Study of the electric distribution network of a mountain village

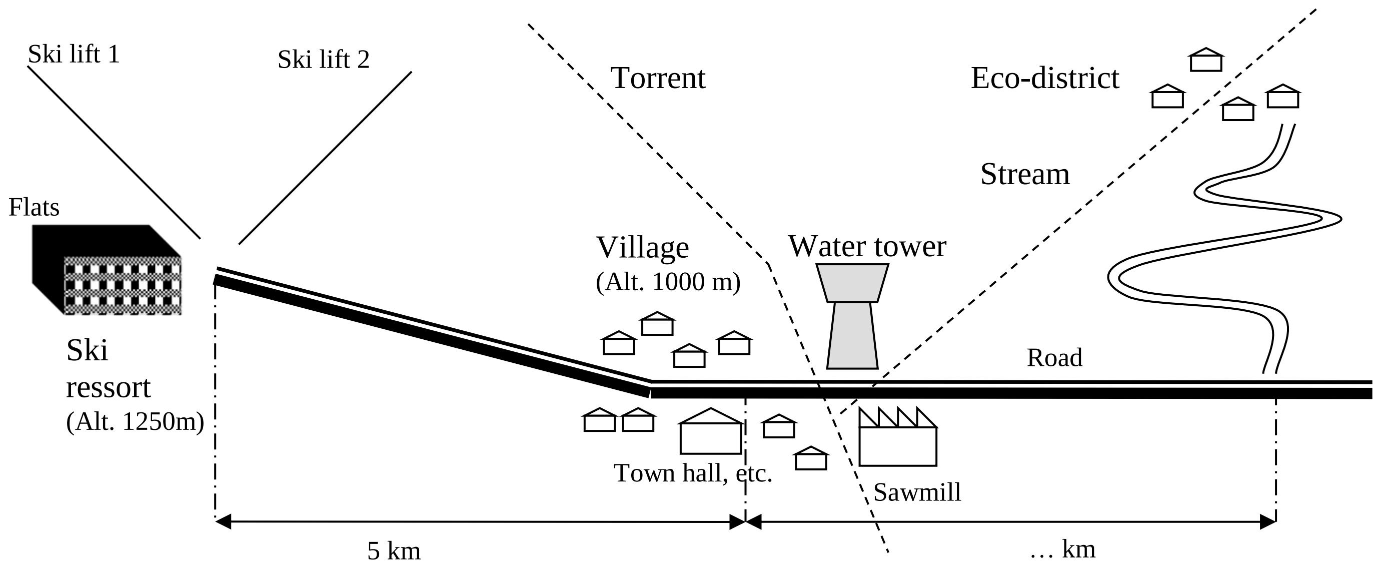
The village is located deep in a mountain valley. Electrical distribution is operated by a municipal utility. The village includes the following electrical systems:

- A nearby ski resort with two chairlifts,
- Street light,
- A water tower,
- A small sawmill business,
- Communal site: Town Hall + multipurpose room + technical services,
- Private subscribers (residential and commercial)

The village center is served by an overhead line of 8 km in length and 20 kV rated voltage (conductor cross section is 150 mm²). The short-circuit power available at the source substation 63/20 kV is 500 MVA. The power at the various points of the village is obtained from a main MV / LV substation situated near the village centre. The ski resort - located 5 km further - is supplied from the latter electric node at the village centre.

In order to develop the village, local authorities are considering the creation of an eco-district in a natural area at the edge of the village and the use of solar and hydraulic production opportunities.

1°/ Village map:



2°/ Other information :

- Both lifts are mechanically identical (75 kW / 1500 rpm motors). However the first one is equipped with a slip-ring motor whereas the second chairlift has been renovated with a variable speed drive (choose from the catalogue ATV66).
- On the ski site: 15 private subscribers of 3 kVA (small apartments).
- Following a major electrical incident on the ski site, the connection and associated elements between the station and the village has to be replaced.
- Private subscribers in the village: 180 subscribers of 6 kVA (houses and apartments), 250 subscribers of 9 kVA and 100 subscribers of 12 kVA (homes and businesses).
- The municipal site: 36 kVA with lighting and water tower.
- The sawmill: 36 kVA
- Various documentation on transformers, lines, motors and Homer software is available on Chamilo.

3°/ Work description:

8/9-student working groups - study, defence and report for each group

There are several possible configurations to power the village and the station from the HV / MV source station.

Preliminary technical study:

- Identify possible configurations and propose the corresponding line diagrams.
- Identify the main load characteristics (behaviour, power, power factor, harmonics, etc.)
- Selection of lines (or cables) and transformers
- Estimation of connection costs
- Ensure compliance with the standards on the voltage provided at each point of delivery (in charge amplitude and harmonic content)
- Confirm your choice of connection solutions from the station calculation of the capitalized cost over 20 years with a discount rate of 8%

Economical feasibility of renewable-source integration: (refer to pages 3-5)

- With the "Homer" program, assess local power generation solutions in the village and in the eco-district.
- Establish the definitive (single line) detailed wiring diagrams of MV / LV networks from the HV/MV substation source to the different points of delivery, showing the connection of equipment, protections, etc.

