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Small Hydropower Projects (SHPP)

Operation & Maintenance of SHPPs

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Operation & Maintenance of SHPPs

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0	28.06.2017	Final	Urs Gantenbein	Fabian Knapp
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Operation and Maintenance (O&M)

Operation

- The Operation of a HPP and its operating regime is linked to its type (Run-of-River, Storage, etc)
- Run of River-schemes cover usually base load, storage-schemes cover peak load
- Possibility of multipurpose use and agreement between various stakeholders (energy, water supply, irrigation, fisheries) → SHPP – Armenia; Provide & Sell Energy as produced
- The HPP operator reports status and availability of generating equipment to the network operator
- The network operator reports load demand schedule to plant operator
- There should be a close cooperation between the operator of a HPP and the network operator
- For the Network Operator Grid stability and demand satisfaction are the primary goals
- Availability of a well designed and maintained HPP can be as high as 97 to 99% of time.

Maintenance

- Maintenance with the purpose of ensuring longest possible life expectancy and highest possible availability of equipment for energy generation.
- Life expectancies for equipment range from 10 years (runner, electronics), to 70 years (transmission lines, penstock) before need of replacement.
- Four (4) types of maintenance philosophies exist: predictive-; preventive-; reliability-centered - ; and condition-based
- Historically condition-based maintenance was the mainly applied method
- Tendency in modern maintenance practice: combination of condition-based and preventive maintenance.
- 2-4% of initial equipment costs need to be budgeted for maintenance and spare parts on annual basis.

Operation: Run-of-River and Daily Storage Plants

Plant Operator:

Estimates the possible energy generation based on river discharge forecast and available generating capacity (and, if available, precipitation forecast, daily storage capacity).

=> Reports to Utility / Network Operator / Owner

Utility / Network Operator:

Prepares load demand schedule on hourly basis.

=> Reports to Plant Operator

Operation: Storage Plants – (for information)

Storage Plants comprise dams and reservoirs, with weekly to multi year storage capacity

They are mostly operated to cover peak demand.

Utility / Network Operator:

Prepares load demand schedule on hourly basis.

=> Reports to Plant Operator

Plant Operator:

Confirms or modifies the possible energy generation based on available storage and generating capacity.

=> Reports to Utility / Network Operator

Maintenance

Purpose:

To ensure the highest possible availability, reliability of the units and HPP equipment for energy generation and the longest possible life expectancy of applied components.

Availability:

Availability of well designed and maintained hydro power generating equipment and overall plant, depending on type of plant and operation environment, can reach operation time or availability of up to 97% - 99 % of time.

Reliability:

Reliability of a unit of HPP is defined as its ability to consistently operate / perform its intended or required function on demand and without limitation, degradation, failure or break down.

Also called quality over time.

Therefore; **Availability** and **Reliability** are complementary features

Operation & Maintenance: Staffing

Number of staff depends very much on:

-- Level of automation and monitoring

-- Quality of design, manufacture, installation and commissioning of equipment

As well as on:

- Number of units, Installed capacity, head,
- Age and level / thoroughness of maintenance performed since start of operation
- Country of Installation (=> Organization, staff‘s skill level and education, cultural aspects)
- State- or private- owned and corresponding attitude of owner’s management
- Level of outsourcing (repair workshops, Controls-System, -Network & IT, residue & trash disposal etc)

Installed capacity and head are representative for physical size and complexity of hydro power projects

