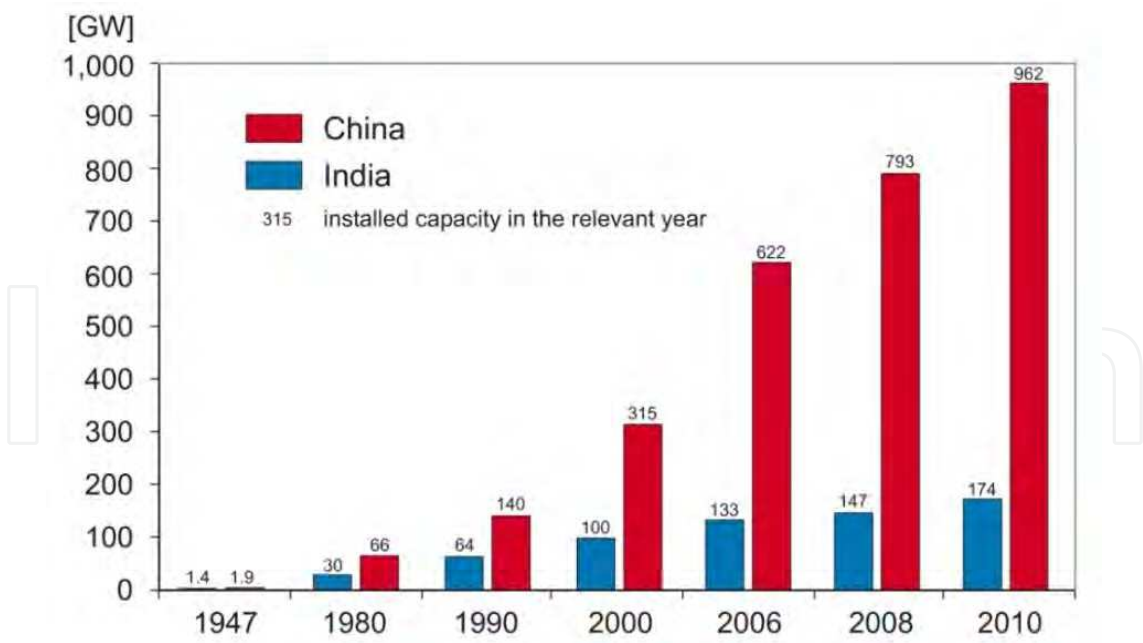


Fig. 1. Comparing China’s and India’s total installed power capacity for selected years

Despite the fact that the challenges of the power sector are in many ways similar, the present state of the sector varies considerably between the two nations [cp. Fig. 1]. Compared to India, China had from the beginning a higher installed capacity as well as a higher energy

production output. Over the years the gap between the two nations grew steadily. In the beginning of both nations (late 1940s) the installed capacity was with 1.8 GW (China) and 1.4 GW (India) quite low. Today (Dec 2010) China's installed capacity is 962 GW, while India's part grew to 171 GW. In mid-2011 China exceeded as the second country the 1,000 GW of installed capacity and soon it will lap the USA as the world's country with the highest installed capacity.

The growth of the Chinese energy sector is so impressive, that in less than two years China adds a new installed capacity which is similar to the total installed capacity of a strong West European economy like Germany or France. This fact is even more impressive, when it gets considered that since 2007 China closed about 77 GW of old, small and inefficient thermal power plants.

Despite the strong growth China's power sector faces cyclic shortages, the latest were in 2002-05 and in 2010. Contrary to the temporary Chinese power problems, is the Indian power sector characterized by a chronicle deficit, which is still about 7%. India's actual shortage would be much higher when the peak demand is considered as well as the unscheduled power cuts. The ambitious goal of the Indian government solving that problem by 2012 seems rather unrealistic.

2.1.1 Thermal power

It is well known for both countries that the primary energy resource is coal. About two third of the installed capacity is thermal power (mainly coal, but also gas and petroleum); its share in the energy production output is even higher. Similar in both countries is also that the coalfields are quite far away from the load centres. Additionally India lacks on sufficient high quality coal, China only to some extent. For that reasons coal either has to get transported over long distances which affects the efficiency of the railways or they have to get imported from other nations (e.g. from Indonesia, South Africa, Australia, etc.). In particular for China's booming South Coast it is cheaper to import the coal from abroad, rather than transport it from Northern China.

To solve India's serious power shortage the government pursues the construction of huge 'hubs' of thermal power stations around selected sea ports. Mainly based on imported coal, state-owned as well as private power companies construct here large thermal power stations. In those hubs the Indian government allows also smaller power plants which often cause serious environmental impacts.

While China's power generation is mostly in the hands of a few state-owned and to some extend also provincial owned generation companies, the share of India's private sector in capacity expansion has gone up substantially over the past decade. It is expected that its share is growing from presently one third to 50 per cent of the total incremental capacity over the next Five Year Plan (2012-17).

2.1.2 Nuclear power and renewables

Beside the massive development for thermal power stations both countries are seriously working in diversifying their power mix and reducing the ratio of carbon emissions. One option has been massive investments in nuclear power development, which plays so far in

both states only a minor role. Despite its scheduled impressive absolute growth rate, relatively nuclear power plays also in future only a minor role. Due to the Fukushima accident in early 2011, China put some of its nuclear plans on hold, while India is proceeding with its nuclear ambitions.

Another option for reducing carbon emissions and diversifying the power portfolio is the development of renewables. In both countries are the absolute growth rates impressive, also they started at a relative low level. India is here relative more successful than China. Massive investments will boost the installed capacity of Wind, PV and Solar energy. Both countries have large territories and one challenge is that the generation areas are far away from the load centres. Massive investments in the relevant transmission system are due to the unstable generation of renewables often not justified.

Under the above premise solely hydropower is the only real alternative to thermal power, for it is considered as a renewable, clean and cost-effective resource. Its relevance has also to be seen in the context of reducing carbon emissions and dependency on fossil energy resources as well as of optimizing the power portfolio (base vs. peak load).

Following is explained the relevance of the hydropower sector in the present and future power scenarios, but it should get distinguished between the small and large hydropower sector.

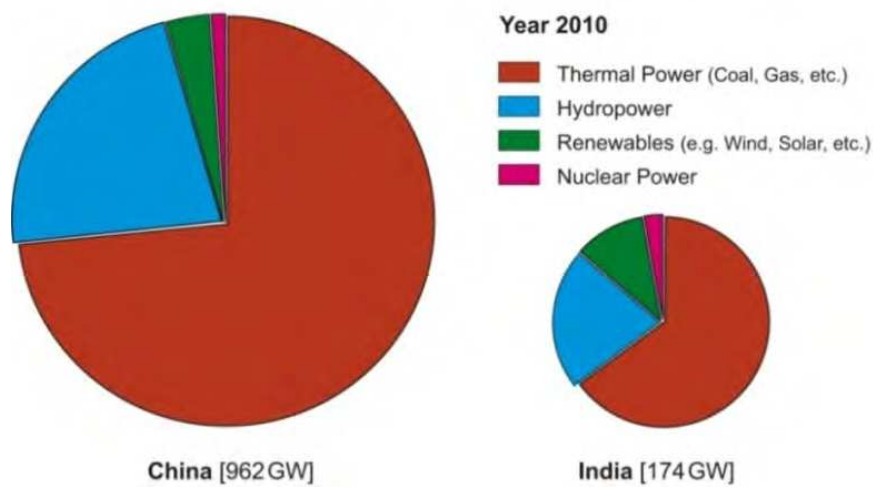


Fig. 2. Comparing the power mix of China’s and India’s total installed capacity in 2010

2.2 Role of the hydropower sector in the present and future power scenarios

Parallel to the rapid development of China’s and India’s power sector in general increased also their hydropower sector.

