2 ASSUMPTIONS

2.1 Model description

The calculation is based on the simplification of having an equal tariff throughout the year. A simulation of and reservoir operation by maximising the profit should have been carried out, but since the future market situation in the different countries is unknown, the criteria of maximising the energy production has been used instead. Another simplification is the disregard of storage allocated for flood control. It is expressed in certain references that the regulation of the reservoirs will take into account flood storage. To what extent this is planned is not known and the practical operation of this obligations are even more uncertain.

Another simplification is ignoring the impact of existing power plants on the historical record used for Mekong (1950-2000). In this period some large reservoirs have been established in Lao PDR (Nam Ngum) and Thailand. Inflow and outflow records from these projects should preferably have been used to generate a “natural” flow series in Mekong. Due to lack of data and since only the second half of the 1950-2000 –record is influenced, the impact has been ignored. A simulation could have been carried out to generate the impact, but actual filling procedures, minimum discharges, irrigation demand (Thailand), operation pattern etc. are not known. Development stages (e.g. Nam Ngum: 1972: 30 MW, 1979: 110 MW and 1985: 150 MW) make it even more difficult.

Two different scenarios are considered, one presenting the status in 2010 and one presenting the status in 2025. The existing stations (with storage) are included in both scenarios.

The operation of the reservoirs may be represented by either a rule curve or by a system approach where water values are used. Because the future transmission system and value of energy (or irrigation or flood control) is unpredictable, a rule curve approach is sufficient at this stage. By using rule curves the reservoir operation tend to be similar for all years. In a larger system a higher flexibility in the reservoir operation is necessary, which is best achieved by using a system approach.

In the present model there is only one rule curve: if the reservoir level is below this curve the power plant will produce less and when the reservoir level is above the curve the plant output is increased. The determination of the rule curve is carried out by iteration trying to find the highest income or energy production of the power plant(s). If there are several reservoirs or hydropower plants in the basin the total energy production in the basin is maximised according to the same rule curve.

Operation of the reservoir in the model is not strictly following the rule curve. If there is a high inflow and the turbines are running at full capacity and the water level in the reservoir is above the rule curve, the excess water will be stored. Spilling will not take place until full supply level is reached.

The reservoir operation has not been optimised by trying to find the potential highest firm power and/or firm energy. A firm power demand will determine whether the inflow is used for storage or power production. A high firm power demand will result in high reservoir levels in order to secure the power obligations, but the risk of spillage will also be high and hence the total power production may drop. Firm power and firm energy is used to characterise the quality of the supplied power and energy. In a system dominated by thermal power, the main problem in planning further development is to ensure that total plant capacity is sufficient to cover the maximum peak load that will occur. The term firm power is used to characterise this capacity.

There are many uncertainties in the simulations. Although there is a gap in the energy balance at present, the grid or market might be a limitation in the future production since the future regional demand and location of transmission lines are unknown. To meet this situation or to meet financial requirements, a project might be developed in stages (as Nam Ngum) and thereby the reservoir is not utilised.

2.2 Technical assumptions

The technical and energy production data referred to in Chapter 3 are taken from [4]. The following general assumptions have been made:

- *Inflow records* has been generated by using some few gauge records of long measurements period; Chiang Saen, Nam Ngum, Ban Signo and Se

Kong- Se San. These records have been scaled by the average inflow for each project.

- *Reservoir capacity curves* provide the relationship between elevation, storage and surface area. This data is required to calculate power production, to determine reservoir operation and evaporation. Where these data have not been available, simplified reservoir curves have been estimated based on active storage, total storage capacities and dam heights.

- Optimisation of reservoirs by finding the *rule curves* giving the highest energy production. Usually the operation is optimised by finding the highest income, but the future tariff structure is uncertain, the market is uncertain (domestic/export) and the project features might change due to upstream development. Determining the real daily reservoir operation would have to be based on expected energy prices, expected inflow and environmental requirements.

- Large reservoirs will have water loss due to *evaporation*. However, it can be argued that difference between the present evaporation and evapotranspiration pre-construction, is small and neglectable. Evaporation from reservoirs is usually included in reservoir simulations. For the projects in the actual area the evaporation could have been included by 500-1300 mm/year. In e.g. in Yunnan the impact on total flow would be less than 0.1 %. The reason is the topography of the reservoir area consisting of steep hillsides implying small reservoir areas in relation to total storage (large regulation zone). In any case the following assumptions have been made: If the pre-inundated area originally consisted of evergreen forest or slash and burn areas, the evaporation would have been almost equal to the evaporation after the construction of the dam. In addition the reservoir surface shrinks in the dry season and bare sand banks are exposed giving almost no evaporation.

In many projects detailed data have not been available and the following technical assumptions have been made to carry out the energy calculation:

- *Losses in waterways*: At full capacity the total head losses in the waterways are calculated based on rated head, maximum discharge and rated capacity.

- At full capacity a total *efficiency factor* of 0.88-0.90 has been used, containing an efficiency of 0.88-0.93 for the turbines (old-new and Pelton-Francis), 0.97 for the generators and 0.99-0.995 for the transformers. Because every project of interest has a reservoir the turbines are operated at optimum discharge or at maximum discharge. The power plant discharge depend on the head as follow: $Q = Q_{max} (h/h_{rated})^{0.5}$

- The energy losses in waterways and efficiency of turbine, generator and transformer depend on the *operation mode*. Running the turbines at full capacity during peak hours and partly in the off-peak period gives a higher loss than running the power plant at same load throughout the day. In the simulation no peak power operation is assumed, i.e. same load throughout the day.

- A *minimum flow* is only included in the Nam Theun projects (only data available).

- *Gravity constant* (g) of 9.81 m/sec^2 is used (actually dependent on latitude and elevation).
- The total of *forced and planned outages* are assumed to be 1% in general. The outages are caused by:
  - Maintenance of electrical and mechanical equipment.
  - Maintenance of tunnels and shafts. Cleaning of sand-trap, inspections of tunnels, painting of steel lined shaft and penstocks.
  - Flood or high sediment concentrations, intake area flushing.
  - Unpredictable outages: E.g. strikes, transmission line break-down, earthquakes, landslides giving very high sediment load in the water, etc.
- The *transmission line losses* between the power plant switchyard and the load centre are not included. A 8-10% loss may be used for rough estimates for transmission and distribution, but shorter lines, refurbishment and new transmission lines will change this figure. The reference point for the energy production calculation is therefore the power station switchyard.

The energy production has been calculated based on the following equation:

(100%-outages) x Efficiency x g x Power plant discharge x Net head x 24 hours x No. of days per month [kWh/month]

The data on simulated energy differs from the project specific data because upstream development is not foreseen in the specific projects studies.