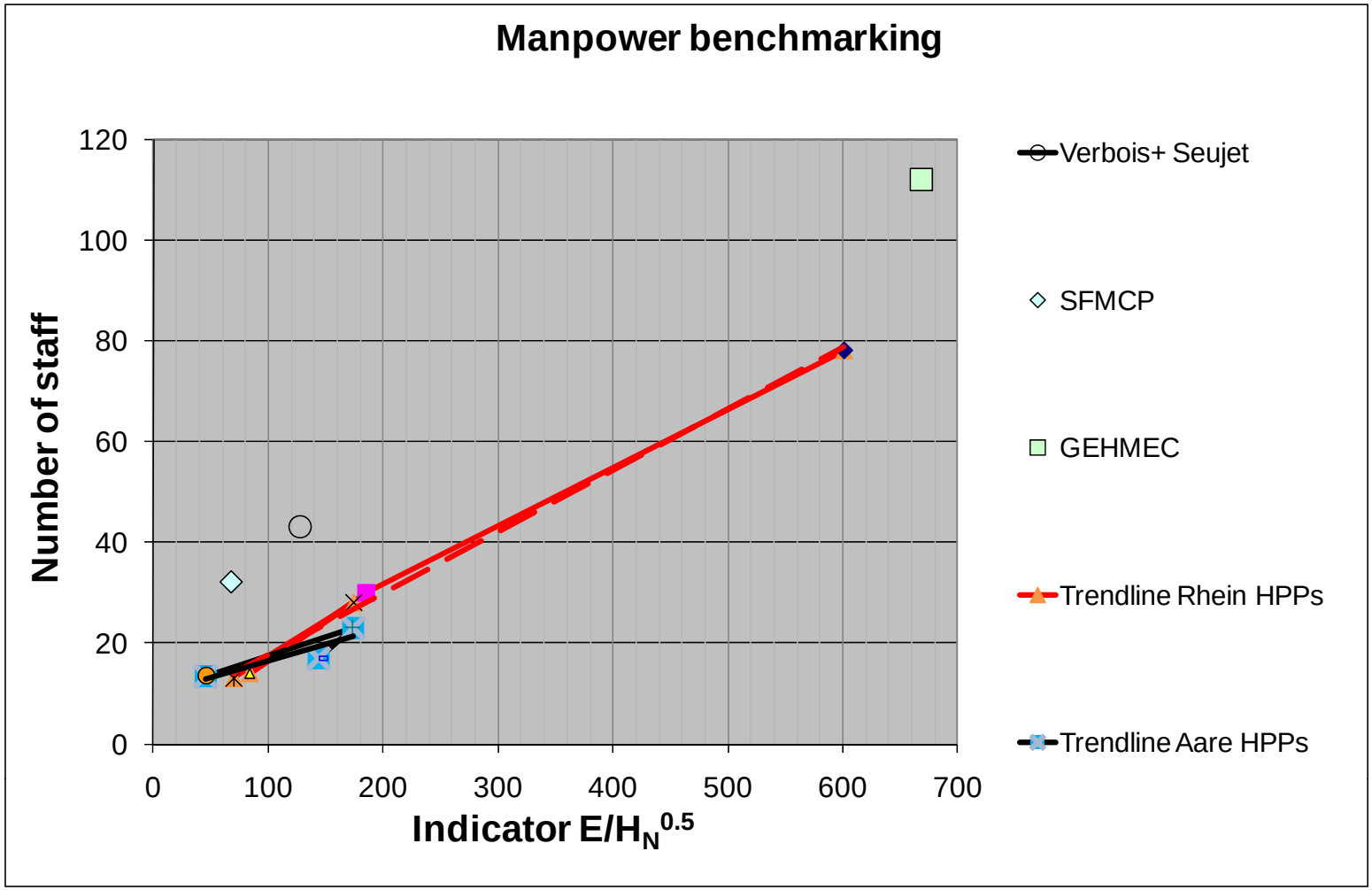
For hydro power projects of similar type (low, medium or high head) a rough estimate of necessary staff can be made based on evaluation of operational and staff records of existing plants

Maintenance: Manpower Benchmarking

Benchmarking for low head plants: Indicator: $f=E/H^{0,5}$

E = Annual Energy Generation [GWh/a]

H = Medium operational head [m]



Life Expectancy: examples for different systems equipment

Plant Item	Expected useful life (years)
Main generating equipment: turbine equipment other than runners, generator, generator/motor, governor, excitation system, main inlet valves.	40
Turbine runners; Control systems & Electronics	10 -20
Power transformers	40
High voltage switchgear and switchyard equipment	40
Low and medium voltage switchgear	30
Control and protection system, remote control, SCADA, communication equipment, metering	20
Plant auxilliary mechanical and electrical equipment (drainage and dewatering pumps, cooling system, compressed air system, HVAC, AC/DC power supply, emergency diesel generator, etc)	30
Transmission Lines	70
Penstocks, gates, stoplogs, trash racks	70

1. Maintenance – Condition Based Maintenance

Relies on knowing the condition of individual systems & pieces of equipment.

Very much depending on Maintenance staff's sensitivity to changes in operational behavior, temperature, vibration, noise, etc.

Advantages:

Monitoring large number of equipment parameters such as temperatures, pressures, vibrations, current, dissolved gas analysis, etc.