In 2010 out of the 962 GW of Chinese installed capacity, immense 213 GW or 22% were generated through hydropower. The same 22% is also India’s hydropower generation, but this is absolute only 38 GW.

In the global context China ranks first and has by far the highest installed hydropower capacity (cp. Tab. 1). The 213 GW (2010) are so high, that it almost exceeds the cumulative installed capacity of the USA, Canada and Brazil which rank second, third and fourth. India ranks regarding the installed capacity after Russia on place six.

2008	Installed capacity [GW]	% of total capacity	Annual hydroelectric production [TWh]	Economic exploitable hydroelectric production [TWh]
PR China (2010)	213,4	22,2	721,0	1.753
PR China	171,0	21,5	580,0	1.753
United States	79,5	5,8	254,8	376
Canada	73,4	61,1	377,4	536
Brazil	77,5	85,6	365,1	818
Russia	49,7	17,6	180,0	852
India	36,9	15,8	115,6	442
Norway	28,3	98,2	140,1	206

Table 1. Comparison of the world’s largest hydropower producers regarding installed capacity and annual hydroelectric production for 2008. Notice: Except China there are no substantial changes in other countries between 2008 and 2010

(Data compiled by author from different sources; 2008 data: World Energy Council. 2010 Survey of Energy Sources)

2.2.1 Brief overview about historical hydropower development

Before the present and future role of the Chinese and Indian hydropower sector is discussed, a brief historical overview is given. The Sidrapong hydropower station near Darjeeling (2*65 kW; later renewed and increased), finished in 1897, was India’s first hydropower station; while China’s first one was built in 1912 in Shilongba (2*240 kW), near Yunnan’s provincial capital of Kunming.

With the founding of their nations in the late 1940s China and India had only a specific number of smaller and a very limited number of larger hydropower stations. This situation was very different from Europe and the United States, which had at that time not only a bigger number of dams but also larger hydropower stations constructed. The US Hoover’s Dam initial 1,345 MW power plant, constructed in the early 1930s on the Colorado River, was at that time by far the world’s largest hydro dam. Only a decade later it was already eclipsed by the 6,809 MW of the Grand Coulee Dam on the river Columbia.

The situation began changing in the 1950s. In particular in the context of the early industrialization of that period the hydropower sector developed fast in China and India. At that time both states were supported and assisted in their hydropower programmes by the Soviet Union. In particular larger projects incl. dams were very prestigious for the young nations, although they required large initial capital outlays. The large dams of that time were mostly multipurpose projects and hydropower generation was only of minor relevance and often justified the large irrigation investments related to that projects.

In both countries the relative share of the hydropower sector grew fast and reached its peak about 30 years ago. In India it was in the late 1970s as the installed capacity was almost 40% and in the energy output the relative share was 45%with even higher even. In China the

peak of the highest hydropower share in the energy portfolio was almost a decade later and, compared to India, the peak was also less (around 30%). Today in both countries the share of the hydropower sector is declining rapidly although the absolute growth is impressive. The relative energy output is declining even faster.

2.2.2 Hydropower potential

China and India combine together about two third of the world's 45,000 large dams. The figure includes dams over 15 m in height or, if less, the reservoir should have a capacity of more than three million cubicmeter. Despite the fact that China and India have combined more than one third of the global gross installed hydropower capacity, is their development level still quite low.

The exploitable hydropower potential has been analysed in both states by different national large-scaled general surveys. China's latest and fourth survey was published in 2005, whereas India's last re-assessment studies were completed in 1987. In consequence from these surveys both countries identified major hydropower bases; India six and China fourteen, whereas the Yarlung Tsangpo is officially not recognized as a base so far (cp. Fig 3).

The stage of development can vary considerably between these hydropower bases. In those surveys it gets distinguished between the technically exploitable and the economic exploitable capacity, whereas the first is naturally far higher. For China the economic exploitable hydropower potential is assessed to 402 GW (1,750 TWh/a), while that for India is 149 GW (660 TWh/a).

The core of that potential is located in the southern adjusting mountain ranges of the Tibetan plateau, which is ranging from the Karakorum over the Himalaya up to the Hengduan mountains. This region has globally the highest hydropower potential and is therefore called Asia's water tower. Within that water tower the key region for the present hydropower development is the transition area between the states of Northeastern India (mainly Arunachal Pradesh) via Myanmar to the Southwest Chinese provinces (mainly Yunnan and Sichuan). The present state of hydropower development in that region as well as potential future projects are discussed in chapter 3.2.

2.3 Spatial and institutional challenges of hydropower development

Neither in China nor in India hydraulic resources with their extremely uneven distribution do match with regional economic development (Chang et al. 2010). The economic hubs with their often high energy demand, which are in China the Southern and Eastern coastal regions and in India selected metropolises of South- and West-India, are mostly far away from the hydropower generation areas.

To get the electric energy to these far away load centres a robust, efficient and expensive high-voltage transmission system is required. In that context it is not amazing that in particular China and to some extend also India are increasingly using UHVDC (ultra high voltage DC) for long distances transmission. This is presently the technically most advanced technology and has only minor losses, although it is far more expensive than the common high voltage AC lines. Quite a few countries are using worldwide this technique, but often only over short distances. China developed over the past few years the world's most powerful DC lines. It

should be already here indicated that the development of hydropower is a major driver for the development of the globally most advanced transmission technologies.



Fig. 3. Economic exploitable hydropower potential of China's and India's hydropower bases as well as of selected neighbouring states.

Another challenge of hydropower development is the fact that most of the key hydropower bases are affected by the monsoon climate with its uneven intra- and inter-annual runoff distribution which causes great differences between rainy and dry seasons. This results in a large quantity of non-beneficial spillage during the rainy season and a deficient generation in the dry season. Then hydropower has to get compensated mainly by support from thermal power. To reduce this discrepancy both countries are also investing heavy in the construction of pumped storage systems. Compared to the large scaled hydropower stations, the large scaled pumped storage projects are mainly located near the load centres. In 2010 China had a hydropower storage capacity of 14.6 GW, which ranks third in the world. But in an ambitious programme it should almost triple to 41 GW over till 2020 (Reuters, 9 June 2010).

India's hydropower storage capacity is presently merely 5 GW, but is also growing slowly.

Most of the hydro projects in China and even more in India are not developed solely for power generation and are therefore multipurpose in nature. Due to the large initial capital outlays for these projects, hydropower provides often the means to pay for required irrigation and related food security as well as for water supply or flood control. In particular the early prestigious projects were multipurpose dams, in which the primary purpose was mostly irrigation. The problem is that the timing for irrigation often competes with the main demand for power generation.

Only over the past decade many projects have been constructed in more suitable humid and mountainous areas, where hydropower became either the solely purpose or it has been the major one. Irrigation plays in most of the recent projects a less crucial role and therefore flood control and improved navigation become beside power generation a primary purpose.

Large hydropower projects require also large capital investments which are often, except for limited prestigious projects, even for governments difficult to arrange. China and India were for long no exceptions, but for China the situation changed over the past decade.

China became due to its growing economic and financial strength less dependent on foreign sources for the financing of its dams. Only at certain projects the Worldbank (WB) or Asian Development Bank (ADB) has been get involved; the 3,300 MW Ertan hydropower station in Szechuan province is a famous example. Built in the late 1990s it was largest hydropower project before the Three Gorges Dam China's. Finished before the World Commission on Dams published its strategic priorities for improved decision-making, management and planning of dams, Ertan received one of the largest single project credits from the Worldbank and it was China's first hydropower plant to be built through international bidding as China's first 200m dam.

