SEMINARAS

Miestų vandentvarkos tvarumo skatinimas: mikrohidroenergijos naudojimas urbanistiniuose vandens tinkluose.

Boosting sustainability of the urban water cycle: energy harvest in water industry using micro-hydropower technology

Kaunas, Lietuva, 12 SEP 2023

Assessment of Hydropower Potential in Wastewater Systems in a Lowland Country, Lithuania

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Contents

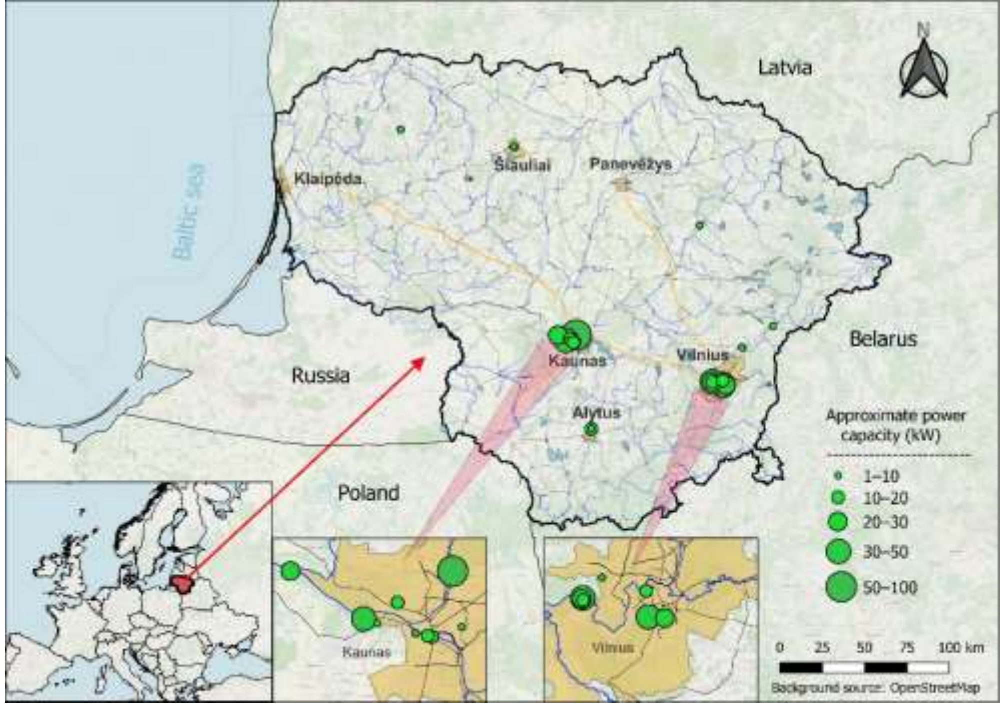
Aim: to evaluate hydro potential in urban networks in low-lying areas and propose methodologies for practical application

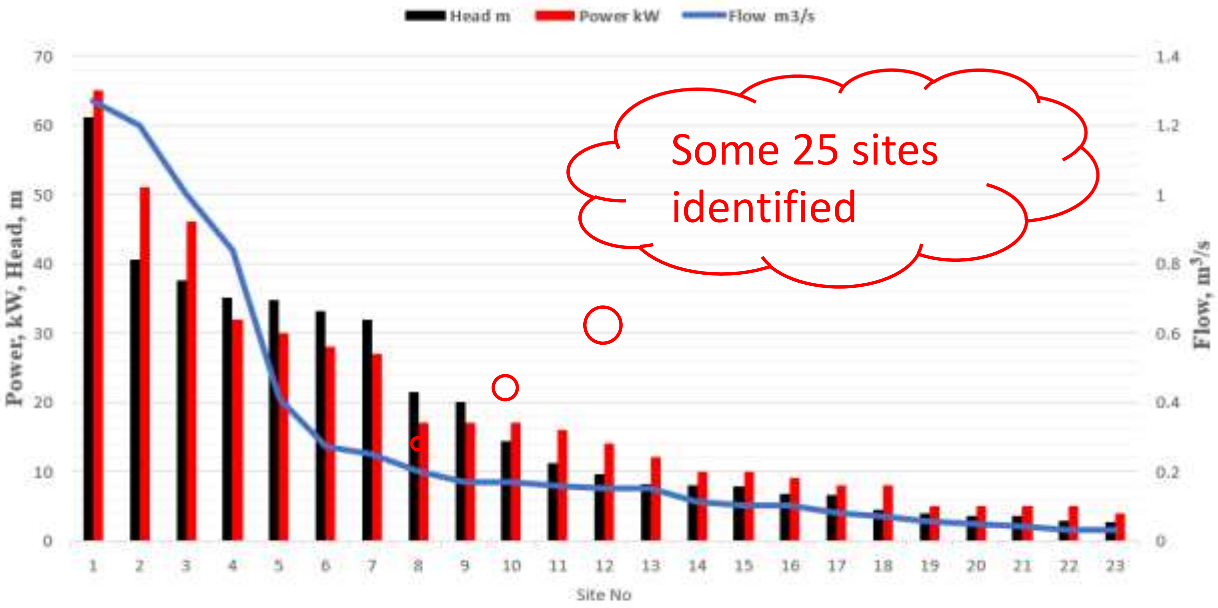
Specific objectives

1. Review best practices of energy recovery in wastewater systems and identify methodology on the basis of local conditions;
2. Search for the potential sites for the installation of hydro turbines and to evaluate wastewater resources in ungauged sites;
3. Review and propose tools to facilitate preliminary and/or feasibility analysis of hydro schemes and to review turbines and their installation layouts in wastewater systems;
4. Show best practice in performing multicriteria analysis for the selection of optimal hydro sites.

Study Area

The urban water network with potential micro-hydro sites to be deployed in the municipal water infrastructure. More than 25 potential sites for installing hydropower turbines were identified.





Key data of potential sites in urban water network (mostly wastewater) for installing hydro turbines.

So far, no such hydro plants operating in Lithuania and other Baltic States.

Potential sites for installing hydropower turbines in urban water networks of Vilnius, Kaunas cities, and Alytus town

Name	ID Label	Population Equivalent (PE)	Service Area (km^2)	Location [1]	Head (m)	Flow (m^3/s)	Outlet
Kaunas (Jonavos st.)	K1	104,300	25.3	U/S	35.0	0.3	Sewage network
Kaunas (Raudondvario st.)	K2	36,800	16.4	U/S	27.4	0.18	Sewage network
Kaunas (Pypliai)	K3	305,500	137.0	D/S	4.0	1.2	The Nemunas River
Vilnius (WWTP-1)	V1	569,500	356.0	D/S	2	1.5	Outlet collector
Vilnius (WWTP-2)	V2	569,500	356.0		2.9	1.5	The Neris River
Vilnius (Prusu St.)	V3	35,000	18.2	-	61.1	0.11	Network
Alytus (WWTP-1)	A1	49,900	39.4	D/S	15.0	0.11	Outlet collector
Alytus (WWTP-2)	A2	49,900	39.4		10	0.11	The Nemunas River

[1] Site location relative to WWTP (upstream—U/S or downstream—D/S)
WWTP – Wastewater Treatment Plant

Source: https://www.lifenexus.eu/en/results/eu-inventory/

2. Search for Potential Sites

There are obviously known sites in drinking water networks with excess head or pressure. The same is true for WWTPs at inlets and outlets - engineering, layouts and drawings are available.

The problem stems from the wastewater collection network placed in the areas upstream of WWTPs.

Spatial information (GIS data) was used to identify potential hydro sites in water distribution systems and geodatabases compiled.

- Spatial databases, i.e., high-resolution digital terrain or elevation models (DEMs).). E. g, Global terrain data from Google Earth or other platforms, the Shuttle Radar Topography Mission (SRTM) DEMs.

- Their data can be used but with caution, i.e., only for the initial assessment of SHP locations and not for flat terrains with a low vertical resolution in topography.

2. Search for Potential Sites (cont.)

- The SRTM DEM with a spatial resolution of 30 m has a reported accuracy of ±16 m, which is acceptable. However, the vertical accuracy crucial for determining elevation has also been reported to be <9 m for flat terrain and 4.3 m for mountainous regions. Such accuracy would exceed any project design standard.

Prospective sites in wastewater networks in Lithuania can be determined from the GIS spatial data portal freely (gross head - a drop in elevation or location coordinates).

