

# **Status of Bhutan cross border interconnection with India & Expected Benefits**

Presentation by Bhutanese team in  
SARI/EI workshop on “competitive electricity  
markets – design, implementation & benefits”  
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# History of Hydro Development Cooperation & Grid interconnections with India

- Bhutan-India cooperation in hydropower started since 1961 and interconnection for sharing of electricity started in 1968 after the commissioning of Jaldhaka Hydroelectric project 27 MW – Powerhouse in the State of West Bengal, India and Barrage & catchment in Bhutan. Bhutan received 250 kW free royalty power (1.314 GWh per annum) from this Project through the 11 kV interconnections at 3 delivery points (Jholung, Chumarchi and Phuentsholing).
- By the middle of 1970s, India also started supplying power at 11 and 33 kV voltage inter-connections in South-Eastern border towns like Daifarm, Darranga/Samdrupjongkhar and Gelephu/Hatisar.
- For Chukha HEP construction, 66 kV power line was extended to Phuntsholing and then to Chhukha and finally to the capital in early 1980s. Penden Cement factory also received 66 kV power from Birpara, WB, India till 1986/87. The price of electricity was varying from 0.30 Nu/kWh to 1.00 Nu/kWh in 1983-84.
- When first Machine of the 336 MW Chukha HEP was commissioned in Sept. 1986, Bhutan started becoming a net exporter of electricity. Power started flowing into Birpara, West Bengal, India at 220 kV level.
- Norm in Bhutan is that whenever a new HEP is engineered and designed, its associated transmission system (ATS) for evacuation of power generated to the desired load center is also incorporated, so that Interconnection does not become an issue later.

# Chukha HEP and its Interconnections

- Chukha HEP of 336 MW capacity (1860 MU) was commissioned between 1986-1988. There are three 220 kV circuit interconnections (one D/C line and one single ckt line, Zebra conductor) between Chukha HEP and Birpara, WB, India at an average line distance of 72 km. The delivery point at the International border is Phuntsholing (mid way), where accounting of energy (for loss sharing etc.) is done.
- About 300+ MW is exported during the Monsoon season and about 10 -20 MW interchange in the winter. The annual energy export (net of) from Chukha is about 1800 GWh.
- The current export price is 2.25 Nu/kWh (US Cents 3.6/kWh).

# Kurichu HEP and associated interconnections with India

- **Kurichhu HEP 60 MW (365 MU)** was commissioned in 2001/2002 in Eastern Bhutan. The surplus power is exported at 132 kV single circuit (Panther conductor) through **Gelephu** delivery point at the India Bhutan border. The 132 kV Gelephu-Salakati (Assam) single ckt line forms the inter-connection. The line distance from Kurichhu, Bhutan to Salakati, Assam is more than 243 km.
- One more inter-connection is established in 2009 through **Motanga**/Samdrupjongkhar delivery point for export of surplus power from Kurichhu to Rangia, Assam. The line distance from Kurichhu HEP to Rangia is 111 km.
- About 20-40 MW hydro power is being exported through these inter-connections in Monsoon and about 25 MW is being imported in winter. The net energy exported is **140 GWh** on an annual basis.
- The current export price is 1.98 Nu/kWh (**US Cents 3.19/kWh**)

# Tala HEP and Associated interconnections with India

- Tala HEP 1020 MW (3962 MU) was commissioned in 2006/2007 downstream of Chukha plant. The surplus power is exported through two nos of 400 kV D/C Transmission lines (twin Moose, 4 ckts) through Khogla and Pagli delivery points at the India-Bhutan border. The line distance from Tala HEP to New Silliguri/Binnaguri Power Pooling point, West Bengal is 140/146 km.
- About 1000 MW hydro power is being exported through these inter-connections in Monsoon and about 20-30 MW in winter. The net energy export is 3500 GWh on an annual basis.
- The current export price is 1.98 Nu/kWh (US Cents 3.19/kWh)