China's provinces have been funding only a few large hydropower stations, mainly relevant projects to sustain their own energy needs; hence the majority of the recent and future large and prestigious hydropower stations are funded by the central government. This situation of financing so many large hydropower projects by a state government is worldwide unique. China's main challenges of ongoing large hydropower projects are the resettlement issues including related costs. There are currently about 23 million registered relocates in China (Hensengerth, 2010), if the number of former past projects is included, the figure is much higher. The consequences caused by resettlements (social implications, large costs, etc.) are a key reason that there are hardly any new large and present hydropower projects in the densely populated Eastern part of China.

Compared to China's financial strength, India still has great difficulties to mobilize finances for the implementation of its planned large hydropower schemes. Therefore it can presently only fund a few large, public projects that are considered of national importance. Alternative funding is for India quite important. It still relies on financial institutes (e.g. WB, ADB or International Finance Corporation) and on cooperations with international agencies (e.g. Germany's KfW) or private partners (e.g. Norway's Statkraft). Parallel is India seriously looking for tapping into the BOT market while allowing private hydro developers (Ramunathan & Abeygunawardena, 2007).

In the context of the challenging power and energy sector incl. the large financial constraints related to it, both countries initiated various reforms of the energy market inclusive the hydropower sector. Following is given a short overview over these reforms.

China	India
Generation companies	
public	
Datang -China Datang Corporation	NHPC - National Hydropower Corp. of India
Huaneng - China Huaneng Corporation	NEEPCO - North-Eastern Power Corp. Ltd.
CPI - China Power Investment Corporation	SJVNL - Sutluj Jal Vidyut Nigam Ltd. (JV between the Gvt. of India & Gvt. of HP)
Huadian - China Huadian Corporation	NTPC - National Thermal Power Corp.
Guodian - China Guodian Corporation	THDC - Tehri Hydro Development Corp. (JV between Gvt. of India & Gvt. of UP)
CTGPC - China Three Gorges Project Corp.	NHDC - Narmada Hydroelectric Devel. Corp. (JV between NHPC & Gvt. of MP)
private	
Hanergy - formerly: Farsighted Investment Group	Reliance Power
CHC - China Hydroelectric Corp.	Athena Energy
	Jindal Steel and Power Ltd.
	Jaiprakash Associates Ltd.
	KSK Electricity & KSK Energy
	DSC Ltd.
Other companies (transmission & distribution; financing; design; consultancy, etc.)	
SGC - State Grid of China	PGCI - Power Grid Corp. of India
CSPG - China Southern Power Grid	PFC - Power Finance Corp.
Sinohydro Corp.	WAPCOS - Water & Power Consultancy Services
Hydrochina Corp.	

Fig. 4. Major drivers and actors of China's as well as India's hydropower development.

2.3.1 Reforms of India's electricity and power market

India's power market was already opened in 1991 and various policy initiatives were taken for increasing the hydro capacity and the participation of private entrepreneurs. Despite these efforts in 2007 the public sector had still a predominant share of 97%. In one of the initiatives the Central Electricity Authority (CEA) prepared in 2001 a vision document giving a road map for expediting hydropower. In that report about 400 schemes totaling about 107 GW have been ranked from the point of view of attractiveness. In a further step the status of a Mega Hydropower Projects were introduced with the goal for bringing substantially down tariffs due to reduced levies, taxes, etc. The threshold for a Hydro-Mega-

Project is 500 MW and 350 MW for peripheral place like Northeast India, Sikkim and Jammu & Kashmir. In another move a three stage clearance procedure should encourage private entrepreneurs to enter into the otherwise high risk hydropower investments. Stage I results in a pre-feasibility report; stage II in a detailed project report (incl. also pre-construction activities, infrastructure development and related land acquisition) and under stage III the investment decision will be given after approval of all the documents.

Despite these initiatives almost all the Mega Hydropower Projects are owned and invested either by the central- or by state owned power generation companies or corporations (cp. Fig. 4). So far the 1,000 MW Karcham Wangtoo hydro scheme in Himachal Pradesh (commissioned in 2011) is the only private funded Mega hydropower project; however in Northeast India a few more are under construction or in planning. An overview over the present and future multiple hydro schemes in Northeast India, which distinguish in certain ways from the rest of India, is given in chapter 3.2.1.

To encourage hydropower development as well as looking for a tool for local development in peripheral regions, the Indian Prime Minister launched in 2003 in a landmark move the so called '50,000 MW hydro initiative'. Under this scheme preliminary feasibility reports for 162 large and medium sized projects with a capacity of 47.9 GW were prepared. Out of these 162 schemes, 133 are in the Indian Himalayan Region (IHR), mainly in Arunachal Pradesh.

Contrary to large hydro schemes, medium to smaller hydropower projects in India are funded and allocated by a competing market of diverse public and private companies. In particular its Ministry of New & Renewable Energy encourages and supports small hydropower projects. Additionally the CDM market attracts hydropower investments, in mid-2011 about 80 hydropower projects are already registered and another 120 projects are at validation (<http://cd4cdm.org>; 09.Sept.2011).

India's hydropower development has also to be seen in the context of building up a strong and vibrant national grid which so far is quite fragmented and split into five regional grids. Today almost half of India's present power transmission is done by regional grids or private funded transmission lines. The latter permit in particular for high energy consuming enterprises a direct commercial relationship to a generation company; some of the large hydropower stations have such an arrangement.

Avoiding a further fragmentation was 1991 the national Indian Power Grid Company incorporated, which carries now about 51% of the India's generated power. One of its major objectives is creating a strong and vibrant national grid. Therefore it already gained that four of the five Indian regional grids are now operating synchronously. Another objective is connecting the regional grids with that of neighboring states like Sri Lanka, Nepal and Bhutan.

2.3.2 Reforms of China's electricity and power market

With the breakup of the former Chinese Ministry of Energy in 1997 and the subsequent State Power Corporation in 2002 the Chinese power generation was separated from the grid but also from the projection. The state power monopoly was in the context of generation split into five national generation holdings (so called 'Big Five': Huaneng, Datang, Guodian, Huadian and China Power Investment) and later came along the Three Gorges Corporation

as the six major hydroelectricity generation company. These six national holdings control a major part of the Chinese power generation and regarding large hydro schemes they control, beside some provincial owned holdings, the market almost exclusively (Hennig, 2007).

Similar to India only a few larger hydro projects are also funded by private companies, whereas they often have an affinity to the political circles in Beijing. The smaller the hydro projects become, that often private entrepreneurs and also local cooperatives invest in hydropower, most of these private investors come from the economic boosting areas of Coastal China. A more detailed overview is given in chapter 3.2.

China's policies designed to support hydropower are formulated at different levels. Chief among them is the Programme for the development of the Western Regions, officially instituted in 2001. Mainly infrastructure development (incl. hydropower) is seen as a key instrument for closing the disparity gap between the rich coastal Chinese provinces and the poor interior western provinces. Under that framework falls also the policy of Send Western Electricity East and Send Yunnan Electricity to Guangdong, another policy is the Rural Electrification Programme which promotes more local and also smaller hydropower development (Magee, 2006; Tullos et al., 2010)

Due to the above indicated facts that most of the hydropower regions are far away from the load centers the various grids and transmission lines play a crucial role in both countries. Until recently the Chinese provinces as well as the Indian states owned mostly their own grids. In the context of the above mentioned Chinese power reforms, two large power grid holdings emerged: China Southern Power Grid Company which is in charge of five South-Chinese provinces and the State Grid Corporation which controls the rest of China. Over the last years all the provinces got interconnected in one of the two grids, except Tibet where it is due to the difficult terrain still under construction. As the first country worldwide China started in 2009 a powerful long-distance high-capacity power transmission technology using direct current. Aiming to bring more power from its remote western and northern regions to the energy-hungry East and South coasts, China is the only country in the world which plans to build large ultra-high voltage (UHV) power-line networks. For that goal four other major lines are under construction or were finished in the last two years.