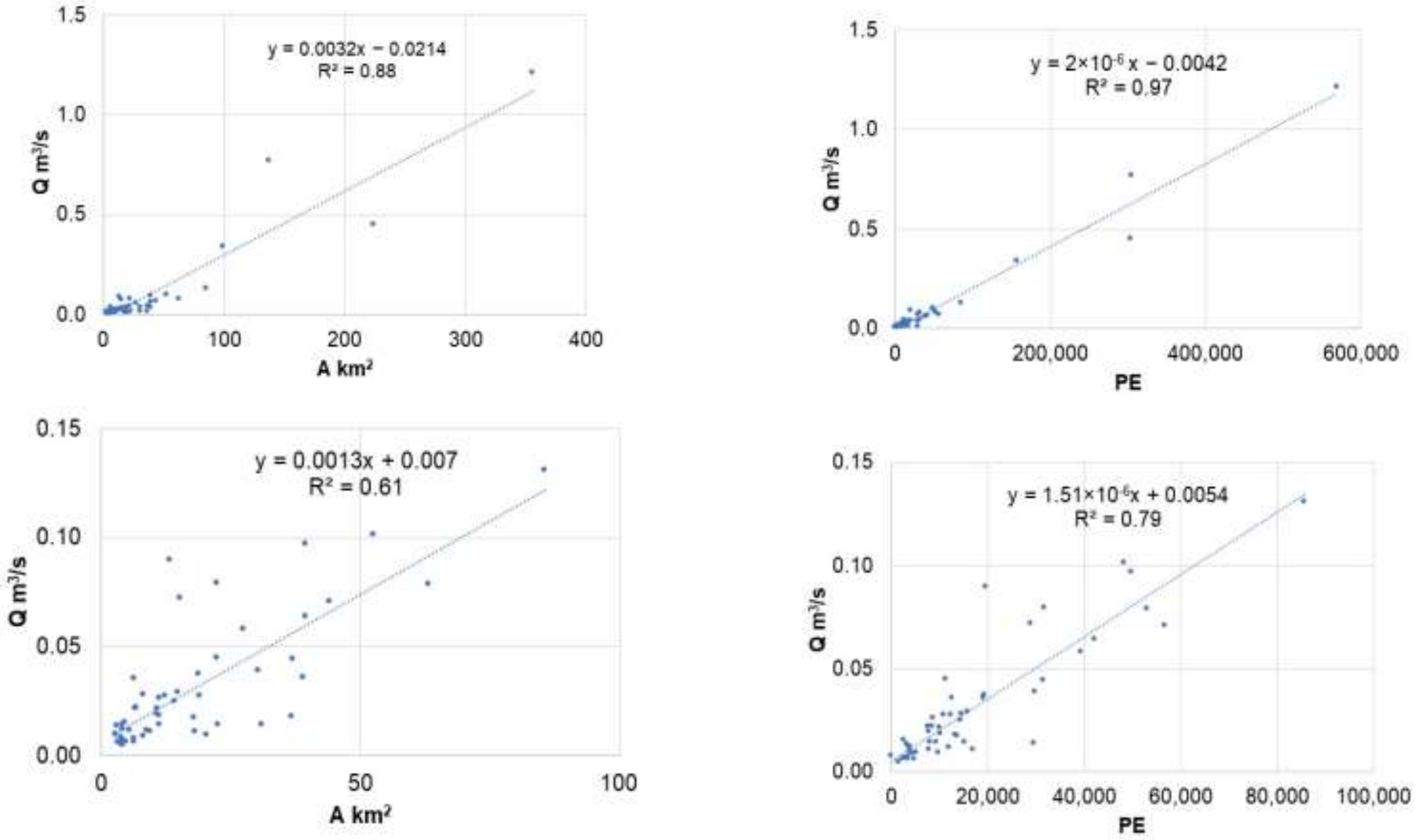
- However, the accuracy of this assessment will be unacceptable for ultra-low or even low-head schemes because the vertical resolution of the DEM would be insufficient.

- **No automatic site search using GIS tools is possible due to the technical complexity of sewage pipeline systems.**

3. Wastewater Resources

If on-site wastewater flow data is unavailable:

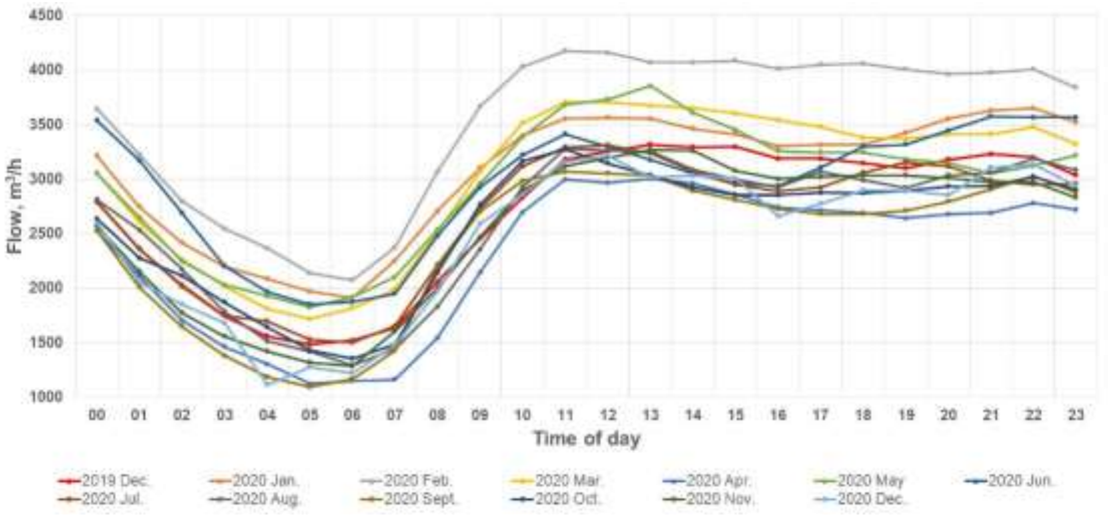
- Estimates can be derived from water use records or other relevant information.
- One of the key metrics for energy estimation is the average annual wastewater flow rate, followed by the distribution of daily flow rates over time: FDC (Flow Duration Curve)



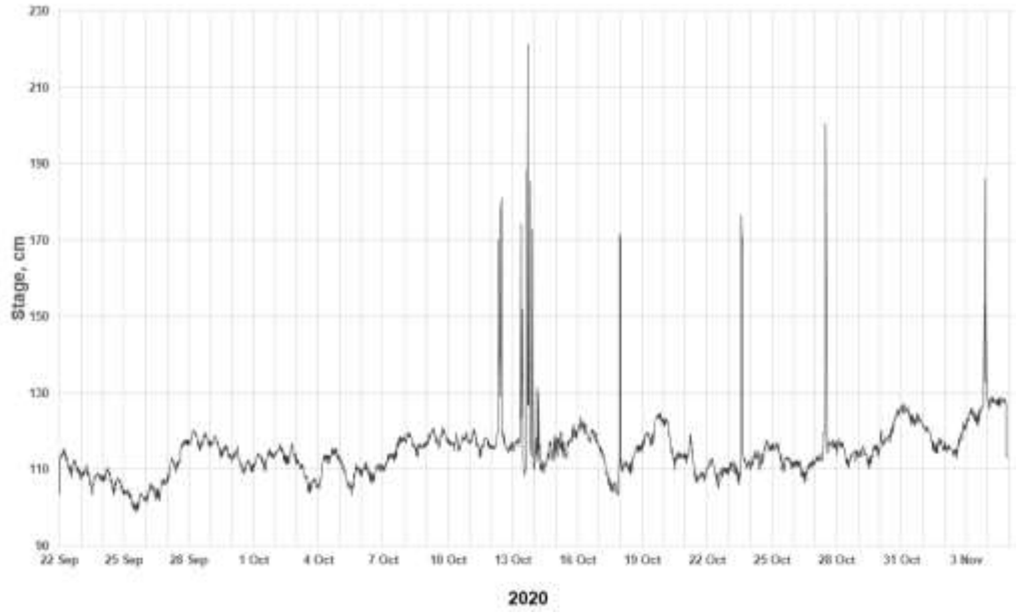
Relationship of mean annual wastewater flow with population equivalent (PE) and collection network service area (A, km^2).

- Top - all 58 WWTPs;
- Bottom - small WWTPs (large cities not included, PE <100,000).

Wastewater flow patterns



Treated water daily fluctuations over 24 h for months at the outfall of the Kaunas WWTP (December 2019–December 2020). No high „spikes“ (Service area A= 137 km^2, PE= 305,500).

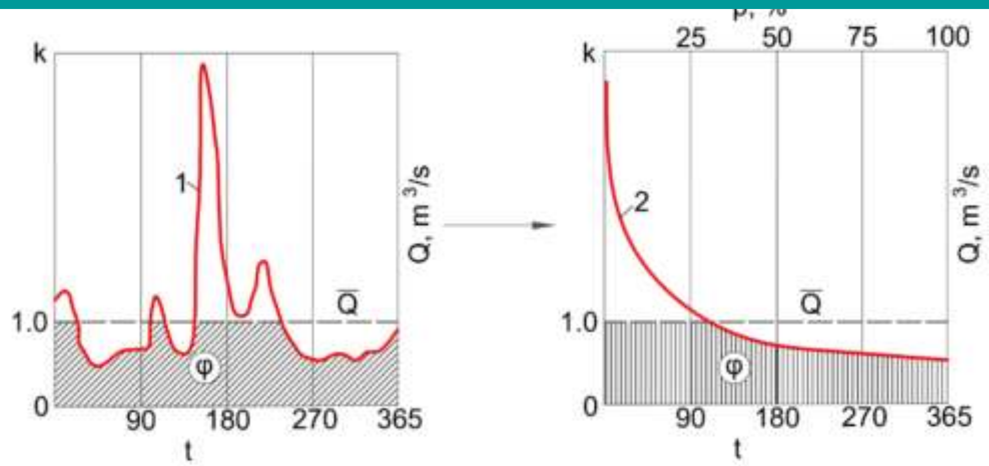


Wastewater hydrograph (22 September to 5 November 2020) perturbated by storm events at Akademija−Marvele (A = 1.5 km^2, PE = 2400).

