

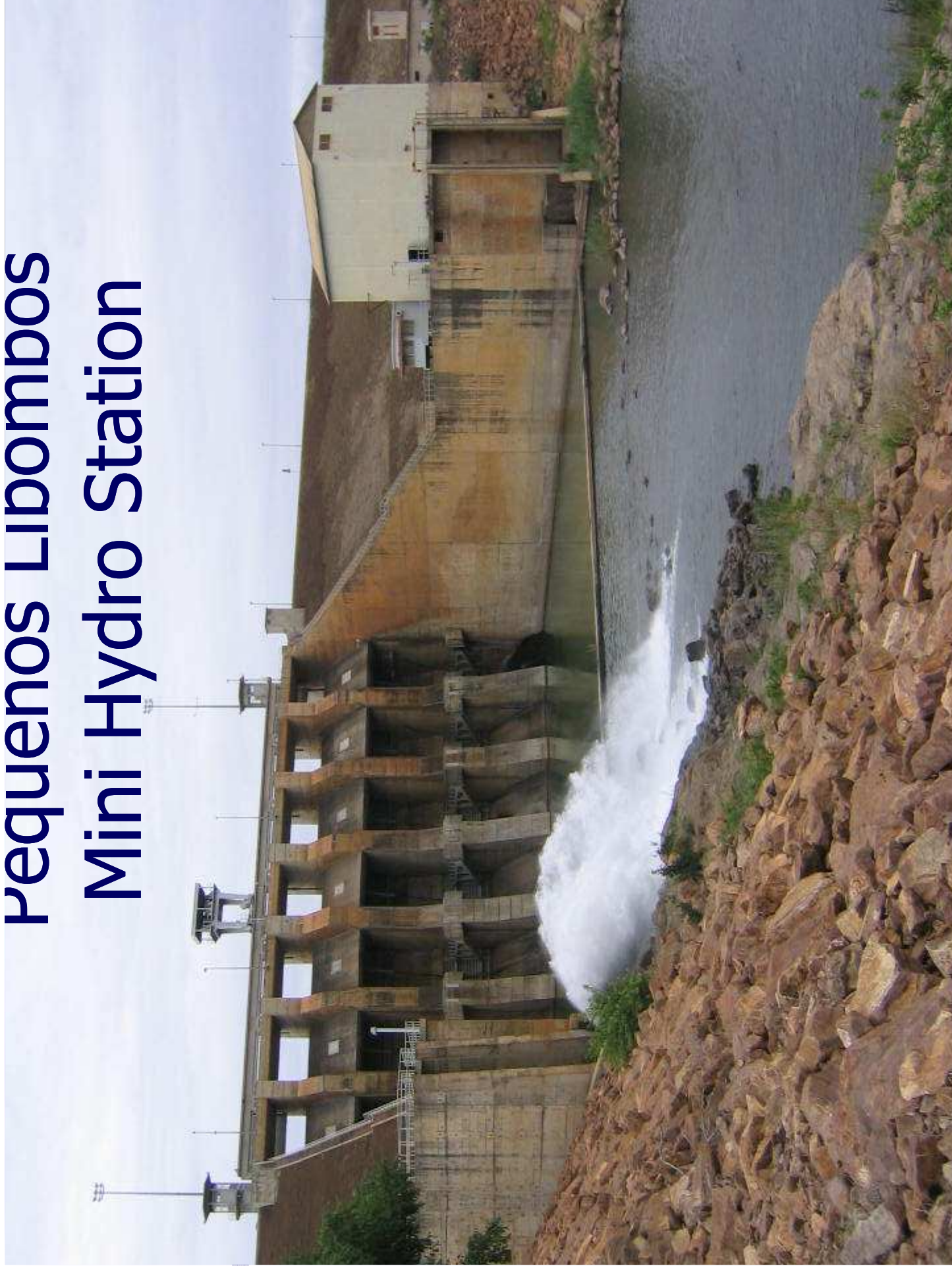
Development of mini hydros

By : Einar Sofienlund

- ♦ **Electrical engineer**
- ♦ **Hydropower engineer**
 - ♦ Economy
 - ♦ Hydrology
 - ♦ Geology
 - ♦ Project management etc
- ♦ **Experience**
 - ♦ 9 years at NEBB (ABB)
 - ♦ 15 years with Norconsult
- ♦ **Project manager, int. proj.**



Pequenos Libombos Mini Hydro Station



Development of mini hydro plants, Why ???