# Summary of existing Inter-connections at 11/33 kV Medium Voltage levels

- 11 kV lines through Sibsoo/Jholung and Chumarchi/Samtse – 2 nos
- 11 kV line from Udalguri/Assam to Daifarm/Bhairab kunda – 1no
- 33 kV line from Rangia/Tamulpur to Darranga/Samdrupjongkhar – 1 no (**not in use**)
- Mostly these lines are for import of power from WBSEDCL and ASEB into some isolated grid towns/villages of Bhutan near the International border.
- The re-import tariff is 2.76 Nu/kWh (**4.45 US cents/kWh**) from West Bengal distribution system into South-West Bhutan; and
- 2.45 Nu/kWh (**3.95 US cents/kWh**) from Assam Distribution grid supply in South-East Bhutan
- Basically it is the Chukha and the Kurichhu power that is wheeled and imported back into Bhutan to supply in border towns/villages.

# Summary of existing export interconnections from HEPs

- 220 kV D/C Line (Chukha-Pling-Birpara) via Phuntsholing for evacuation of Chukha power
- 220 kV S/C line (Chukha-Malbase-Birpara) via Malbase for evacuation of Chukha power
- 132 kV S/C line (Kurichhu-Gelephu-Salakati) via Gelephu for evacuation of Kurichhu power
- 132 kV S/C line (Kurichhu-Deothang/Motanga-Rangia) via Motanga for evacuation of Kurichhu power
- 400 kV D/C line (Tala-Khogla-Binnaguri/New Silliguri) for evacuation of for evacuation of Tala power
- 400 kV D/C line (Tala-Pagli/Malbase-Binnaguri/New Silliguri) for evacuation of Tala power