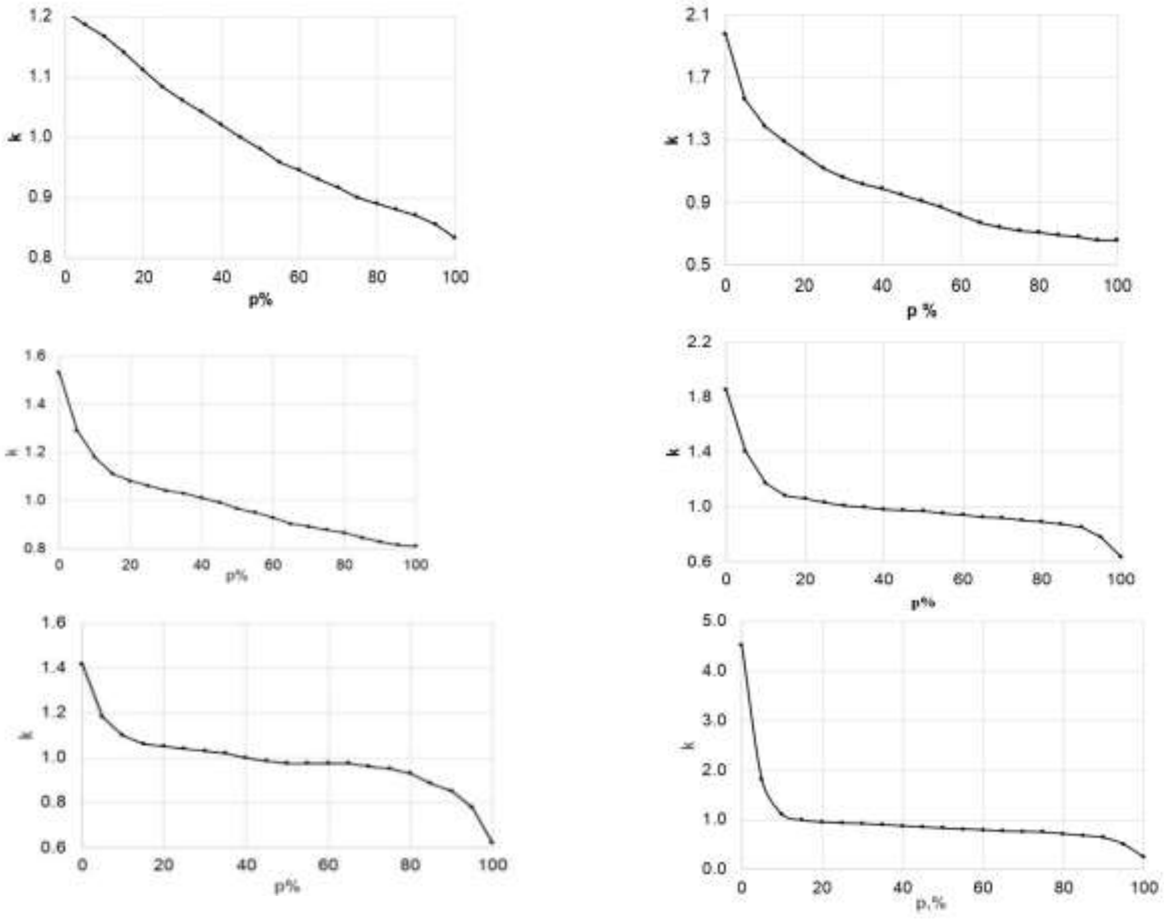
No turbine could handle these instantaneous sewage peaks without compromising performance.

Some studies examined the variation in wastewater flow due to heavy rain events in WWTPs to optimize turbine selection. However, few such studies were conducted on the sewage network to install turbines.

Flow duration curve (FDC)



Hypothetical hydrograph (1) and flow duration curve (FDC) (2). *Q*—flow, m^3/s; *k*—normalized flow; *t*—time, days; *p*—percentage time, %; *Q*—mean flow, m^3/s; *Φ*—parameter.



The proposed methodology allowed for establishing a flow duration curve for an ungauged site using only three values:

- the highest flow,
- mean flow, and
- lowest flow, taking into account the parameter Φ.

Normalized (dimensionless) FDCs (from left to right): Kaunas 1, Kaunas 2, Kaunas WWTP, Vilnius WWTP, Vilnius PRV, and Alytus WWTP; k—normalized flow; p—percentage of time equaled or exceeded.

Selection field for classical turbines is relatively narrow in a flat terrain where elevations are relatively low and low flow rates.

Only reaction-type turbines can be used at low-head schemes, e.g., propeller, Kaplan, seldom crossflow, and Francis.

- Despite the significant advantages of Archimedes screw turbines (low head, tolerance to water quality, and debris or clogging), their applicability in urban areas is restricted.

- In municipal sewage networks, this kind of turbine is not likely to be accepted by the city’s residents due to bulky and heavy construction that causes visual pollution and incurs operational noise. They can thus only be installed within the WWTP, outlets, away from residential areas.

Vilnius WWTP: Archimedes screw pump

Main features of modular turbines currently available on the market and suitable for in-conduit hydropower in a low-head segment.

	Turbine Type	Net Head (m)	Flow (m^3/s)	Power (kW)	Comments
1.	Amjet ATS	1.5–12.8	0.2–26.0	3–2500	A range of series is available
2.	StreamDiver	2.0–8.0	2.0–12.0	50–1450	There are at least 7 modules
3.	Turbiwatt	1.2–8.0	0.1–3.6	3–120	Three available modules/series
4.	Flygt	2.5–20.0	0.7–10.0	40–850	Six available modules/series
5.	HYDROMATRIX	2.0–25.0	5.0–13.0	200–2200	Very large flow

http://amjethydro.com/downloads/Whitepaper4-2-15.pdf

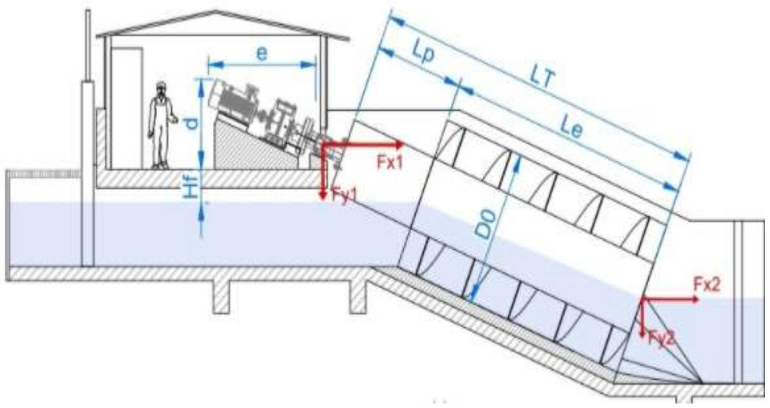
https://issuu.com/zekmagazin/docs/zek_international_2021

https://www.turbiwatt.com/en/choisir-sa-turbine-2.html

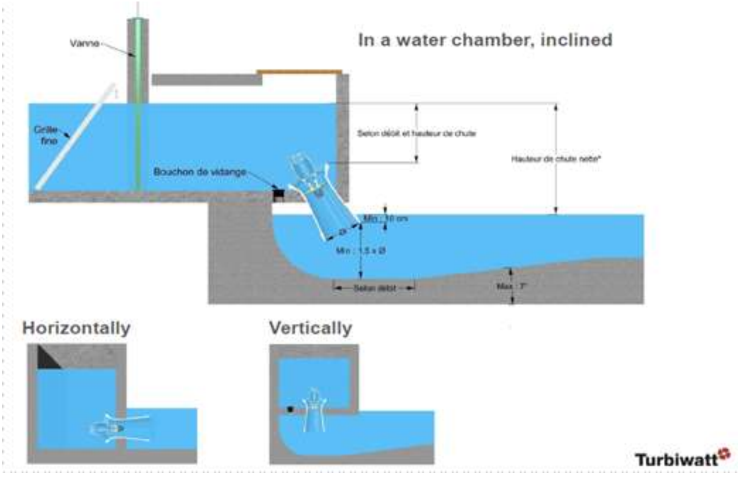
https://www.xylem.com/en-us/products--services/hydro-turbines2/hydro-turbines/

https://www.andritz.com/resource/blob/31692/f484084e0869b431e2362b1e82bef5b2/hy-hydromatrix-en-data.pdf

Turbines



Not attractive solution



Source: HPP Design, Turbiwatt

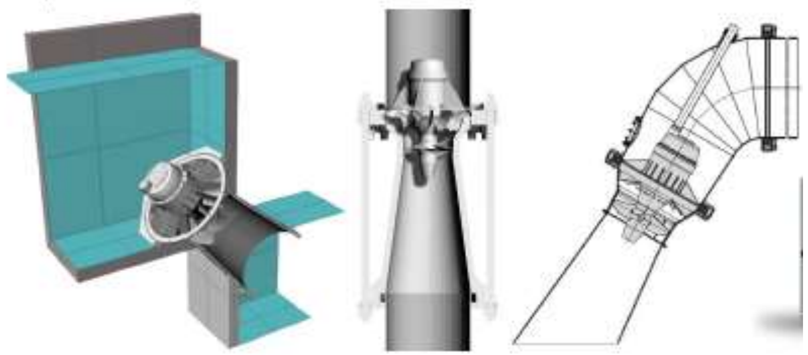


Figure 2-21: Pump-as-Turbine

Pump as Turbine (PaT)

Submersed power units, low visual and noise impact, compact design, low construction costs and a comprehensive economical solution.