Testing on a periodic basis and/or when problems are suspected such as Doble testing, vibration testing, and infrared scanning.

Features and some Drawbacks:

Very difficult and expensive to monitor some quantities.

Requires knowledgeable and continuous analysis of the collected data be effective.

The condition monitoring equipment and systems themselves require maintenance.

2. Maintenance – Reliability Centered Maintenance

Provides appropriate amount of maintenance at the right time to prevent forced outages while at the same time eliminating unnecessary maintenance. Concentrates primarily on “sensitive” systems.

Advantages:

May result in a more streamlined, efficient maintenance program.

Attractive in times of diminishing funding, scarcity of skilled maintenance staff, and the pressure to “stay online”.

Features and some Drawbacks:

Labor intensive and time consuming to set up initially.

Requires additional monitoring of quantities, like temperature and vibration, to be effective (means new monitoring equipment or more human monitoring with multiple inspections).

May result in a “run-to-failure”.

May require initial and later revisions to the maintenance schedule in a “trial-and-error” fashion.

3. Maintenance – Preventive Maintenance (PM)

Maintaining equipment on a regular schedule based on elapsed time or meter readings. The intent of PM is to prevent problems or failures before they occur and to achieve fewer, shorter and more predictable outages.

Advantages:

Predictable in budgeting and planning.

It generally prevents most major problems, thus fewer forced outages, and reduces „reactive maintenance“ and maintenance costs in general.

Drawbacks:

Time consuming and resource intensive.

Does not consider actual equipment condition when scheduling or performing the maintenance.

Can cause problems in equipment in addition to solving them by unnecessary „tear and wear“ (e.g. damaging seals, stripping threads).

Maintenance – Tendencies and Costs

Tendency in modern maintenance practice:

Combination of Condition-Based and Preventive Maintenance and even Predictive Maintenance.

Maintenance and spare parts costs:

Depending on type of plant end working environment, 2 to 4 % of the initial equipment cost has to be budgeted annually for maintenance and spare parts, and replacement of used spare parts.

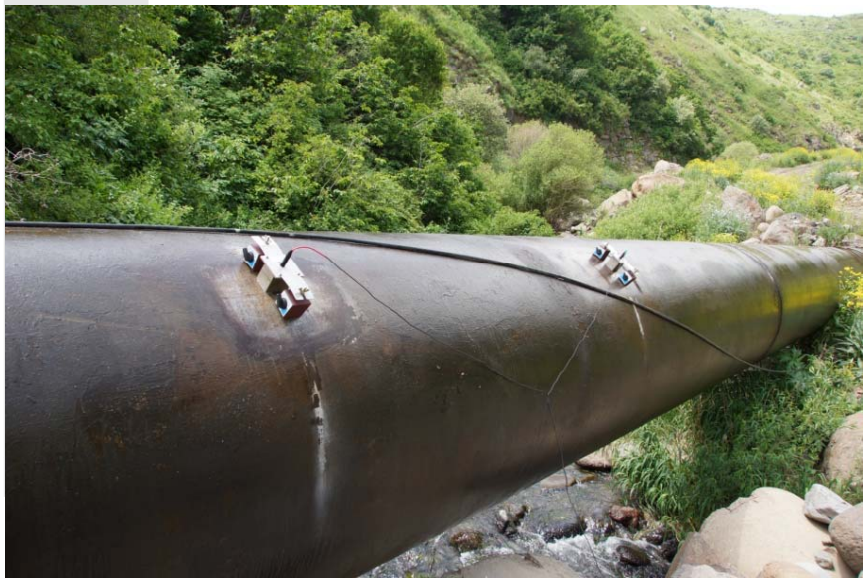
Maintenance

The provision of critical spare parts (with long lead times!) such as runners, injectors, bearings etc. can significantly reduce the down-times for maintenance and forced outages.

The concept of the envisaged maintenance & operation concept must be discussed within the design phase and must be decided latest when the technical specifications are prepared.