**Google map showing existing trans-boundary interconnections and power pooling points**

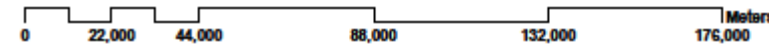
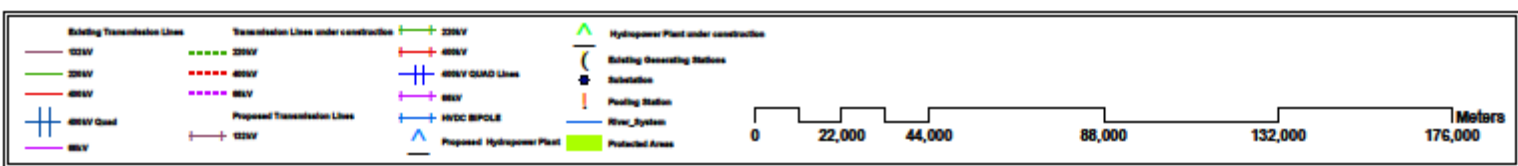
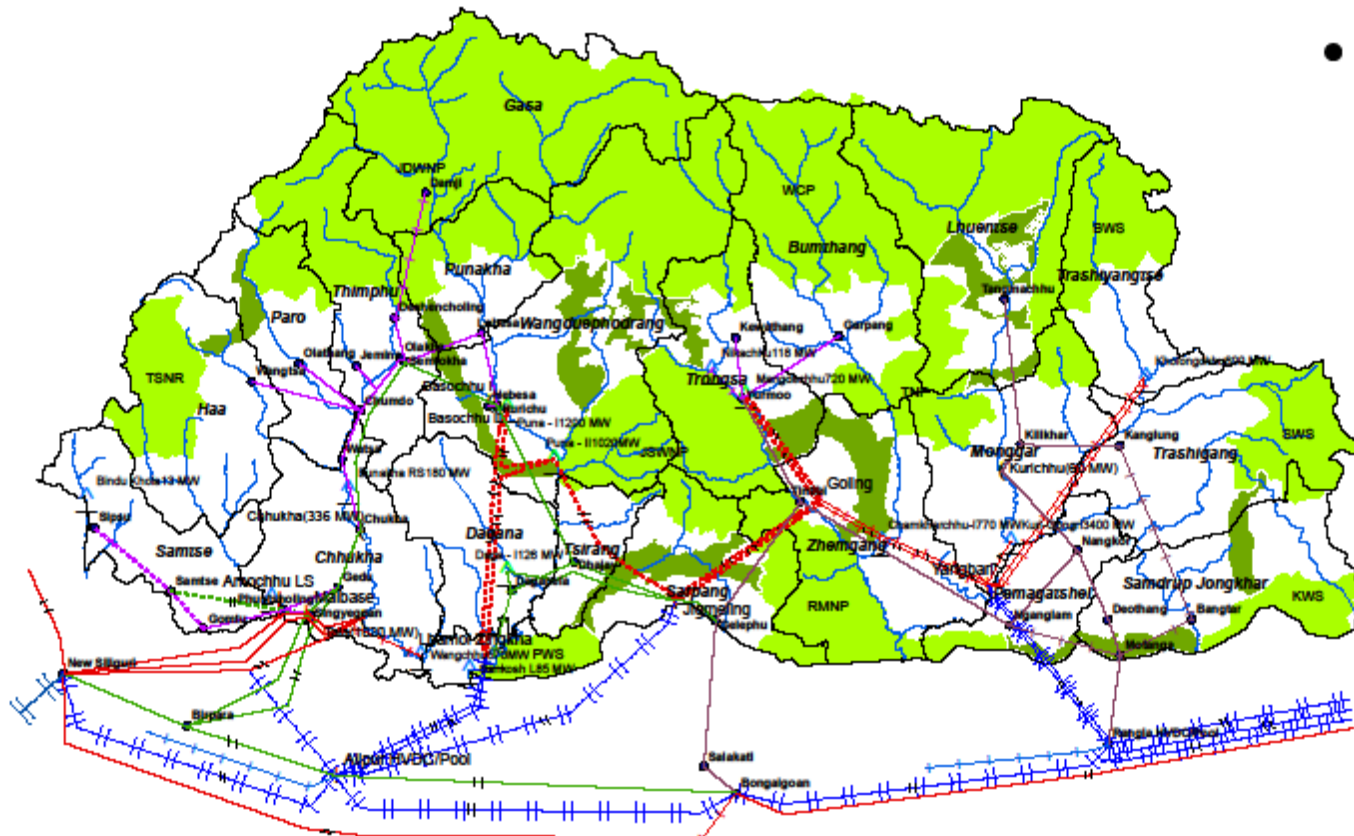


# Associated Transmission Interconnections under construction for evacuation of surplus power from Puna-I, II & Mangdechhu HEPs

- 2 nos of 400 kV D/C 93 km lines (twin Moose) from 1200 MW Punatsangchhu-I HEP to Lhamoizingkha border and one no. 400 kV D/C 45 km line (Quad Moose) to Alipurduar HV DC/Power Pooling point in West Bengal, India.
- 2 nos of 400 kV D/C 80 km lines (twin Moose) from 720 MW Mangdechhu HEP to Jigmeling/border pooling point and 1 no. 400 kV D/C 130 km (Quad Moose) line to Alipurduar Pooling point/HV DC in the plain.
- 1 no. of 400 kV D/C 65 km line (twin Moose) from 1020 MW Punatsangchhu-II HEP to Jigmeling Pooling point with a provision for LILO with Puna-III HEP (1020 MW) in future.
- A power pooling substation (GIS) with 500 MVA, 400/220 kV ICT is planned to be built in Jigmeling, Bhutan near the international border.
- These lines and ICT substation are scheduled to be built and commissioned by 2017/18.
- Budgetary estimate of the above works is Nu 23 billion.