Major differences between Turbines and PaTs

	Turbine	PaT
Advantages	Well-documented, accurate design	Cost-efficient
	Best efficiency	Widely available
	Wide range of control	Standardized, simple design product, short delivery, and low maintenance and repair costs
Disadvantages	Expensive	Not as well-documented as turbines, limited availability of turbine operation curves [1]
	Limited local suppliers	Lower efficiency [1]
	Complex design may be required	No variable guide vanes for varying flow

[1] *Some large turbines or pump producers offer PaTs with high efficiencies (up to 87%), along with their operating ranges and guaranteed hydraulic characteristic data from prototype tests*

Turbine costs

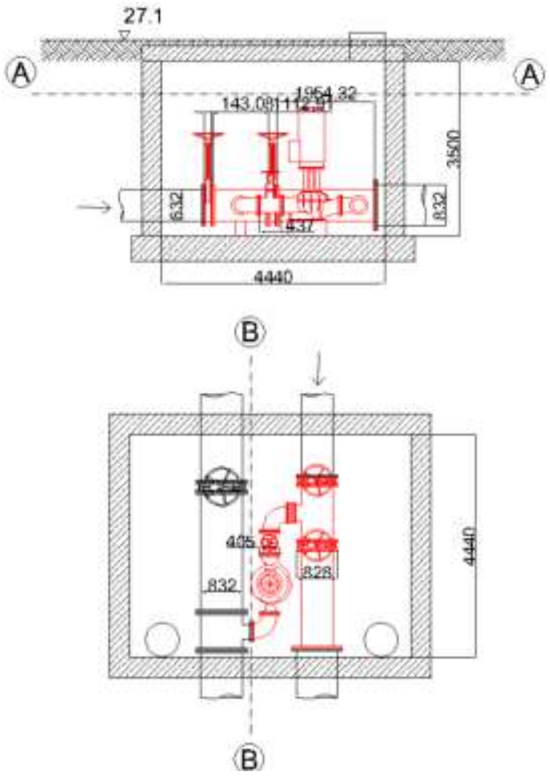
- Turbine costs comprise approximately half of the conventional hydropower project development costs.

- Lower-end unit costs start from 1100–2800 EUR/kW.

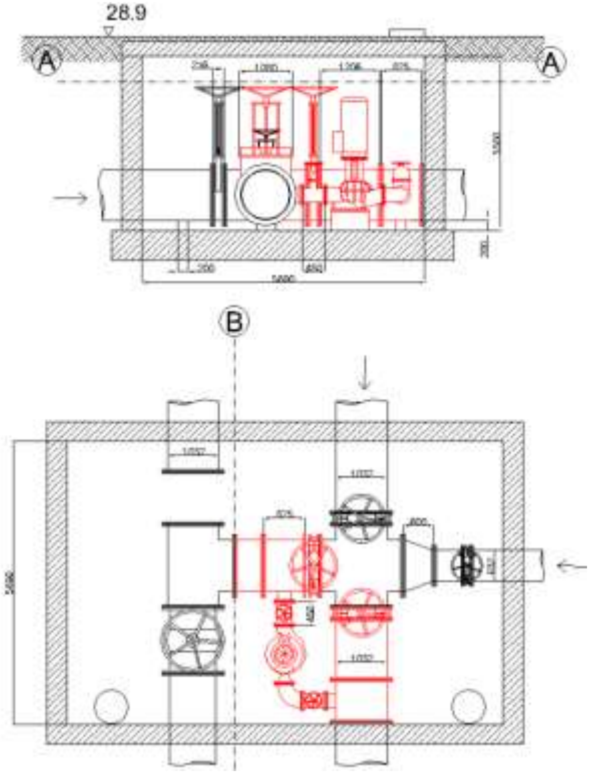
- Significant opportunities to lower development costs through specific research and development are proposed including low-cost generators, e.g., pumps as turbines (PaT).

- The use of PaTs for energy recovery has been demonstrated to be cost-effective, as low as 12% !!!!!! of the cost of conventional small turbines.

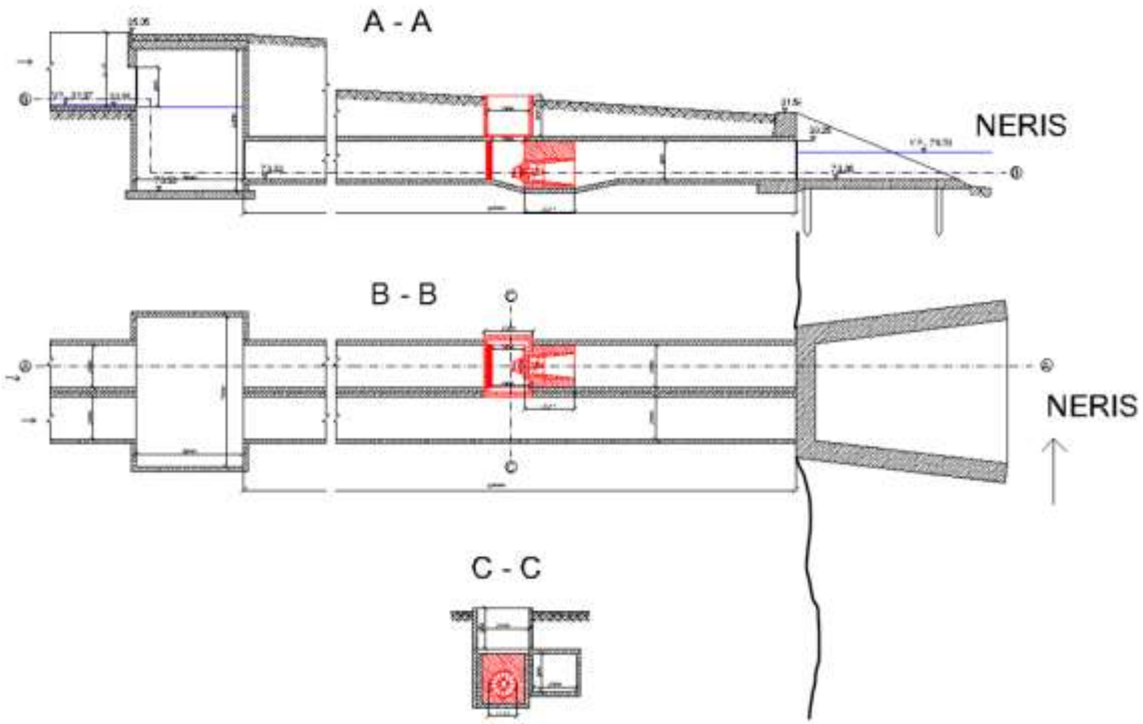
Layouts of integrating turbines and PaTs in wastewater network



Kaunas, upstream WWTP (Raudondvario st.)