Operation and Maintenance

- 31 (+9) Turbines at 12 (+2) SHPPs funded through the GAF-RE Programme
- 6 Turbine types (Pelton, Francis, Turgo, Crossflow, S-Turbine, Propeller)
- Armenian, Russian and European Turbine Manufacturers
- Wide Range of efficiencies



Different impression of same Type Turbine

Francis Turbine Comparison

Francis Turbine : Local Production

Francis Turbine: European Production

Different impression of same Type Turbine

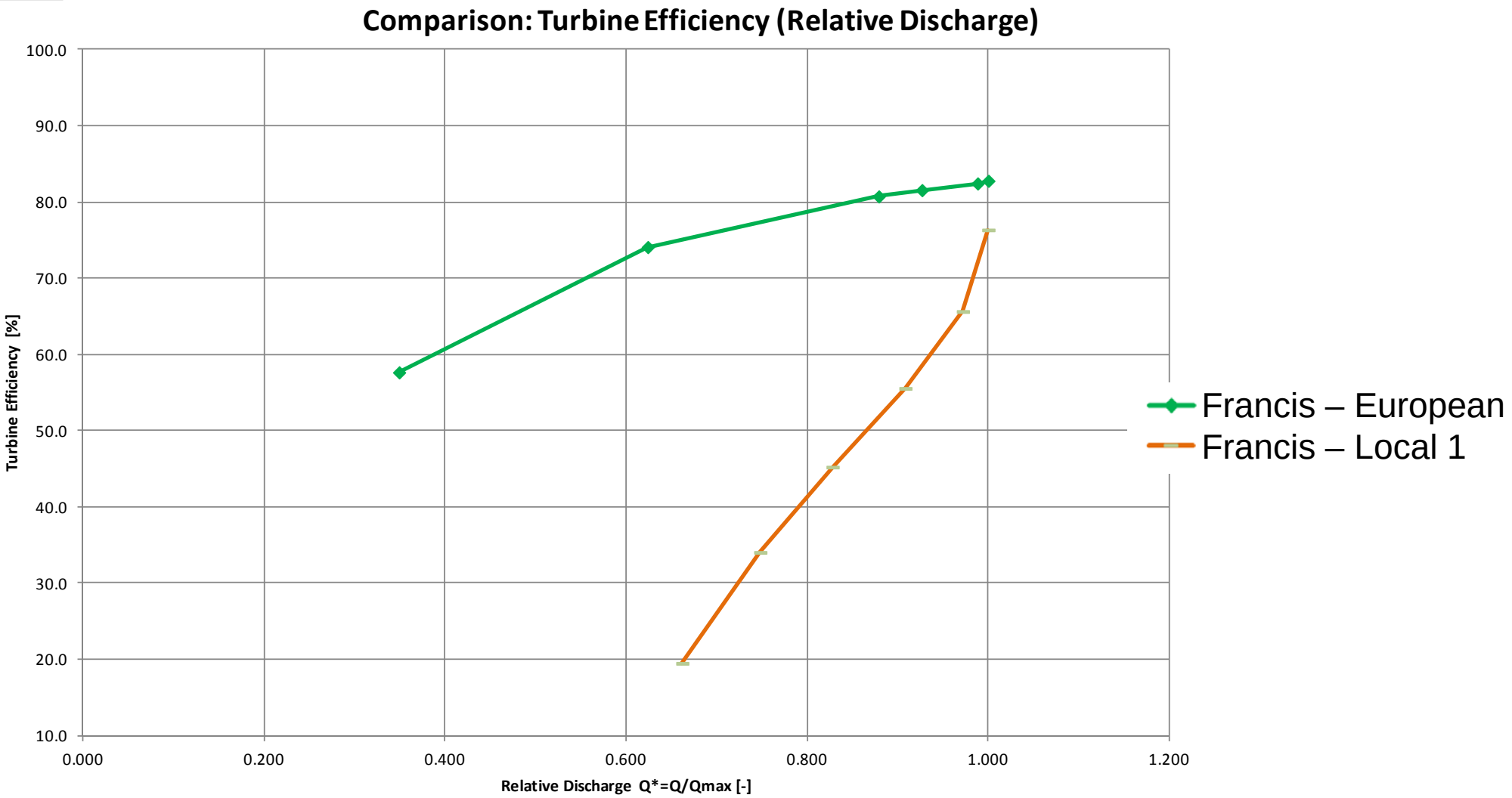
Pelton / Turgo Turbine Comparison

Turgo Turbine : Local Production

Pelton Turbine: European Production