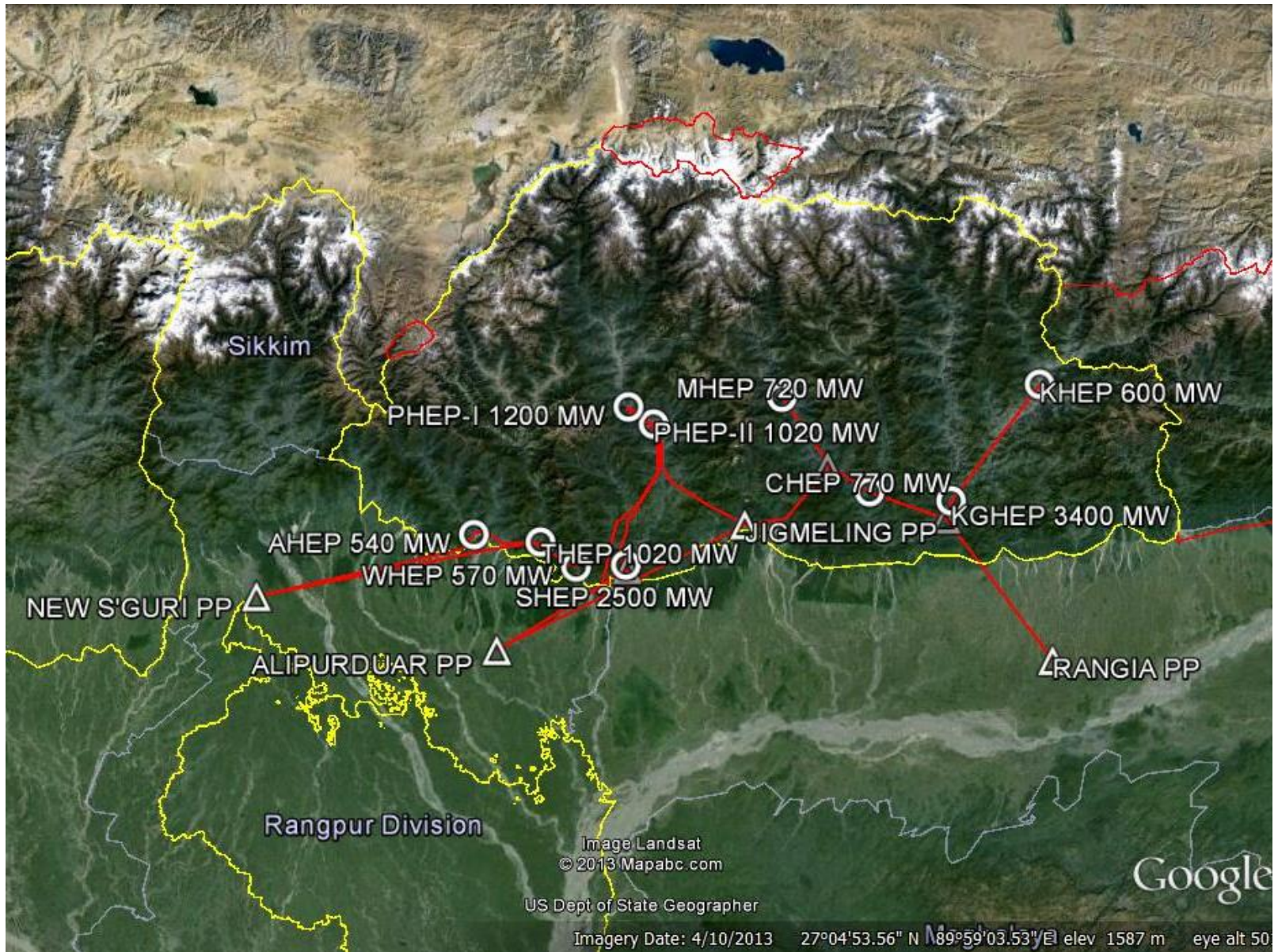
# National Transmission Grid Master Plan for Bhutan by 2020

(with associated Transmission inter-connection to power pooling pairs in India)