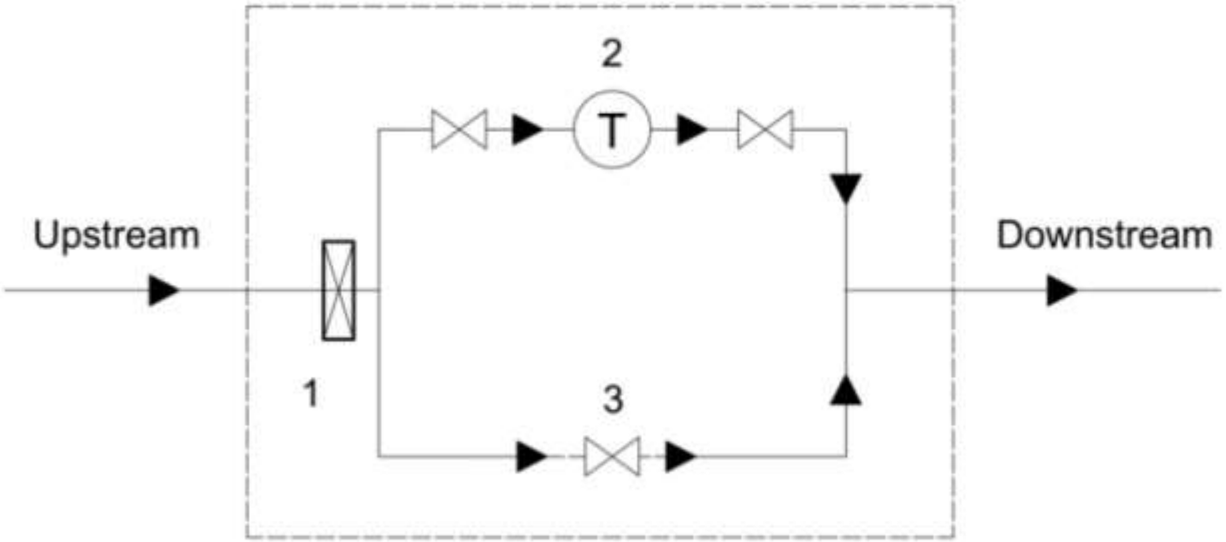


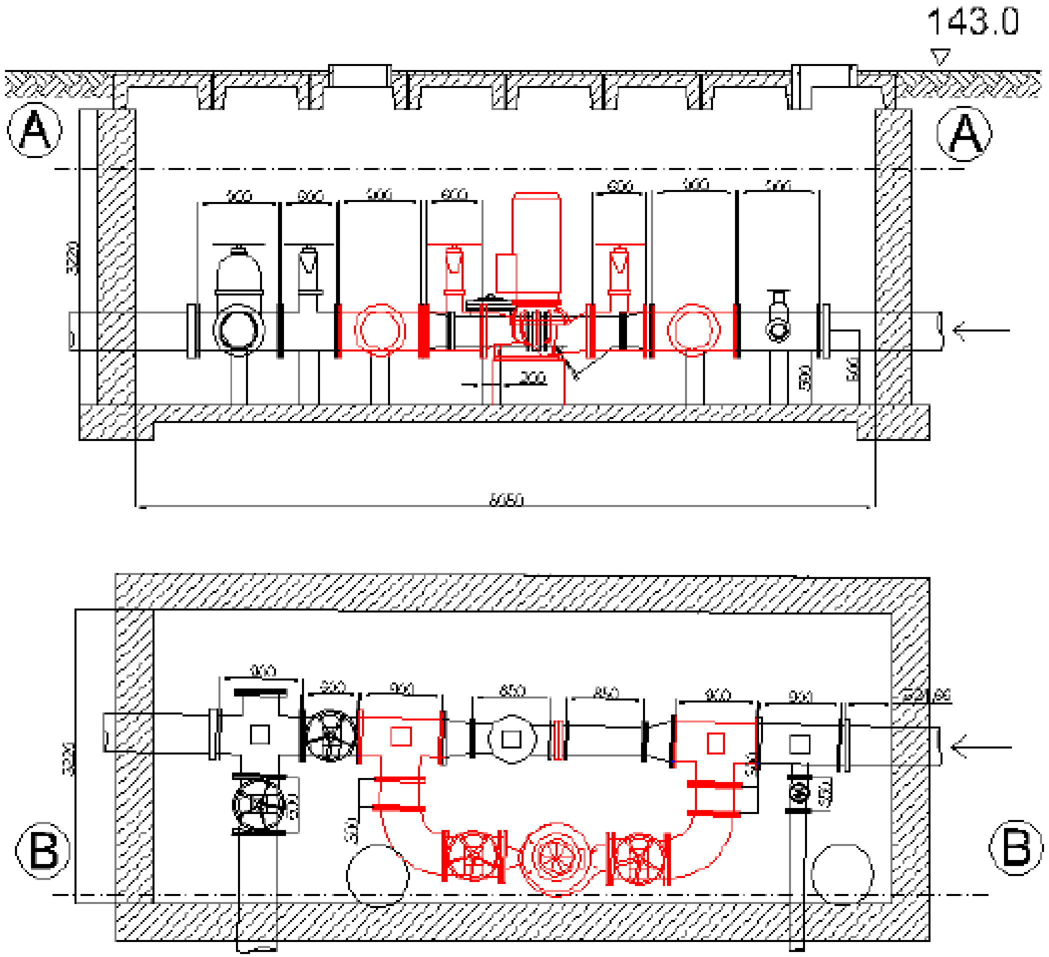
Kaunas, upstream WWTP (Jonavos st.)



Vilnius, downstream (outfall of WWTP; Receiving water body – the Neris river)

The so-called bypass configuration is a classical layout for installing a turbine in a sewage pipeline system. The unit is usually operating in parallel with the existing pipeline.





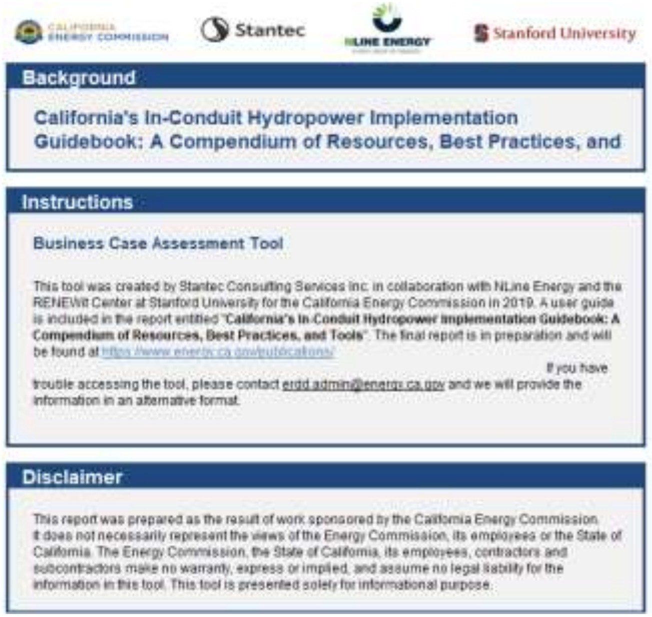
Turbine (PaT) installation layout of wastewater pipeline (main) upstream of WWTP (simplified bypass scheme): 1—trash rack, 2—turbine, 3—regulating valve

5. Tools for the Assessment of Technical and Economic Feasibility of Installing In-Conduit Hydropower Systems

	Year	Developer	Operating System	Applicable Countries	Application	Accessibility	Features								
							Units	Energy	Hydrology	Hydraulics	Turbines	Costing	Economic	GHG	Design Level
RETScreen	1998	Canada	Software	International	Conventional HP	Open [1]	SI	x	FDC	x	PaT not included	x	x	x	Feasibility and preliminary design
ICHPST	2013	Alden, US	MS Excel	USA	WSW	Open	I [2]	x	FDC	-	Mostly all types, including PaT	x	x	x	Screening
BCAT	2019	Stantec, US	MS Excel	USA	WSW	Open	I [2]	x	Design flow	-	Mostly all types, including PaT	x	x	x	Screening

[1] Only in viewer mode. [2] Imperial. x—Feature included.

Small hydropower assessment software intended for the assessment of in-conduit hydropower at individual sites.



Computer programs (pre-/or Feasibility studies)

In-Conduit Hydropower Project Screening Tool For Water Supply and Wastewater Treatment Facilities (ALDEN) and California's In-Conduit Hydropower Business Case Assessment Tool (USA)

(less suitable)

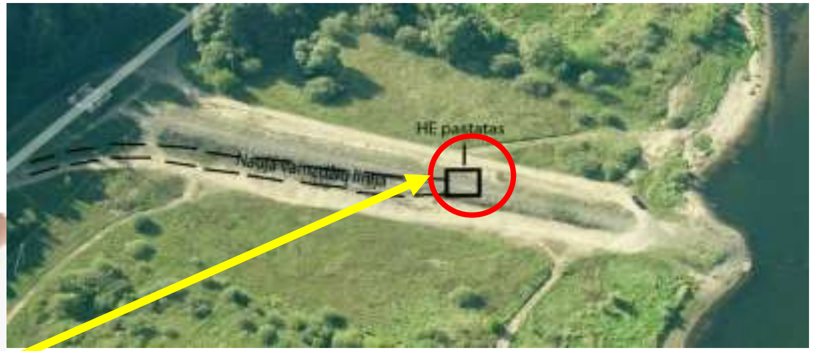
RETScreen® International

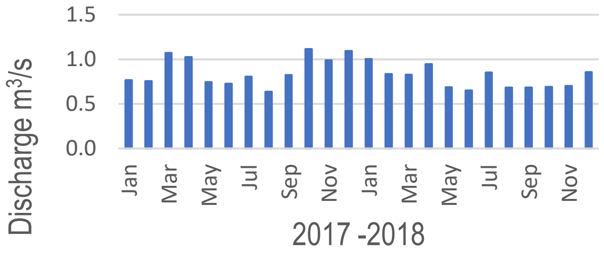
Clean Energy Project Analysis Software (Hydropower module). RETScreen Expert, Canada (most suitable)

https://natural-resources.canada.ca/maps-tools-and-publications/tools/modelling-tools/retscreen/7465

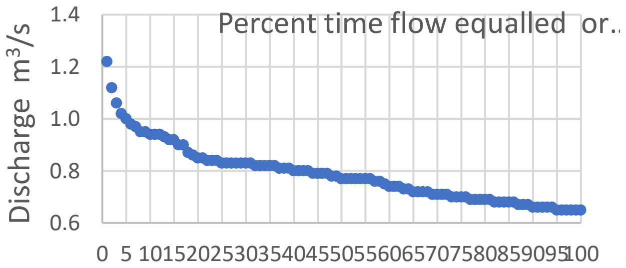
Kaunas: Micro-hydro plant downstream Kaunas WWTP (Pypliai/Kacergine)