2.4 Brief introduction of China's and India's small hydropower sector

There is no internationally consensus on the definition of small hydropower (SHP). In Europe is the generally accepted norm 10 MW (European Small Hydropower Association), while in India it refers to a capacity up to 25 MW and in China depending on the context between 25 and even 50 MW.

In India SHP was neglected over a long time. Only after the present and renamed Ministry of New and Renewable Energy was formed in 1992, the development of SHP projects acquired good pace. However the policy and therefore the implementation varies considerably between the Indian states. India is planning to increase the SHP power generation capacity from present 900 MW (2009) to about 7,000 MW by the end of the 12 year plan (2017). From the potential 5,415 identified SHP-sites, merely about 800 have been implemented so far (Nautiyal et al., 2011). Except for remote villages, mainly in the Himalaya, most of India's SHPs are feeding into the regional as well as the national grids. Naturally the largest potential is in the Himalayan states and along the Western Ghats.

Also due to the other definition of SHP, China's potential as well as its implemented capacity is far higher. Already in 2005 more than 40,000 SHPs had an installed capacity of 38 GW and an annual average power generation of 130 TWh, which was about one third of the total hydropower generation in that year (Huang & Yan, 2009). China's major backbone for rural electrification has for long been SHP and about 653 rural counties had achieved preliminary electrification from SHPs. Today, with the rise to about 55 GW installed SHP capacity (in 2009) China's SHP sector has become a major grid feeding player. Despite its strong growth, the development is still far below its estimated potential of 128 GW capacity and 450 TWh/y average generation (Huang & Yan, 2009).

Additionally China has been establishing about 15 bases and Yunnan province another two bases, each having a capacity of about 1,000 MW each, which mainly consists of small hydropower projects. These SHP-bases are a specific and unique characteristic of China's ambitious SHP development. Their development is mainly driven by private entrepreneurs as well as local governments and local power grids.

3. Hydropower development in Asia's watertower

3.1 Common natural and cultural heritage of the case study areas - the key region between SW-China and NE-India

As mentioned above the southern adjusting mountain ranges of the Tibetan plateau, which are ranging from the Karakorum over the Himalaya up to the Hengduan Mountains, have the world's largest hydropower potential and supply water for almost half of the global population and regulate the climate in upland and lowland areas of Asia adjacent to it (Jianchu, 2007). Within that region, the core area for present hydropower development is the transition area between the states of Northeastern India (mainly Arunachal Pradesh) and the Southwest Chinese provinces (mainly Yunnan). This key region for hydropower development features, despite its present political splitting into different states, geographically a similar natural as well as cultural characteristic. It can even be regarded as one cultural landscape.

Following is given a short introduction of that region.

3.1.1 Environmental diversity

The Tibetan Plateau in general and its south-eastern extension (incl. its adjacent mountain ranges) in particular play as part of the 'Asian water tower' a crucial role. Some of the world's largest rivers with their tributaries flow through the region (e.g. Yarlung Tsangpo/Brahmaputra; Jinsha/Yangtze; Lancang/Mekong; Nu/Salween, and Irrawaddy). In that region the rivers change their topography (hydraulic gradient) from plateau via a long transition area with often deep gorge topography or rain-drenched Himalayan slopes to that of lowland topography and landlocked alluvial plains. Combined with its wide range of climatic setting is the region one of the global core areas for hydropower development, both that of larger scale as well as of smaller scale.

The area is a product of the collision and subduction of the Indian subcontinent with Eurasia, resulting in an impressive geodiversity but also in a fragile geological base and active seismic-tectonic instability. This unique physiogeographic setting includes with the

Eastern Himalaya and the Hengduan Mountains some of the highest mountain ranges in the world. But it includes also diverse Karst landscapes and huge plateaus and basins. The territory's geodiversity, combined with a climatic setting that ranges from tropical to temperate, has led to a unique diversity of ecosystems: from tropical rainforests in the south to shrub and grasslands in the mountainous north.

This small region is part of three of the world's major biodiversity 'hotspots' and several important ecoregions (WWF 2001). Alone the province of Yunnan hosts about half of China's biodiversity and boasts the second highest species abundance index in Southeast-Asia (Kwai Wong, 2005) and Northeastern India houses 21% of India's important bird areas, identified as per international criteria (Vagholikar & Das, 2010). Larger areas in that region are still poorly documented and biologists have been discovered in recent years a number of new species including large mammals.

3.1.2 Heritage and ethnic diversity

For more than 2000 years the region and in particular areas of today's Yunnan province were a major trade hub along the southwestern silk road connecting China with the economic centres of Southeast Asia, Tibet and India. The regions long and outstanding role in regional trading history has led to thousands of years of migration in and out of the region. While many of the migrant groups were small and assimilated with the local population, several were big enough to establish independent local and regional empires (e.g. bronze-age Dian-culture, medieval Nanzhao and its successor, the Dali empire and the medieval Ahom empire; Hennig & Linde, 2008).

A result of this history is a remarkable ethnic and cultural diversity, which makes this region the ethnic-richest area in India as well as China. Most of the hydropower projects under construction and / or planned are situated in areas inhabited by these minorities.

3.1.3 Economic potential and regional commitments and initiatives

Northeast India is a collective term for the eight states of that area, which are connected to the subcontinent only via the 22 km narrow Siliguri corridor, which is popularly referred as Chicken's neck. Hence, the region is similar to Yunnan in a peripheral and economic disadvantaged position. In spite of massive infrastructure improvements the economic and political centres of both countries are still far away.

Despite this economic disadvantage the region has the privilege to be a key passage between China and India as well as to Southeast Asia. Therefore it is in a good geostrategic position regarding favourable revenue arrangements and allocating funds for regional infrastructure development, mainly construction and upgrading of roads, railways, waterways, and pipelines. This infrastructure development has to be seen in the context of the rapid economic growth which causes a seeking for additional resources, trade- and market links to sustain it (Hennig & Linde, 2008). Therefore both countries expand their bilateral partnerships - often based on already existing political dependencies and patronages as well as increasingly engaging in multilateral partnerships. Fostering such transboundary economic partnerships are particularly beneficial to both regions due to their proximity to the other side and to the Southeast

Asia. But it has so far not affected a joint hydropower development or even a joint watershed development initiative. Two major examples for the regions engagement in joint development cooperations are the Greater Mekong Subregion (GMS) Economic Cooperation Programme, and the track-II Kunming Initiative.

Among the various rich 'green resources' hydropower is becoming in both regions a key pillar, both for the large as well as for the small hydropower sector.

3.2 Present state of hydropower development (incl. upcoming projects)

Despite the above mentioned similar common cultural and natural heritage, the hydropower development is very much affiliated by its political ties, therefore it will be separately described and only later jointly assessed.

3.2.1 Northeast-India

In mid-2011 India has been developed only 25.6% of its present economic exploitable hydropower potential of 149 GW. Three quarter or 117 GW of India's hydropower potential is located in the Indian Himalayan Region, an area which accounts contrary only for approximately 18% of India's total geographical area. Within the Himalayan Region more than half (=63.3 GW) comes in the Brahmaputra Basin of NE-India (Agrawal et al., 2010).