# Additional Transmission Interconnections planned by 2020

- 2 nos of 400 kV D/C lines from 600 MW Kholongchhu HEP upto the Bhutan-India border (option: for pooling at Goling and Yangbari Power Pooling Points in Bhutan)
- 2 nos of 400 kV D/C lines from 2560 MW Sunkosh HEP to Sunkosh HV DC Power Pooling point and to LILO with Puna-I Lines to be terminated at Alipurduar.
- 1 no of 400 kV D/C line from 770 MW Chamkhar HEP to Goling Pooling point and 1 no. line from Chamkhar HEP to Yangbari Power Pooling HV DC point.
- 2/3 nos of 400 kV D/C lines from 3400 MW Kuri-gongri HEP to Yangbari Pooling/HV DC and to Rangia/Rowta HV D/C Pool in India on Quad Moose lines.
- Loop-in-loop out of 400 kV D/C line from Wangchhu 570 MW HEP to Tala-Khogla Feeder ckt 1; and loop-in-loop out of 400 kV D/C line at 540 MW Amochhu HEP with Tala-Pagli Feeder ckt 3;
- 220 kV D/C line from 180 MW Bunakha HEP to Malbase/Khogla and LILO of 220 kV Thimphu-Chukha line at Bunakha.
- Major **Power Pooling/Interconnection points in India** are foreseen to be at **Alipurduar** HV DC/Power Pool Substation, West Bengal and **Rangia** HV DC/ Power Pooling substation in Assam in future.
- Bhutan has a National **Transmission Grid Master Plan (NTGMP) for 2020 and 2030** for integrated development of Associated Transmission Systems (ATS) and HEPs .



**Google map showing locations of Bhutan's major HEPS and Power Pooling Points expected by 2020**

# Expected economic & financial benefits from grid inter-connections

- Avoided fuel costs (eg hydro surplus country can supply renewable energy through the Inter-connection and import of depleting and GHG causing fossil fuel can be avoided in the region).
- Avoided generation capacity costs (avoid new generation in one place by importing surplus power from the other). Flattening the load curve- Indian demand is in summer and Bhutanese demand is in winter – complementary effort – now pursuing energy banking arrangement through the grid interconnections!
- Avoided operations costs (as of consequence of above two costs as well as waste/ash disposal eg in coal fired power plants, reduction in emission of green house gases , CO<sub>x</sub>, NO<sub>x</sub>, Sox etc )
- Avoided T&D infrastructures (eg areas lying near the Interconnections/pooling points are served from grid electricity from the nearest Pool –Bhutan benefits from cross-border connections)
- Income from power sales (forex earning for balance of trade payment)
- CDM benefits (CERS earning potential from export and benefit sharing with consumers in future)
- Opportunity for trade and business in other services and goods supply- Stimulus of local economies through construction, O&M, improved power supplies

# Estimated Financial Benefits

- Currently Bhutan is exporting about 1300 MW power in the peak Monsoon season - 5558 MU, which is 73% of the Bhutan's clean & green generation is exported in 2013). This accounts to about 27% of the annual revenue to the exchequer from export of hydropower. Dagachhu HEP 126 MW, 515 GWh is soon going to be commissioned in June 2014 which will start exporting additional power to India.
- Bhutan is also getting CERs (carbon credits in tons of CO2 equivalent) for development of Dagachhu HEP (126 MW) and Punatsangchhu-I HEP 1200 MW. It is expected that the revenue earned from selling CERs will value add to the sustainable development of renewable energy resources as well as help globally to mitigate the climate change affect due to global warming. If we could earn CERS on all exported hydropower, then additional income from the sale of CER in 2019 would be =  $\$10 \times (0.82 \times 17000 / 1000 \text{ mil tons}) = \text{US\$ } 139.4 \text{ million}$  (say **Nu 10,037 million in 2019**).
- By, the export of additional energy from Puna-I (1200 MW), Puna-II(1020 MW), Mangdechhu (720 MW) by 2017/18, it will add on to the export earning capacity and more foreign exchange to the economy. Nikachhu (118 MW, 491 GWh) HEP is being planned to be built/commissioned by 2019.
- It is estimated that Bhutan will be exporting a minimum of 17,000 GWh hydropower in 2019; which can fetch net earning worth (return on equity) **about Nu 20,000 million (say 280 million US\$)**- an increase of 4 times the present contribution to the exchequer. By 2020, we are optimistic that we should have at least commissioned/built 5,000 MW installed capacity (22,000 GWh) of hydropower potential and will be exporting atleast 85 % of the total annual generation, which can fetch an earning (Corp taxes+dividends) worth Nu 22,000 million. If we would have developed say 10,000 MW capacity as envisaged, by then we should have been earning Nu 44,000 million in the same proportion.
- Income from Wheeling/interconnection charge would be minimum of **Nu 2,000 million in 2019**.