Technically

dynamic processes => more interesting
more aspects => more challenging

Economy

private development
=> income now but limited
=> pension in the future

Future

Energy constraints
=> high energy prices
Difficult to get permissions
=> important to construct now

Development of mini hydro plants, Hydrological facts

Catchment area

14 km²

Average run-off

0,145 m³/sec

Max flow (100 years)

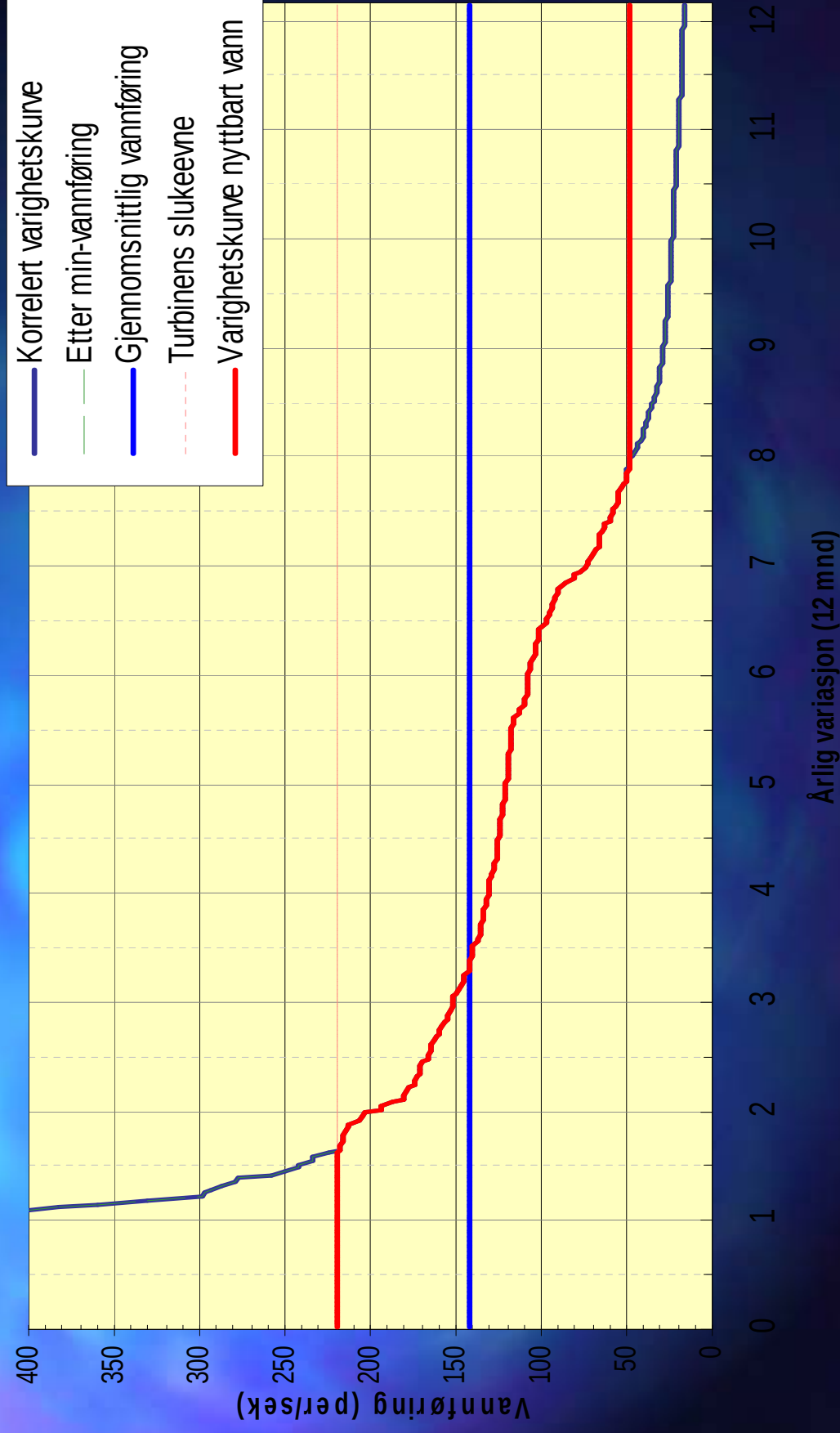
3 m³

Altitude

555 m asl



Development of mini hydro plants, Hydrology duration curve



Development of mini hydro plants, Key figures for "Fønhus"

Catchment area	14 km ²
Average run-off	0,14 m ³ /sek
Head	355 m
Installed capacity	600 kW
Machinery	Vertical Pelton Asynchronous generator
Transmission line	22 kV underground cable
Production	about 2,5 GWh
Energy price	about 0,20 – 0,25 kr / kWh
Annual income	about 500 000 kr
Construction time	6 months
Total costs	5,5 mill NOK (abt. 0,7 mill €)
Economic bench mark	2 kr per kWh developm. cost

Development of mini hydro plants, Dam



Hight 5 m
Length 25 m
Live storage 40 000 m³

Development of mini hydro plants, Pénstocktracée



Head	355 m
Length	1614 m
- PE pipes	1334 m
- Ductile cast iron	280 m
Dimmension	300 mm
Slope gradient	37 degree (on picture)

Development of mini hydro plants, Penstock construction



Slope gradient 37 degree (on picture)