Beside the main stem of the Brahmaputra, which is known in China and Tibet as the Yarlung Tsangpo and in Arunachal Pradesh as Siang, there are few major tributaries, each having a large hydropower potential. While the Tista is draining Sikkim and West Bengal and the Barak Manipur and Assam, all the other relevant tributaries are in Arunachal Pradesh. Most of those North-Bank tributaries of the Brahmaputra are of Himalayan origin and are fed by glaciers in their upper reaches, e.g. Subansiri, Kameng (Jia Bhareli), Dibang, Lohit, etc.

Due to the fact that more than 40% of India's hydropower potential comes from the Brahmaputra Basin, the region and in particular Arunachal has been proactively tagged as the 'future powerhouse' of India.

The focus for massive hydropower development in the Northeast of India was pushed by the Indian Central Government. With the gradual liberalisation of hydropower policies, the Indian states were allowed to invite private players. Sikkim kick-started this process about ten years ago allowing private companies exploiting the hydropower of the Tista river and its tributaries. Today the tiny Sikkim-State is together with Arunachal Pradesh at the forefront in the initiative to sign multiple Memoranda of Understanding/Agreement (MoU/MoA) with private and public power developers. Alone the state of Arunachal Pradesh allotted hydro schemes with a capacity of more than 40 GW till 2010 and most of these projects involve private Indian players (Vagholikar & Das, 2010). The impressive share of private entrepreneurs is contrary to the national trend. It is also fostered by the above mentioned initiatives by the national government as well as the state policy.

So far only 423 MW of the exploitable hydro resources have been developed in Arunachal, which is merely 1% of its potential. By 2012, the 2,000 MW Lower Subansiri Scheme will be





Fig. 5. Map of present and forthcoming large hydropower projects (above 500 MW) in Asia.

commissioned and from then onwards Arunachal Pradesh becomes an exporter of electricity. It is the first Mega-Project in that region and it will be operated by the state owned NHPC.

So far the Northeastern power grid is the most inefficient one in India and in particular the distribution is the weakest link in the power system. With almost 40% the transmission and distribution losses are the highest in India and far above the Indian average. In some regions the losses range up to two third of the generation (Rao, 2006). The construction of an efficient transmission system is a key issue of the regions hydropower development.

The transmission system for power evacuation from the Northeast is of serious geopolitical interest. Actually it should get finished at the end of the present five year plan in 2012 as a 800 kV HVDC bi-pole line and a 400 kV double circuit AC lines in a hybrid system, which would be one of the global most advanced transmission lines. This forthcoming transmission corridor, which requires a stretch of about 800 to 1,200 m, should at a later stage evacuate 25-35 GW of electricity mainly to energy hungry Northern and Western India. It has to pass through the geopolitical sensitive narrow Siliguri corridor and should later also include hydro generated power from Sikkim as well as from Bhutan and Myanmar (Rao, 2006; CEA, 2008).

But due to lack of central funding the prestigious project is seriously delayed. Alternatively the Indian government is seriously looking for a cheaper version passing through Bangladesh. Additionally India tries to increase private investments of such geostrategic important transmission lines as well as to increase the power and capacity of those lines in order to reduce land requirements and transmission losses (Planning Commission of India 2011).

All the project developers of Northeast India need to obtain a Long Term Open Access for transmitting power through the corridor. The first mega hydro projects which will be gradually commissioned over the next years, will be located on the Brahmaputra-tributaries more close to the Indian mainland (rivers Kameng and Subansiri respectively). They will be projects by public funding, either by NHPC or by NEEPCO. India's presently largest privately funded project is the 2,700 MW Lower Siang project on the main stem of the Brahmaputra. It is owned by Jaypee Power Ventures and should be completed by 2017. That project is like other private funded projects on BOT bases, which means the owner is the local state (e.g. Gvt. of Arunachal Pradesh) and the investing company gets over a concession period of 40 years the right of utilisation.

Due to environmental and social concerns various Indian State Governments (including Arunachal) encouraged the development of run-off-river (RoR) type hydro projects. Quite a few of formerly scheduled storage schemes in the Pre-Feasibility Reports were converted into RoR-schemes, either as one big one or as 2 to 3 smaller ones.

The controversial upper Siang project (about 10,000 MW) on the Brahmaputra/ Yarlung Tsangpo would be by far India's largest hydropower station. Due to China's recently published plans for future development of the Yarlung Tsangpo, India revived immediately its plans for the prestigious project. As such a large scaled and scoped hydel project has never been attempted in India, it is presently discussed to hive off the project into two or even three modules, so as to keep better tab on costs and aid implementation (cp. chapter 4.2).

3.2.2 Southwest-China (Yunnan-province)

The Southwest Chinese provinces are the backbone of China's ambitious present and future hydropower development and within that area the province of Yunnan is the focus for China's forthcoming hydropower expansion plans.

The ambitious programme makes Yunnan, which is in its size almost comparable to Germany, in a few years to the world's most powerful hydropower base. It will then have the largest installed hydropower capacity as well as the largest annual hydropower production, more than states like the USA, Canada, Brazil or Norway.

What is the backbone for this development?

The principal item is the construction of large and even mega hydropower projects on the major rivers and along their tributaries (Hennig, 2009 & 2007; Dore & Xiaogang 2004), secondary also the development of smaller hydropower bases. For Yunnan are three rivers special relevant; the Jinsha river, which is the upper part of the Yangtze river; the Lancang or Mekong river and the Nu or Salween river. The proposed power stations on the main stem of these rivers are all planned as cascade systems. Most of the projects will be very large ones, and often they are designed as run-off-river systems, where parts of the river are diverted through huge tunnels. Only a few projects are designed as huge reservoirs and are in combination with a large installed capacity even called mega-projects.

The Jinsha has by far the highest hydropower potential worldwide. Not in Yunnan, but on the Yangtze is also presently the world's largest hydropower station in terms of installed capacity (20,300 MW); the Three Gorges Dam. Its first commercial operation began in 2008. The owner, China Three Gorges Corporation (CTGC), is presently constructing a cascade of four other hydropower stations on the Jinsha river, which have a combined capacity double that of the Three Gorges Dam. Two of the projects (Baihetan and Xiluodu) belong to the largest worldwide. Presently China is one of the few countries which uses 700 MW turbines. But based on Jinsha's Wudongde and Baihetan hydropower stations, China gets as the first country the ability for independently design and manufacture the world's largest hydropower-generating single units (1,000 MW).

In the upper reaches of the Jinsha is a second cascade under construction. Originally it should be a cascade of 8 major dams, but one was cancelled due to environmental and social concerns. A few other dams were stopped for a while due to environmental problems (see next chapter). The cascade is developed by the Jinsha Hydropower Development Corp., but the projects are mostly owned by different state owned companies. The 2,400 MW Jin'anqiao-project is not only the first commissioned project of the cascade (in 2011), it is also China's first large hydropower station invested by a private company, Hanergy.

The Lancang or Mekong river reduces in Yunnan its altitude difference by 1,780 m and has therefore a high potential. The lower cascade of proposed 8 dams is Yunnan's first major hydropower project. It is now developed by Hydrolancang, a subsidiary of Huaneng company. The 1,500 MW Manwan Dam completed in 1995 was the first dam on the Mekong and also Yunnan's first major dam. Its funding had at that time model character, because no international donors were included. With the second dam (Dachaoshan; 1,350 MW; commissioned in 2003) Yunnan became a power exporter. The third dam (Jinghong; 1,750 MW; commissioned in 2009), was China's first hydropower joint venture with a foreign country (Thailand). After completing a 1,070 km long transmission line, Thailand will be

also a primary consumer of electricity generated by the dam. With the fourth dam, Xiaowan (4,200 MW; finished in 2010), China exceeded its 200 MW installed hydropower capacity. Presently it is China's second largest dam but in a decade it will be only of a 'mid-ranged' size. On the upper part of the Lancang/Mekong China is presently starting a second hydropower-cascade. But due to concerns of the lower Mekong riparian states its details are still not finalized.