# Expected Social and environment benefits from inter-connections

- Improved electricity supply to the people
- Income and savings from export can be used for social economic development services/activities (being done in Bhutan)
- Ancillary social benefits during construction and O&M of interconnections (access road, employment opportunities, earning from sale of local produces/market)
- Avoidance of space build-up/siting for thermal power and polluting plants and saving from climate change impacts(GHG emission & climate change)  
– Can avoid public protests from building unsafe, noisy and polluting power plants in the locality !
- CER/CDM benefits + “**clean and green**” image/branding of power plants based on renewable energy resources development and use.
- Fostering technical cooperation and institutional linkages for sharing best fit practices between Utilities, in consultative process for decision making (eg. this workshop) as well as capacity building (training) of people for **Smart Grid interconnections, system operation and load dispatch.**

# Social benefits of Interconnections

- In the beginning, India supplied power through small trans-boundary inter-connections. Today, Bhutan supplies about 73 % of its hydro-generation to India through major inter-connections. This “win-win” strategic inter-connection brings lots of good will and trust between the two peoples and countries and provides trusted platform for economic cooperation and trade in electricity.
- It helps in optimal development planning of resources including power mix to enhance the security of grid supply.
- CDM facilitates sale of CER as well as benefit sharing between the green energy producer and consumers (10% to 50% benefit sharing with customer)
- It provides an opportunity for optimal sharing of resources (eg reliable electricity services at affordable price) and enhanced grid supply reliability.
- Energy Banking can also be done through the Inter-connections besides trading of surplus power and managing grid optimally. Inter-exchange whenever required from surplus to deficit region.
- Clean and Green Energy trading (both energy and CER) through Inter-connections will facilitate the climate change mitigation measures.



# Way forward

- We should continue to build Bilateral Interconnections between the Nations and as many as possible, and create a sense of counterpart dependence on each other for energy security and reliability;
- Explore electricity trading for accounting of energy using the concept of “Electricity displacement”; Assume there is a unified trade agreement amongst the parties, we can raise a bill as per energy sharing and accounting methodology in the trade agreement: eg. Bhutan injects 100 GWh into the Indian grid, and as per the unified power trade agreement, say 70% is for Indian constituents, 20% for Bangladesh and 10% for Sri Lanka, then bill will be as per this accounting arrangement in an integrated unified grid connected network of business operations! Ofcourse power flow will take place from “surplus to deficit” region (electricity has no colour to be distinguished!)
- So, we should pursue to sign a broad electricity trade agreement and accounting protocol, and let the stakeholders (buyers/sellers/traders, grid asset managers and system operators ) start strategizing and come out with an ACTION PLAN to make electricity trade and interconnections happen; and
- We believe that will surely happen one day and we eagerly look forward to it!

# Trans-boundary Inter-connections & Evolving Power Pools in Bangladesh, Bhutan & India



**THANK YOU FOR YOUR KIND ATTENTION !**