Treated effluent chamber

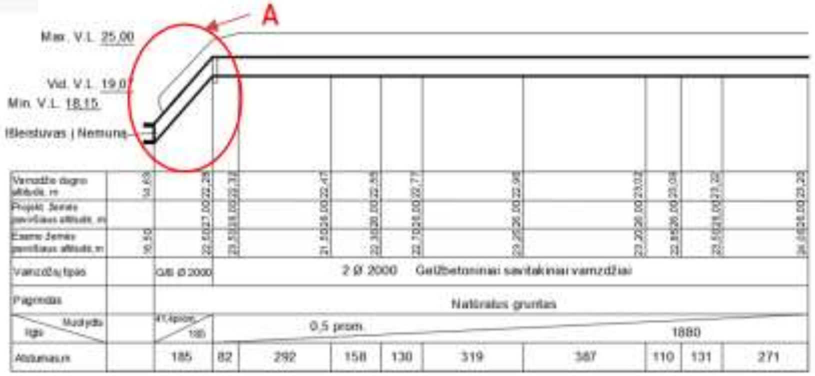


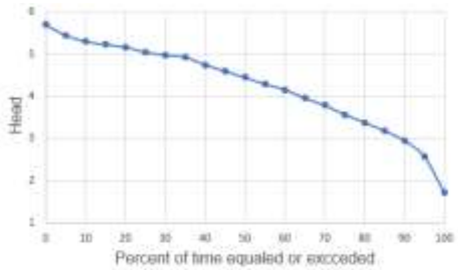


Monthly flow time series

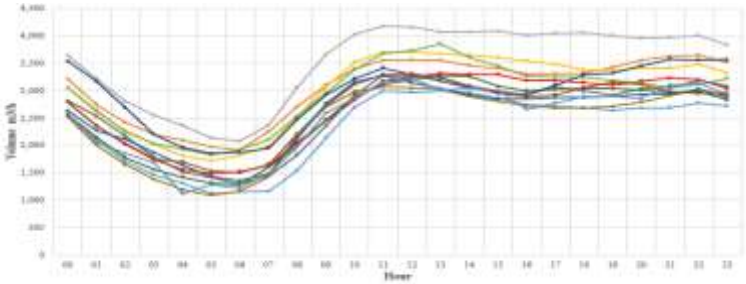


Flow duration curve (FDC)

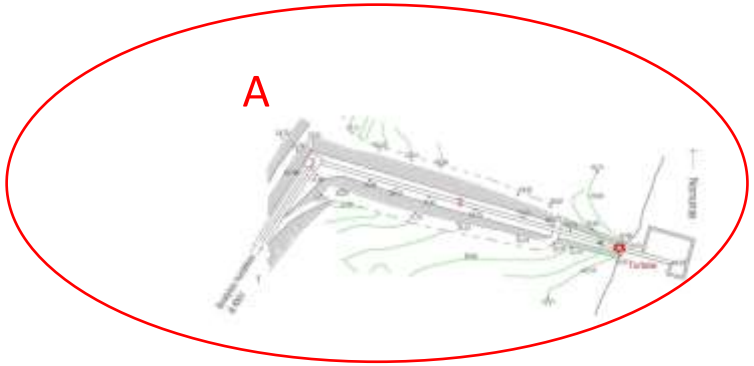




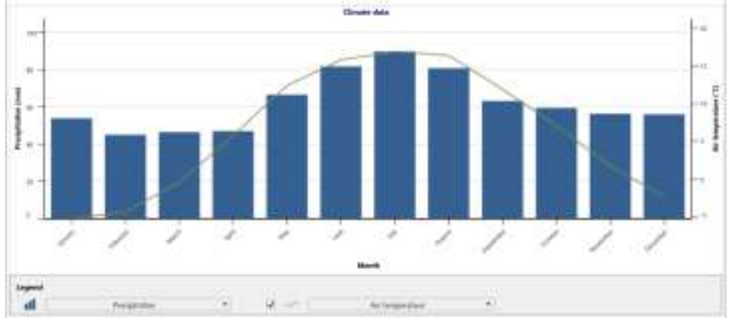
Head duration curve



Effluent variation during 24 hours

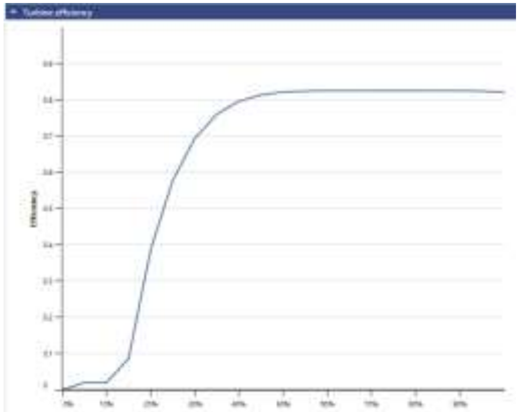


RETScreen Expert: Results



Facility type	Power plant
Type	Hydro turbine
Description	Site No 3 Kaunas WWWTP, Kacergine
Prepared for	LIFE Nexus
Prepared by	ASU
Facility name	Site No 3 Kaunas WWWTP, Kacergine
Address	*Address*
City/Municipality	Kacergine
Province/State	Kauno
Country	Lithuania

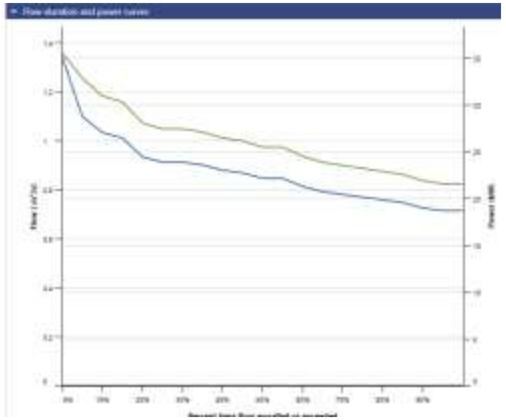
Resource assessment		
Proposed project		~~[illegible]~~
Hydrology method		User-defined
Gross head	m	4
Maximum tailwater effect	m	1
Residual flow	m^3/s	0
Percent time firm flow available	%	100%
Firm flow	m^3/s	0.65
Hydro turbine		
Design flow	m^3/s	1
Type		Kaplan
Turbine efficiency		Standard
Number of turbines		1
Manufacturer		
Model		
Design coefficient		4.5
Efficiency adjustment	%	0%
Turbine peak efficiency	%	80.1%
Flow at peak efficiency	m^3/s	0.75
Turbine efficiency at design flow	%	79.8%



Resource assessment and hydro turbine (the outlet of treated wastewater from Kaunas WWTP)

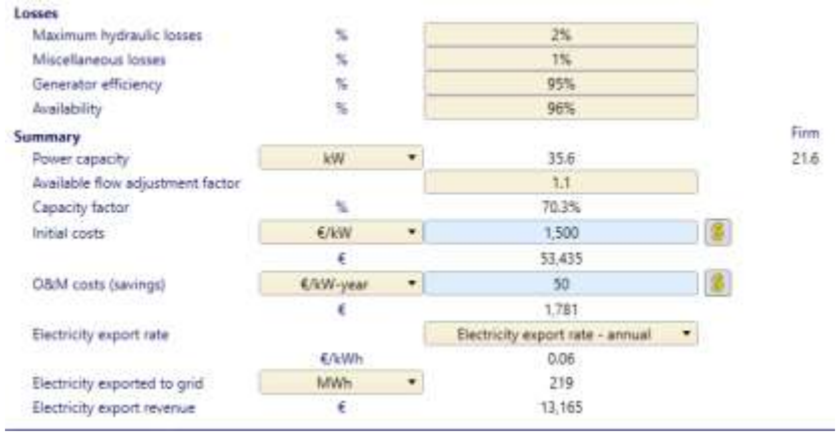
Flow-duration and turbine efficiency curve data

%	Flow m^3/s	Turbine efficiency	Number of turbines	Combined efficiency
0%	1.22	0.00	0	0.00
5%	1.00	0.00	1	0.00
10%	0.94	0.00	1	0.00
15%	0.92	0.07	1	0.07
20%	0.85	0.17	1	0.17
25%	0.83	0.56	1	0.56
30%	0.83	0.67	1	0.67
35%	0.82	0.74	1	0.74
40%	0.80	0.77	1	0.77
45%	0.79	0.79	1	0.79
50%	0.77	0.80	1	0.80
55%	0.77	0.80	1	0.80
60%	0.74	0.80	1	0.80
65%	0.72	0.80	1	0.80
70%	0.71	0.80	1	0.80
75%	0.70	0.80	1	0.80
80%	0.69	0.80	1	0.80
85%	0.68	0.80	1	0.80
90%	0.66	0.80	1	0.80
95%	0.65	0.80	1	0.80
100%	0.65	0.80	1	0.80