EVALUATION OF LOCAL SOLUTIONS OF ELECTRICITY PRODUCTION

The distribution of electricity in the mountain village and the resort is managed by a DNO (Distribution Network Operator). EDF is the electric provider and RTE operates the transmission grid and the source station.

1°/ Project of a self-feeding eco-district :

The local authorities wish to study the feasibility of building an eco-district at a remote site 8 km from the village. This site is located in a small sunny valley through which flows a stream. A small water reservoir is available, it was originally used for the purposes of an old sawmill, now moved to the village.
The power supply is a component of the construction project. Taking into account the solar energy and hydropower potentials of this valley, the local authorities, in collaboration with the DNO, want to make a comparative technical and economic study of electrical power solutions for the eco-district. The aim is to focus as much as possible on a production based on renewable energy while not neglecting the financial aspect of the project. The solutions to be compared are:

- Self-feeding of the eco-district (= isolated grid) by photovoltaic panels integrated into buildings and / or a small hydroelectric plant,
- The construction of a line connecting the eco-district to the village.

2°/ Development of the village facilities :

Alongside the proposed eco-district, the DNO would like to study the integration of distributed generation in the existing local network (village + ski resort) connected to the transmission network. The goal is to evaluate solutions that reduce the cost of subscription to EDF. Choose a subscription contract in order to avoid the additional costs due to the consumption peaks exceeding this subscription. Indeed, kWh over subscription is charged at a very expensive rate to the DNO by the supplier.
A small river runs through the village and the stream of the eco-district is a tributary of the river. The study will therefore include a local photovoltaic and / or hydro production.

Comparative studies will be done using HOMER, energy modelling software for renewable and hybrid energy systems.

3°/ Problem inputs:

Eco-district encompasses approximately twenty buildings:

- 5 contracts of 6 kVA, 12 contracts of 9 KVA and 12 contracts of 3 kVA.

The simultaneity coefficient generally found on MV / LV substations is between 0.25 and 0.45 for predominantly residential areas and between 0.6 and 0.8 for predominantly industrial areas. This coefficient is defined here as the ratio between the maximum power measured at the station and the sum of the subscribed power.

We provide charge curves and site temperature on Chamilo:

- The village load curve measured by the DNO,
- The load curve of the ski station measured by the DNO,
- The forecast load curve of the eco-district estimated by the DNO on the basis of village consumption,
- The outdoor temperature curve measured by a small weather station in the village.

The load curves are given in W for each hour on a 1 year period from 1st January 0:00 to 31 December 11 p.m. The temperature curve is given in ° C, also for each hour and over the same period. Files containing such data are available on the Chamilo base.

Below is a table of hydraulic data measured by the village authority:

	River (village site) Average monthly flow (m3 / s)	Stream (éco-district) Average monthly flow (l / s)
January	0.82	12.2
February	0.75	11.4
March	0.71	13.3
April	0.72	13.6
Mai	1,03	12.3
June	1,06	15.7
July	1,1	12.2
August	1,09	11.4
September	0.9	10.1
October	0.96	9.5
November	0.87	9.9
December	0.78	11.5

Two different water intakes can be used for the eco-district stream.

	River (village site)	Stream (éco-district)	
Head (m)	22	219	342
Penstock ∅ (cm)	110	10	15
Length (m)	250	1400	2400
Turbine efficiency (%)	75	82	

We'll take a discount rate of 8% and the project life is 20 years.

Additional data relating to the implementation of electricity production sites can be found through a personal search. We give a few documents / websites readily available to help start this research:

- http://www.photovoltaique.info
- ADEME (Fr): Guide for the installation of small hydropower projects
- Micro-Hydropower Systems – A buyer's Guide https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/buyersguidehydroeng.pdf
- Ministry for Ecology, Sustainable Development and Energy:
  * "Decree of 20 July 2012 concerning the rates of transfer of electricity to local distribution companies" (Arrêté du 20 juillet 2012 relatif aux tarifs de cession de l'électricité aux entreprises locales de distribution)
  * "Public Summary of reference costs of electricity production" (Synthèse publique des coûts de référence de la production d'électricité).
- Insolation data: http://re.jrc.ec.europa.eu/pvgis/.
- RETScreen 4 databases, project analysis software for renewable energy
- Ground reflectance radiation: http://www.bembook.ibpsa.us/index.php?title=Ground_Reflectance

4°/ Work objectives :

- Analysis of the power curves: knowing the three categories of consumers (residential, commercial and industrial) that are conventionally defined. Discuss the structure of the provided curves (cyclical, correlation with temperature, average power, maximum power, simultaneity coefficient, etc.).
- Modelisation of the eco-district problem in HOMER. You can use the document HOMER_mode_demploi.pdf which contains an example of an hybrid system.
- Concurrently to this modelling, a research of data will be necessary.
- Launch of the optimization calculations and analysis of the resulting solutions.
- Repetition of the previous steps for the integration of distributed generation in the local existing grid of the village.