The proposed cascade of 13 dams along the Nu/Salween river raised international attention, because it has been still halted due to environmental concerns. Background is that the Nu is the only undammed major river of China and a few of the project sites are affecting the UNESCO world heritage site 'Three parallel rivers'.

On the other (former) undammed river, the Yarlung Tsangpo, is since 2011 a first hydropower station under construction, the 510 MW Zanwun dam. Subsequently a major cascade is scheduled on the Yarlung Tsangpo.

Beside these mostly large or even mega dams along the main stem of the rivers a number of other hydropower stations are finished, under construction and/or planned within the respective watershed. In the other three relevant watersheds of Yunnan (Irrawaddy, Red River and Nanpan) a large number of moderate to large hydropower stations are presently coming up.

Most of those projects feed into one of the three major transmission lines, which send power to the economic hubs of China's east and south coast. The development of an effective grid is an integrative part of China's hydropower strategy.



(Photo: Hennig, 2006)

Fig. 6. The 108 MW Dayin-1 hydropower station on the Dayin/Tarpein river was finished in 2007. It was the first of a series of 6 cascades in the Chinese-Burmese border region. The dam is located in a protected area. It was constructed by private entrepreneurs from the Chinese east coast and was later purchased by the state-owned Guodian Corp.

Part of that is also the construction of an efficient UHV-DC transmission system. China is presently the only country building such a network. Since 2010 the first line connects Yunnan with Guangdong (5,000 MW) and a second line between Yunnan and Shanghai (6,400 MW) is under construction. Their DC-voltage level of 800 kV is far above the present existing maximum of 500-600 kV.

At present there are in Yunnan 157 hydropower CDM projects approved, another 110 are at validation (<http://cd4cdm.org>; 09.Sept.2011). Most of those projects are small hydropower stations (SHP). Surprising in that context is also, that the majority of SHPs in Yunnan are grid feeding and an integral part of the power transfer. Beside the omnipresence of SHPs in Yunnan, there are two major SHP hubs existing. This is a cluster of SHPs and some bigger projects within a small area and each has a cumulative installed capacity of about 1,000 MW. Yunnan's two SHP-hubs are in the Fugong-county of Nujiang-prefecture and in Yingjiang-county of Dehong-prefecture. Recent studies in Yingjiang indicate serious environmental cumulative consequences of the recent SHP-development. Cascades of SHPs, which are according to international classifications mid-sized projects, result in the drying up of a number of smaller rivers in the dry season. This is caused by water diversion and the failure of ensuring a riparian distance between the hydro projects and the failure of enforcing a minimum water discharge.

3.3 Environmental and socio-economic challenges of the hydropower development in SW-China and NE-India

China as well as India officially reject the famous and influential 2001 report by the World Commission on Dams (WCD). However, both governments are not averse to international cooperation. Their domestic hydropower and dam legislation policy, which includes resettlement issues as well as Environment Impact Assessment, has been influenced by international debates and by their own characteristic domestic learning policy. Despite not recognizing the WCD-guidelines, hydropower projects which are internationally funded (e.g. from WB, ADB, IPC or from Western donors) have to follow the rules by the World Commission on Dams. This counts also for hydel projects requesting for CDM.

Whether or not hydropower projects are constructed is decided in both countries on the basis of their assessment of their economic development and the related energy needs. Comparing both states over the last two decades it is peculiar that China's hydropower sector is growing faster than predicted, while India's is growing more slowly than expected and needed.

Despite this simple characteristic the hydropower sector in both states belongs to the fastest growing worldwide. This impressive growth is naturally accompanied by certain environmental and socio-economic problems and challenges. Following a few of these challenges are explained and discussed more detailed.

3.3.1 Environmental and resettlement policy in China (Yunnan)

There are currently about 23 million registered relocatees in China (Hensengerth, 2010) and according to the WCD-report between 1949 and 1999 about 12 million people were displaced due to reservoir construction. Millions more were displaced due to the construction of the Three Gorges Dam and other large hydropower schemes. In many cases people were moved to other areas and provinces, which raised assimilation problems and

resulted in conflicts with the resident population (Heggelund, 2006). Growing problems related to resettlement were solved by passing a number of new laws and regulations. Now the implementation of newly approved resettlement plans are in the responsibility of county and sometimes even provincial governments, while the monitoring and evaluation are carried out by external agencies.

The immense and steadily growing costs of resettlements are a major objective of the lack of new hydropower projects in the more densely populated areas of eastern and southern China. Only prestigious and important projects like the controversial Danjiangkou reservoir as part of the S-N-water transfer project get acceptance. It is with 350,000 people the largest present resettlement project and one of the very few Chinese projects which are heavy delayed.

Studies by the author of recent hydropower related relocation projects in Yunnan (interviews conducted in 2010 and 2011) indicate that they were done according to the Chinese rules. Relocated villagers (incl. village committees) do not complain about the relocation itself, but about the intransparent decision making and the lack of participating in relevant decision making and co-determination.

The development of the Chinese Environmental Impact Assessment (EIA) since 1979 is the result of domestic learning processes and the studies of international examples and experiences and underlying therefore frequent modifications.

Chinese formal EIA-procedures are according to the international standards but however their implementation is often doubtful. In some cases the EIA got published and approved only after the hydropower project was constructed. Additionally public disclosure of the entire EIA report is not necessary and only summaries of EIAs have to get published. For strengthening the EIA-procedure many hydropower projects have now to get reviewed and approved by either provincial or even central authorities. Despite the often still weak EIA-implementation a few cases spurred the debate on hydropower projects in Yunnan:

1. In June 2009 China's Ministry of Environment Protection halted two large hydropower projects along the Jinsha river (Upper Yangtze). The move was considered as the severest punishment in the country's environmental appraisal history as it involved two large state-owned conglomerates Huadian (with the 2,200 MW Ludila project) and Huaneng (with the 1,700 MW Longkaikou). But in November 2010 the mighty National Development and Reform Commission (NDRC) gave official clearance. In that context the 2,400 MW Jin'AnQiao project on the same river, which is the first and largest private funded LHP in China, got in 2010 the formal EIA-approval only just before finishing the construction.
2. The development of the Nu river cascade is halted since 2004 and subjected to environmental investigation. The Nu or Salween is an international river and its development is therefore a central government responsibility under the charge of the Yangtze Water resource commission. Although first ideas about the Nu-projects came up in the 1970s, only in 1999 the NDRC adopted a plan of a cascade based on 13 dams with a combined capacity of 23 GW. The proposed developer, state owned Huadian Corp., tried together with the provincial government of Yunnan to rush China's State Council into approving the projects before the new EIA-law could come into effect in 2003. China's former SEPA (now Ministry of Environmental Protection) and a Beijing-based NGO began to organize national and even international opposition to the project. This resulted in an unique situation for China, establishing a link between researchers,

NGO activists and also politicians. Huadian was forced to conduct an EIA and submit it to the SEPA. Finally in 2004 then Prime Minister Wen Jiabao put the project on hold due to an insufficient EIA. In between the EIA report had been completed and approved by the SEPA for a reduced number of dams, also their number is contradictory. The present situation is still diffuse, despite many hints of an upcoming official approval of the stop are existing. But on the other side, preliminary work is under progress and beside Huadian is now also Guodian active in the region, as seen in a field trip by the author in early 2011.