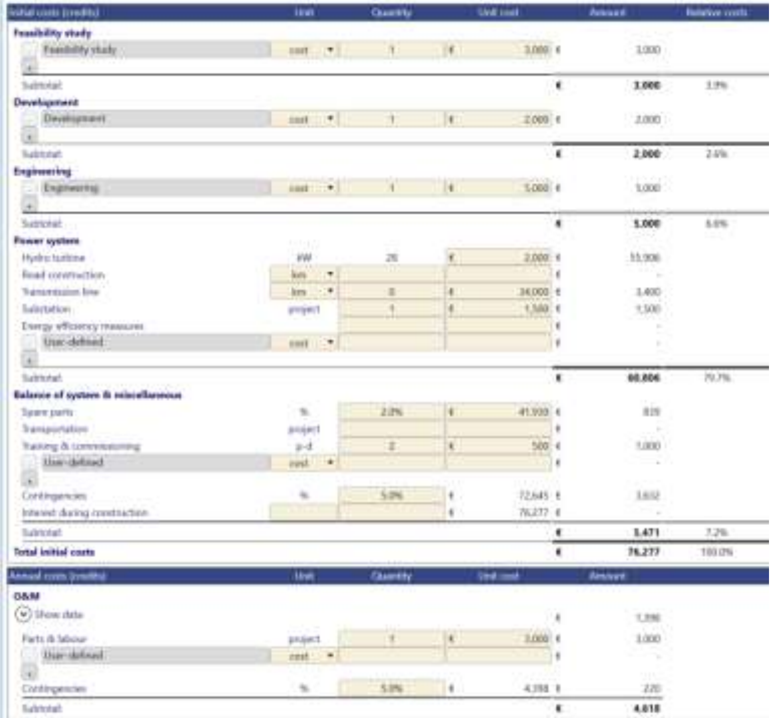


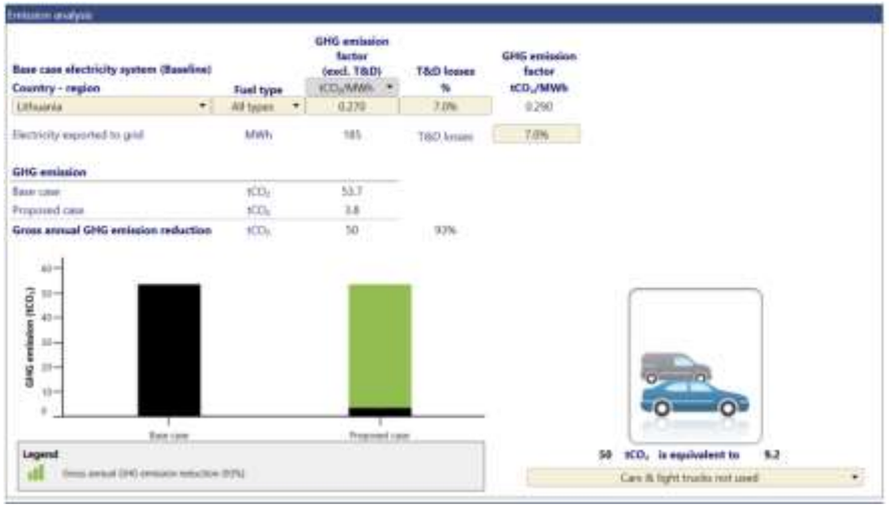
Flow-duration and power curves

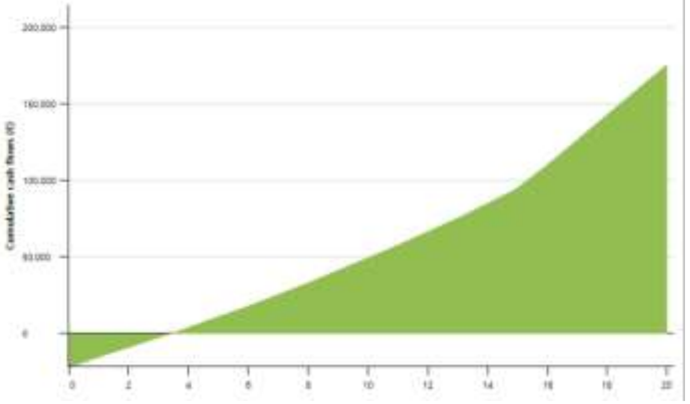
Summary of power indicators, electricity revenue

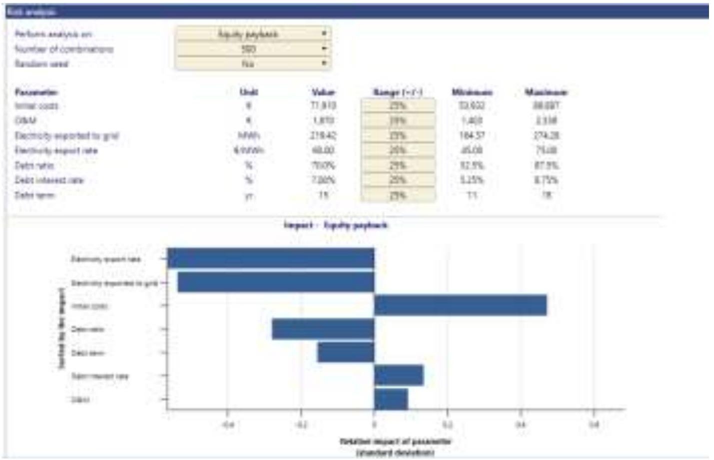


Initial cost analysis









GHG emission reduction

Financial and risk analysis

Key findings (for a replication report)

Design flow , m^3/s	Gross head m	Power capacity kW	Electricity exported to grid MWh	Electricity export revenue €	Initial costs €	Simple payback yr	Gross annual GHG emission reduction tCO_2	Pre-tax IRR-assets%
1.0	4	28	185	18,510	76,277	5.5	50	12.4

6. Wastewater Quality and Possible Effects on Turbine Operation

- No studies have been performed in Lithuania on the impact of wastewater quality (raw sewage) on the operation of hydraulic machines and their clogging. The causes of hydro turbine clogging are the same as those for pumps, i.e., the suspended solids transported by the sewage.

- Solids in the flow are gradually increasing, which is an issue for many water utilities. Standardized qualitative wastewater monitoring of chemical parameters is carried out at entrance and exit of WWTPs but not inside the sewage network. The total suspended sediments (TSS) are only occasionally recorded. Available data from water companies show that the average concentrations of TSS in the raw effluent can reach 500 mg/L. After treatment, they decrease at least 25-fold, down to 20 mg/L

- The actual cause of clogging is not solid, but fibrous material contained in the sewage. When long, stringy solids or fibers are present in the flow, problems can occur, particularly for axial (propellor) and radial flow machines, when these materials are caught on the rotating parts

Risk of clogging

- Large solids, rags, and other fibrous materials from wastewater can be a severe issue for operating turbines if not monitored. Spot measurements conducted upstream of Kaunas WWTP showed that manual cleaning of the K2 grating (rack gap = 5 cm, mean flow = 0.18 m^3/s) is performed twice a week, and approximately 2–5 kg of fibrous dry matter is collected. Approximately 500 kg of dry material can be accumulated per year. This harsh environment can be considered when installing turbines in such locations.

- In contrast to an axial propeller (or Kaplan) turbine, PaT and Francis units are much more sensitive to clogging issues when operating in effluents charged with suspended particles.

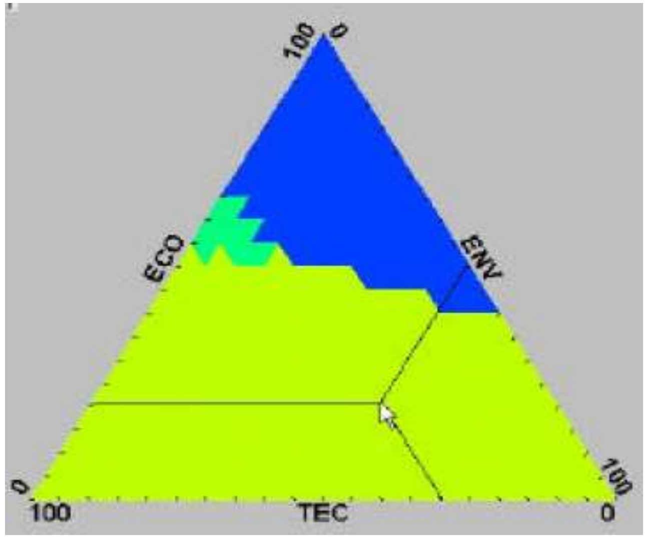
- For hydropower schemes using untreated wastewater, a trash rack chamber must be installed at the intake. The trash rack chamber's operational cost was identified to range from 0.03 to 0.08 USD/kWh (*Switzerland*).

7. Multicriteria Analysis (MCA) for Selecting Potential Sites

- There are many software worldwide to performrme multicriteria analysis (MCA)
- MCA of siting potential micro-hydro facilities in urban water networks was carried out using the software HYPSE. The analysis considered a classical outranking technique, ELECTRE.
- Collected field data and data generated by RETScreen Expert software were used as the input for the impact matrix.