Performance Testing Campaign

Francis Turbine Comparison

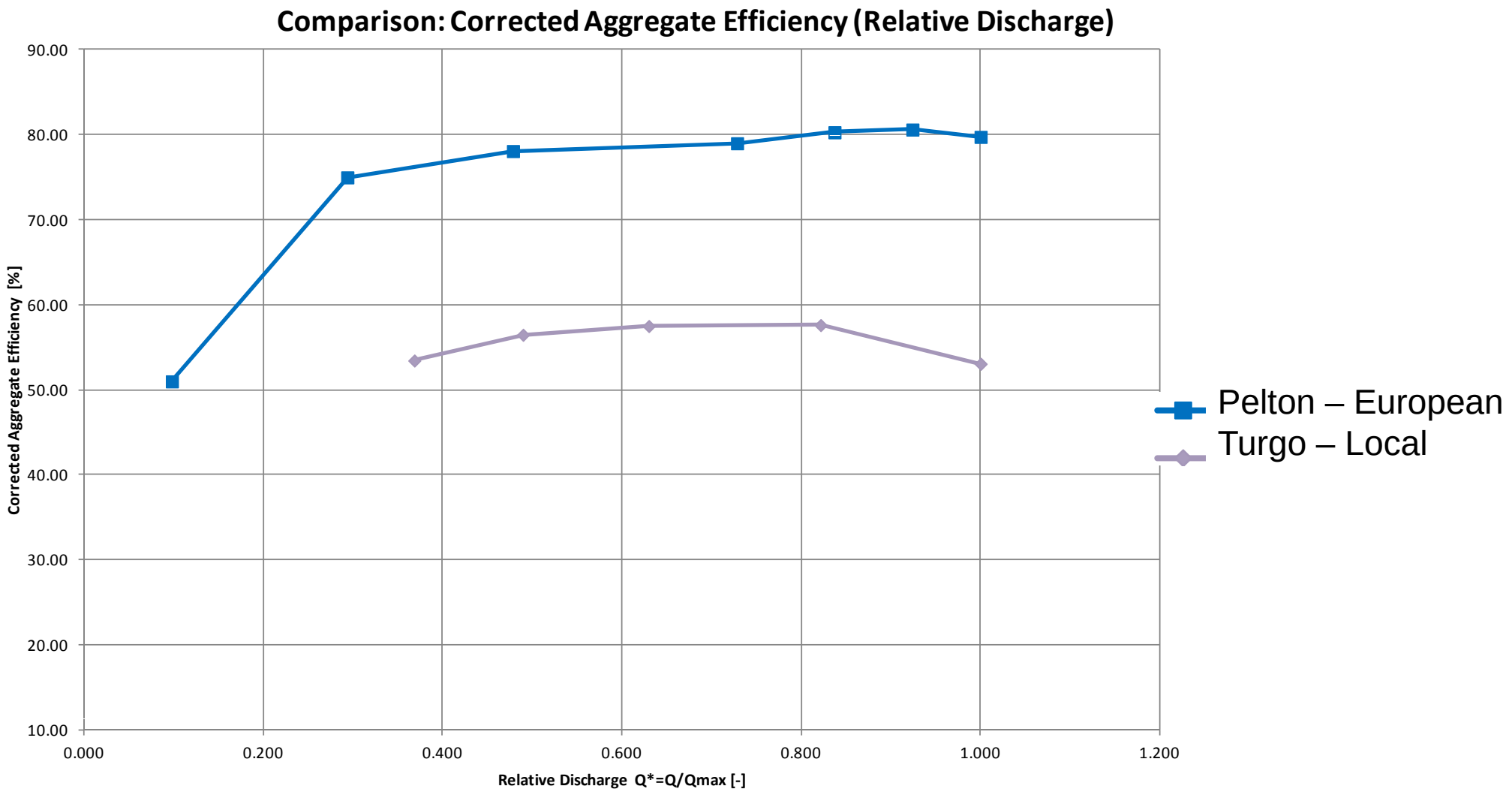


Performance Testing Campaign

- Francis turbines: 40% difference in efficiency at partial load
- Pelton / Turgo turbines: 25% difference in efficiency for entire operating range
- Efficient use of natural resources (hydraulic potential)?
- Possibility for sharp increase of energy generation through replacement of generating equipment
- Evaluation: Efficiency, Energy Generation, Downtimes, Costs (purchase + operation)

Performance Testing Campaign

Pelton / Turgo Turbines Comparison



Thank you for your Attention!