3. Beside the Nu-cascade the most controversial hydropower project in China is the 2,800 MW Upper Hutiaoxiao project in Yunnan. The proposed dam, with a height of 276m would officially relocate more than 100,000 people, mostly minorities; unofficial the number is much higher. The location is on the Tiger Leaping gorge on the Jinsha (Upper Yangtze), one of the worldwide most spectacular canyons. The proposed dam was also aimed at diverting water from the Jinsha to the provincial capital Kunming which lacks drinking water. The plan opposed by Chinese NGOs caused an unexpected public outcry, which was supported by Chinese Media and it received also international attention. Therefore the plan has been shelved since 2004 and in late 2007 the project was cancelled due to a report by The South China Morning Post. But so far no official statement was given.

These examples about environmental and socio-economic issues present a mixed picture about China's hydropower decision making process. On the one side the process is still secretive, top-down oriented and authoritarian, but on the other side democratic procedures get introduced and in certain cases individuals and civil society organisations can organize effective protests and even stop controversial projects. How is the comparable situation in India?

3.3.2 Environmental and resettlement policy in India (northeast India)

India ranks fourth in the world in terms of the number of its large dams, but after China it ranks second in terms of displaced people. The main objective for dam construction is irrigation, but in the last years there is also clear trend towards hydropower. Although the government is the owner of almost all those dams, there exists no official data concerning resettlements. It is estimated that in India between 32 and 56 million people were displaced up to the new millennia, most of them in tribal areas (Choudhury, 2010).

Compared to China's top-down authoritarian decision making on dams, in India it is more akin of a polycentric process which involves at various stages multiple actors.

In its young history India faced many serious tensions about the utilization of water resources, most of them were interstate conflicts. But with the controversy over the Sardar Sarovar Multipurpose project in the late 1980s began in India to emerge an era of social and environmental movements and civil-society-driven consciousness-building. The civil-society became the major actor working towards progressive and gradual changes in dam related policies (Choudhury, 2010).

The role of public participation is historically limited, similar to China's situation. But what changed in India is the relevance of the environmental sphere, namely the compulsory public hearing, relevant for the EIA documents. Those public hearing became one of the

most contested and controversial arenas, strongly affected by civil society organisations and environmental and social activists as well as the local communities.

These civil societal organisations and activists criticize the quality of many EIA-reports, which are poor in many social and environmental aspects, their inadequate baseline information and additionally act often only as a post-clearance study. Contrary to China, India's 'Right to Information Act' binds the government to make all the relevant documents public accessible (e.g. Feasibility study, Environmental Impact Assessment, etc.).

In case of NHPC's 3,000 MW Dibang-Multipurpose project in Arunachal, which will have India's highest gravity dam (288m), it came also to serious opposition and public awareness campaigns. For the first time civil society organisations from an upstream state (Arunachal) jointly engaged in agitation with organisations from a downstream state (Assam).

Also as a reaction to the strong criticism of the civil societal organisations towards the public hearing and the EIA-documents the then Union Minister of State for Power, Jairam Ramesh, now Environment Minister, raised concern about the 'MoU-virus' of Northeastern States like Sikkim and Arunachal Pradesh. He referred to the large number of projects handed out by these states to private hydropower developers, whereas most of these agreements have been accompanied by huge monetary advances. Often they were signed before compulsory public consultations or mandatory clearances (Vagholikar & Das, 2010).

As a result to those critiques many hydropower projects in Northeast India got seriously delayed. None of the many large (> 500 MW) hydro projects by private players are finished so far. Also the state-owned NHPC, which is on the forefront of hydropower development, commissioned till now only the 510 MW Tista-V project; and in 2012 the 2,000 MW Lower Subansiri is following.

Also resulting from those critiques with the well-known environmental and socio-economic impacts of large scaled hydropower projects, a few Indian state governments encouraged the development of run-off-river (RoR) type projects. In that context quite a few LHPs had being converted and split from proposed storage schemes in the Pre Feasibility Reports to one and often even more than one RoR-schemes, which have been allotted to private developers for project implementations. On the other side there is strong opposition of conversion of more storage schemes into RoR-schemes, because the multipurpose-function of reservoirs (flood control, irrigation, drinking water supply) gets reduced which results in higher power tariffs.

4. Hydropower development in transboundary watersheds of SE-Asia

Finally a short overview should be given about international hydropower ambitions of both countries as well as about implications for transboundary watersheds.

4.1 China and India overseas hydropower activities

Over the last decades Chinese dam builders have accumulated a vast expertise and knowledge base in hydropower construction. Getting economically strong and based on growing financial reserves, Chinese state owned dam builders and financiers appeared on the global hydropower market with a bang in the early years of the new century. They started to take on large and often destructive projects in countries like Myanmar (former Burma) or Sudan,

which had previously been shunned by the international community. Their emergence threatened to roll back progress regarding human rights and the environment which civil society had achieved over many years (Bosshard, 2010; Mc Donald et al., 2009).

However, the situation is changing and Chinese dam builders and financiers are trying to become good corporate citizens rather than rogue players on the global market. Presently about 40 foreign hydropower stations are completed and more than 200 are under construction or planned. Chinese hydropower activities are global, but the majority of the projects are in Southeast Asia and Africa where China has fostered strategic regional and bilateral ties. The major actors and drivers of Chinese overseas hydropower ambitions are the six major state owned power suppliers, but also companies like Sinohydro, China Southern Power Grid, various Chinese Banks (mainly China Exim Bank) and Yunnan based companies.

For Chinese hydropower activities abroad Yunnan plays a crucial role due to its geopolitical position close to Southeast Asia. A number of projects in Myanmar are of direct relevance to Yunnan, like the cascade of six dams along the Upper Irrawaddy (11,160 MW); two dams on the Salween (Upper Thanlwin – 2,400 MW and Tasang – 7,100 MW); as well as four other dams on the Shweli and Dayin/Tarpein rivers. Some of the projects caused political tensions between the countries, because a number of hydel projects are in areas which are controlled by various rebel groups (Shan, Kachin, etc.). These groups are partly blaming Chinese companies for doing other activities than hydropower construction and in 2009 even attacked a hydropower construction site. Further Myanmar surprisingly suspended in late 2011 a key project, the \$3.6 billion Myitsone dam, causing diplomatic irritations.

Most of Chinese hydropower projects in Myanmar are on a 40 years BOT basis and therefore they get directly connected to Yunnan's power grid for transmission which transfers Myanmar's electricity to the load centers along the Chinese coast. Beside the strong activities in Myanmar, Yunnan sends further electricity to energy hungry North-Vietnam and in future also to Thailand.

Contrary to Chinese global hydropower activities, India's dam building abroad is quite moderate and only in the beginning. Except a relative active global hydropower consultancy business (mainly by the state-owned WAPCOS), India's foreign dam projects concentrate only in the neighborhood (e.g. Afghanistan, Nepal, Bhutan and Myanmar).

In particular India and Bhutan have agreed to realize 10 LHPs with a combined capacity of 11.6 GW which should feed in future into the Indian Grid. So far only three projects are under construction and one is finished, despite India has committed to draw already 10 GW by 2020 from Bhutan. Even more difficult is the situation with Nepal, which has with 42 GW by far the highest economic exploitable potential in the Himalayan region, but has still only an installed capacity of 0.7 GW and faces therefore an ongoing power crisis (cp. Fig. 3). Although India has been assisting Nepal for long in the development of its SHP sector, but the prestigious projects which are already for many years under discussion at various mutual interest levels have not been realized so far. These large projects should also straight feed into the Indian grid.