Development of mini hydro plants, Powerhouse

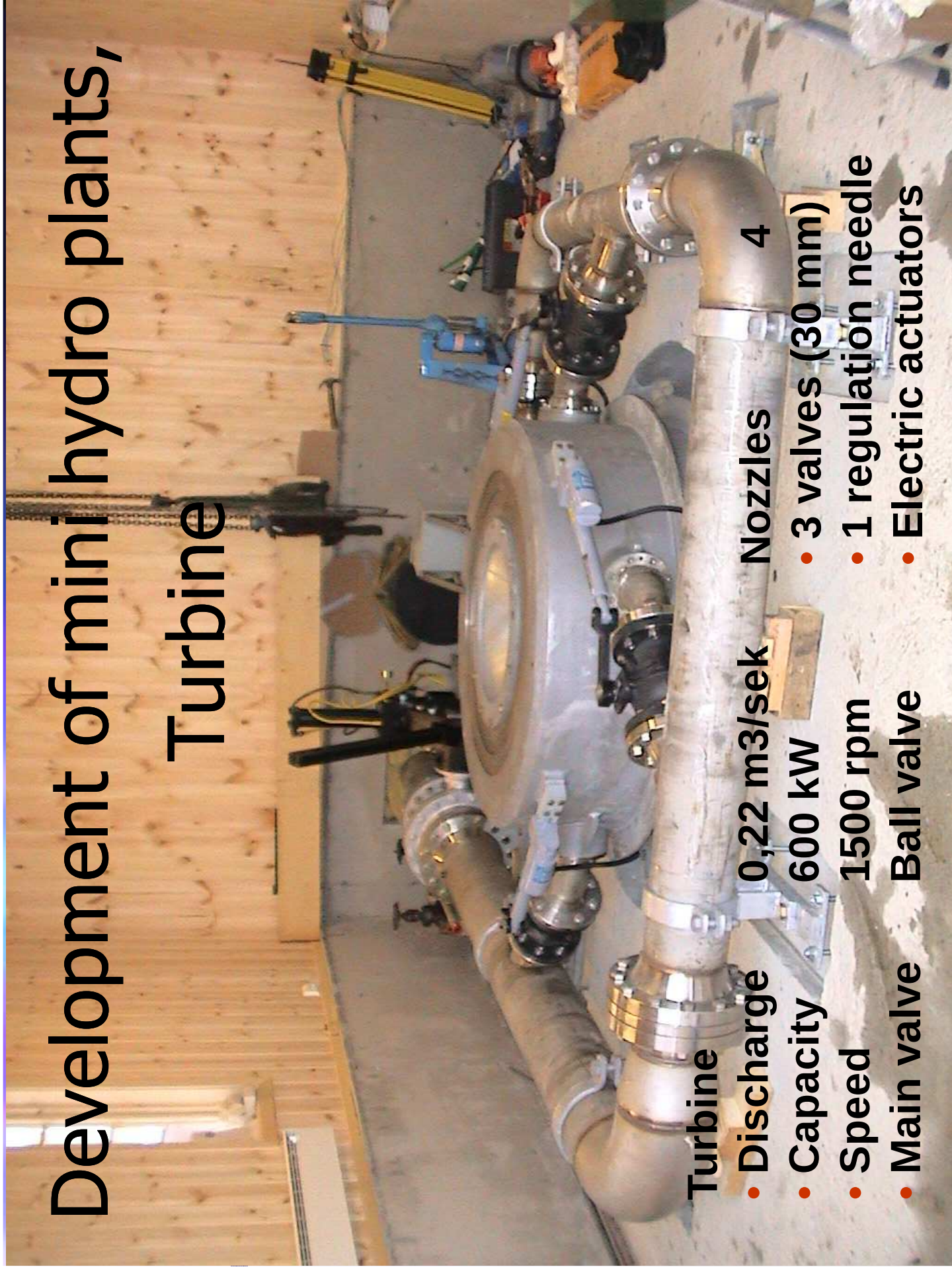


Elevation 200 m asl
Square size 30 m²
Foundation 70 m³ (concrete)
Crane beam 6 tonnes

Development of mini hydro plants, Turbine

Turbine

- Discharge 0,22 m³/sek
- Capacity 600 kW
- Speed 1500 rpm
- Main valve Ball valve
- Nozzles 4
 - 3 valves (30 mm)
 - 1 regulation needle
 - Electric actuators



Development of mini hydro plants,

Runner

4 Nozzles

- 3 valves (30 mm)
- 1 regulation needle



Development of mini hydro plants, Discharge



Turbine outlet at full load

Development of mini hydro plants, Generator

Generator

- Speed 1500 rpm
- Capacity 660 kVA
- Voltage 690 V
- Type Asynchronous

Transformer

- Capacity 800 kVA
- Transmission 0,69 / 22 kV



Development of mini hydro plants, Control and protection

Fully Computerised

- Processor industrial PLS
- MMI is PC with touch screen
- Communication via SMS
- Internet WEB (future)
- Protection
 - * electronic
 - * software



Development of mini hydro plants,

Grid connection

- 1 km long underground 22 kV cable (project concession)
- Load break switch remote controlled
- Metering at T-off by grid operator
 - Installation paid by Fønhus
- Tariff structure
 - Capacity charge
 - Energy cost (+ or -)
 - Metering fee
- Reactive compensation (cos phi 0,91)
- Power sales to the local utility
 - - Alt 1 – Spot sales
 - - Alt 2 – Fixed price
 -

Development of mini hydro plants, Key economic & finance figures

- Development cost 2 kr per kWh
- Electricity tariff 0,20 to 0,30 kr per kWh
- Internal rate of return 10 - 15%
- Equity 750 000 kr
- Loan 4 800 000 kr
- Return period 12 – 20 years (price dependent)

Conclusion :

A developer lives poor, but dies rich ???