Compared to China's very active hydropower activities in Myanmar, India pursues presently only two large projects of a strategic venture in Myanmar, the Tamanthi 1,200 MW and Shwesayay 600 MW. Although the MoUs were already signed in 2004, the projects are still not realized.

Comparing the global hydropower activities, it is striking that in both countries the drivers are the state owned power generation, transmission and design as well as consultancy companies. Hydropower is seen as a strategic venture. China became here over the last decade very successful and has been realizing many projects, both in its neighborhood as well as globally. Contrary India's engagement in its neighborhood is characterized more by discussion instead of realization. Additionally is China entering into the hydropower markets of India's Himalayan neighbors, mainly Nepal.

4.2 Transboundary watershed policy

Further a short overview about implications for transboundary watersheds should be given. In particular for the Lancang/Mekong river exist quite a few studies e.g. Grumbine & Xu, 2011; Osborne, 2009. China is with Yunnan and Guangxi part of the GMS-initiative but it is not part of Mekong River Commission. In particular the serious drought which affected in 2010 the region, produced controversial discussions and argumentations between upstream Yunnan (or China) and downstream states about the causes and effects of damming up Yunnan's Lancang/Mekong River. Beside these discussions also the downstream Mekong states plan the construction of another 13 major dams in the lower part of the Mekong. The developers of those projects are mainly from China and from Thailand, but also from Vietnam and France.

For the binational watershed of the Nu/Salween- river it is striking that China stopped so far damming up its own part of the river but is again, together with Thailand, very active in the hydropower development along the Salween in Myanmar.

The hydropower-development of the transboundary and geopolitically conflictual West-Himalayan regions is based on the Indus-Water treaty from 1960. Contrary to all the tensions between India and Pakistan there are so far no serious geopolitical tensions about the realization of all the projects along the Indus and its tributaries, which are shared between the two nations. The situation may change, because recently tensions arose about the proposed 330 MW Kishanganga hydroproject along the Neelum River where India and Pakistan disagree on the application of the provisions of the Treaty. In 2011 Pakistan had approached the international court of arbitration constituted by the United Nations against the Indian move to construct the hydel project by diverting the Neelum River.

Pakistan's ongoing power shortage should be faced by a massive hydropower development of its economic exploitable potential of more than 55 GW. Contrary to India is China here involved in a few hydropower projects and the number may soon increase. However in 2011 caused the 1,100 MW Kohala-project on the Jhelum-river political tensions between the two countries.

More serious is the oncoming conflict on the Yarlung Tsangpo where China and India are directly involved. The River which is called Brahmaputra in India and Siang in Arunachal is so far hardly dammed up, but huge and very prestigious projects are in the pipeline. In early 2011 China officially announced the first dam along the Yarlung Tsangpo which caused a political outcry in India. In direct response to China's plan of constructing a proposed 40 GW project (double of the Three Gorges Dam) on the famous bend of the Yarlung Tsangpo, India revived its idea of constructing a 10 GW project on the Upper Siang. This would be by far India's largest hydel project. New Delhi is pushing state-owned power companies (namely NTPC and NHPC) and the Arunachal government to speed up with

their own projects on the river. Background is the doctrine of prior appropriation, which indicates that the priority right for the river falls to its first user.

5. Conclusion

China as well as India are characterized by the globally fastest growing hydropower development. Over the past decades China gained an engineering and technical expertise, which made it by far the worldwide most advanced hydropower market. Additionally China is economically so strong that it can realize a big number of large and expensive hydel projects. Since the new millennia China's expertise and financial strength is also globally seen, because it is constructing and funding a fast growing number of hydro power projects worldwide.

Contrary to China is India still depending on foreign technology. This is true enough in particular for very large projects or projects in difficult terrains. Additionally India is, despite various political initiatives, not able to finance a larger number of big hydel projects parallel. The path of India's hydro capacity generation, both in India itself but also due to its strategic partnerships in neighboring states, has been very slow. In particular for Northeast-India with its huge hydropower potential, projected implementation has been dismal so far.

In both countries hydropower used to be a part of classical multipurpose projects, whereas power generation was often the means for large scaled irrigation projects. Today (hydro-) power generation is essential for sustaining the economic growth and therefore large hydro projects are part of regional development initiatives. This results also from the fact that the highest hydropower potential is far away from the load centers and their economic and urban hubs. While China uses this opportunity for developing economically peripheral regions and developing and fostering the globally most advanced grid and transmission systems India is not able to do similar.

The driver for China's as well as in India's hydropower development is the government, both on the central as well on the provincial /local level. In particular the NE-states of Sikkim and Arunachal Pradesh signed plenty of Memoranda of Understandings/Agreements with private players, but still many of that signed projects have not been realized so far.

The other major drivers are the state-owned power generation, transmission and design companies. Private companies play in both countries for large projects only a minor role so far. However in India's context the government tries eagerly to involve also the private sector, mostly on BOT basis. But due to the high initial investments, private companies are still hesitating.

Compared to the LHP-sector the small hydropower development is in both countries quite successful pushed by the governments. Most of the investments came here from the local private sector, and many of the recent SHP-projects are applying for CDM.

Both countries reject officially the WCD guidelines but their decision making process differentiates. China is following in its hydropower policy a classical authoritarian top-down approach. The decision making on dam development is based on domestic laws, which adopt gradual global norms. Despite this progress the environmental implications and to some extend also the social consequences of hydropower decision making are still

not transparent at all. Despite this critique, get some projects surprisingly halted up for a while or some even stopped.

Contrary to China, is India's hydropower decision making more akin of a polycentric process which involves at various stages multiple actors. Despite the critique of civil societal organisations and environmental as well as social activists over poor EIA-reports is India's decision making quite transparent, in particular that all the relevant documents are publically accessible. However due to the quite active civil society structures, the implementation of many hydropower projects has been slow and causes often a restructuring of many projects.

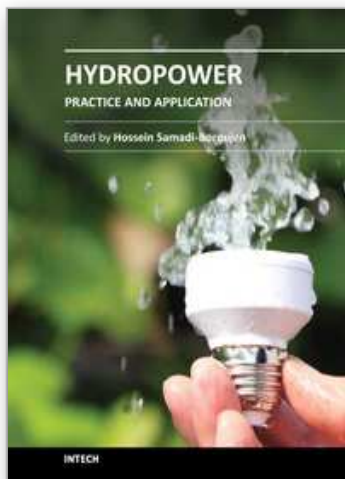
The main critique by the author is that in both states hydropower development is seen as the only tool for watershed development. There is no serious assessment for developing a concept of the whole watershed which goes far beyond hydropower. This concept should create an innovative management model, which considers water, environment, livelihood, food security, etc. and therefore enhancing public participation and transparency as well as financial benefits for the people in the watershed.

This is underpinned by the fact that most of the rivers in Asia's watertower (from the Karakorum over the Himalayas to the Hengduan Mountains) are transboundary rivers. Therefore should be a shift from a sovereign state-focused watershed development to an integrated transboundary watershed approach which also recognizes political sensitivities of the whole region.

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Hydroelectric energy is the most widely used form of renewable energy, accounting for 16 percent of global electricity consumption. This book is primarily based on theoretical and applied results obtained by the authors during a long time of practice devoted to problems in the design and operation of a significant number of hydroelectric power plants in different countries. It was preferred to edit this book with the intention that it may partly serve as a supplementary textbook for students on hydropower plants. The subjects being mentioned comprise all the main components of a hydro power plant, from the upstream end, with the basin for water intake, to the downstream end of the water flow outlet.

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