17 criteria were used for the multicriteria analysis. Twelve criteria were to be maximized, while five were to be minimized.
Grouping:

- ❑ Technical-related (TEC; layout, turbine type, design flow, gross head, etc.),
- ❑ Economic-related (ECO; investment costs, electricity generated, simple payback, etc.),
- ❑ Environmental-related (ENV; GHG reduction and use of electricity).



Data employed for multicriteria analysis (MCA) for siting hydropower turbines in urban water networks (the basic scenario, equal weights for all criteria).

#	Criterion	Unit of Measure	Direction	Weight (%)	Group and Weight		Alternatives (Projects)							
							K1	K2	K3	V1	V2	V3	A1	A2
1.	Layout	Score: [1, 2]	Max	5.88	TEC	58.81	1	1	2	2	2	2	2	2
2.	Turbine type	Score: [1, 3]	Max	5.88	TEC		2	2	3	3	3	2	2	2
3.	Design flow	m^3/s	Max	5.88	TEC		0.36	0.14	1.00	1.80	1.80	0.17	0.17	0.17
4.	Gross head	m	Max	5.88	TEC		35	27	4	2	2.9	53	15.5	10
5.	Substation	Score: [0, 1]	Max	5.88	TEC		0	0	0	1	1	0	1	1
6.	Transmission line	km	Min	5.88	TEC		0.05	0.05	0.1	0.05	0.05	0.05	0	0.4
7.	Power capacity	kW	Max	5.88	TEC		98	29	28	20	34	73	20	13
8.	Capacity factor	%	Max	5.88	TEC		43	40	76	65	64	73	39	38
9.	Tailwater effect	%	Min	5.89	TEC		0	0	25	0	20	0	0	25
10.	FDC type	Parameter	Max	5.89	TEC		0.47	0.42	0.56	0.6	0.6	0.57	0.62	0.62
11.	Total initial costs	k€	Min	5.88	Econ	29.42	101.1	61.7	76.3	50.8	80.9	47.3	18.7	14.0
12.	Electricity generated	MWh	Max	5.88	Econ		367	102	185	111	189	331	69	43
13.	Simple payback	yr	Min	5.89	Econ		4.3	15.5	5.5	7.3	5.8	1.6	4.4	6.7
14.	O&M costs	k€	Min	5.88	Econ		13.5	6.2	4.6	4.2	4.9	3.8	2.6	2.6
15.	Electricity revenue	k€	Max	5.89	Econ		36.7	10.2	18.5	11.1	18.9	33.1	6.9	4.3
16.	GHG reduction	tCO_2/MWh	Max	5.88	ENV	11.77	99	28	50	30	51	89	19	12
17.	Use of electricity	Score [1, 2]	Max	5.89	ENV		1	1	1	2	2	1	2	2
Total (%)				100		100								

Description of the criteria used for MCA (only TEC)

Name	Brief Description
TEC 1. Layout type: The facility can be installed downstream of or inside the WWTP, or upstream of the WWTP in the effluent network. 2. Turbine type: PaT, Archimedean screw, and conventional submerged (in-conduit) turbines. 3. Design flow: Typically taken as 30% of FDC. 4. Gross head: Drop in elevation at the site. 5. Substation: Cost depends mainly on the voltage and the installed capacity of the power plant. 6. Transmission line: Cost depends on the line’s type, length, voltage, and location, as well as the installed capacity of the power plant being developed. 7. Power capacity: Calculated hydro system power capacity or maximum power output of the site. 8. Capacity factor: Ratio of the average power produced by SHP over one year to its rated power capacity. 9. Tailwater effect: During high flows, a reduction in the gross head can be significant for low-head sites. 10. FDC type: The shape of the FDC indicates the distribution of daily mean flow over a sufficiently long period; initially steeply sloped curve results from an uneven flow; FDCs that have a very flat slope indicate slight variation in the flow pattern.	1. Priority should be assigned to the hydro turbine downstream of the WWTP (clean water); turbine placement upstream will require extra O&M costs (trash rack cleaning). 2. It is recommended to avoid Archimedean screw turbines because of their excessive superstructure and visual pollution, especially in urban areas. 3,4,7,8. Design flow, gross head power capacity, and capacity factor must be as high as possible. 5. Presence of any substation nearby hydro installation. 6. Distance to the electric distribution grid or the point of use of power must be as short as possible. 7,8. Must be maximized. 9. Range of water-level fluctuations in receiving water body should be minimal, i.e., to avoid any reduction in the available gross head during times of high flows in the outlet. 10. A flat-sloped FDC resulting in a high j value is desirable for any hydro scheme.

Summary of rankings with the final ranking global synthetic index (GSi):

1 = best position; 8 = worst position.

	Alternatives	Index											
		c_i Concordance Dominance Index		$d_{i,SD}$ Simple Discordance Index		$d_{i,WD}$ Weighted Discordance Index		$d_{i,AD}$ Aggregate Discordance Index		$d_{i,AWD}$ Weighted Aggregate Discordance Index		GS_i Global Synthetic Index	
A. Basic scenario: Criteria weights are equal, and group weights are different (ECO—29.42%, TEC—58.81%, ENV—11.77%)													
1	K1	6	0.001	5	0.108	5	0.099	6	0.732	6	0.730	6	−0.728
2	K2	8	−1.530	7	0.301	7	0.299	8	1.931	8	1.929	8	−3.460
3	K3	5	0.059	4	0.0	4	−0.007	4	−0.444	4	−0.444	5	0.503
4	V1	2	0.764	1	−1.768	1	−1.758	1	−1.514	1	−1.511	1	2.275
5	V2	4	0.353	6	0.127	6	0.133	3	−0.855	3	−0.853	3	1.206
6	V3	1	1.060	2	−0.409	2	−0.417	2	−1.186	2	−1.186	2	2.246
7	A1	3	0.529	3	−0.086	3	−0.081	5	−0.148	5	−0.147	4	0.676
8	A2	7	−1.236	8	1.727	8	1.729	7	1.484	7	1.482	7	−2.718
B. High economic scenario: Criteria weights are not equal, and group weights are different (ECO—49.39%, TEC—42.18%, ENV—8.43%)													
1	K1	2	1.076	5	0.108	1	−1.720	6	0.732	3	−0.345	2	1.421
2	K2	7	−1.606	7	0.301	8	2.371	8	1.931	8	1.276	8	−2.882
3	K3	5	0.098	4	0.0	6	0.633	4	−0.444	5	−0.120	5	0.219
4	V1	4	0.151	1	−1.768	5	0.198	1	−1.514	2	−0.439	4	0.591
5	V2	3	0.423	6	0.127	7	0.812	3	−0.855	4	−0.287	3	0.710
6	V3	1	1.722	2	−0.409	2	−1.560	2	−1.186	1	−1.039	1	2.761
7	A1	6	−0.073	3	−0.086	3	−0.773	5	−0.148	6	0.072	6	−0.145
8	A2	8	−1.792	8	1.727	4	0.039	7	1.484	7	0.882	7	−2.674

Results

Initial data/Impact matrix

Analyses Data

File Edit View Evaluations Help

Evaluation:

Criteria and Weights / Projects and Impacts

Criteria	Measure	Weight	K-1	K-2	K-3	V-1	V-2	V-3	A-1	A-2
B Layout	Score	5.88	1	1	2	2	2	2	2	2
B Turbine type	1-3	5.88	2	2	3	3	3	2	2	2
B Design flow	m3/s	5.88	0.36	0.14	1.00	1.80	1.80	0.17	0.17	0.17
B Gross head	m	5.88	35.0	27.0	4.0	2.0	2.9	53.0	15.5	10.0
B Substation	0-1	5.88	0	0	0	1	1	0	1	1
C Transmission li...	km	5.88	0.05	0.05	0.10	0.05	0.05	0.05	0.00	0.40
C Power capacity	kW	5.88	98	29	28	20	34	73	20	13
B Capacity factor	%	5.88	43	40	76	65	64	73	39	38
B Electricity gene...	MWh	5.88	367	102	185	111	189	331	69	43
C Tailwater effect	%	5.88	0	0	25	0	20	0	0	25
B FDC type	Value	5.89	0.47	0.42	0.56	0.60	0.60	0.57	0.62	0.62
C Investment costs	kEuro	5.88	101.1	61.7	76.3	50.8	80.9	47.3	18.7	14.0
C Simple payback	yr	5.89	4.3	15.5	5.5	7.3	5.8	1.6	4.4	6.7
B O&M costs	kEuro	5.88	13.5	6.2	4.6	4.2	4.9	3.8	2.6	2.6
B Electricity reve...	kEuro	5.89	36.7	10.2	18.5	11.1	18.9	33.1	6.9	4.3
C GHG reduction	tCo2/MWh	5.88	99	28	50	30	51	89	19	12
C Use of Electricity	1-2	5.89	1	1	1	2	2	1	2	2

Groups ECO :29.42 ENV :11.77 TEC :58.81 | Selected Project : K -1

Normalization us Min Max

Higher the blue, better the project result.

FULL BLUE: the best result

FULL RED : the worst result

Results

Indexes | DiscordanceDominance | AggregatedDiscordance | ConcordanceDominance | WeightedDiscordance | A_W_Discordance

		DiscordanceDominance	AggregatedDiscordance	ConcordanceDominance	WeightedDiscordance	A_W_Discordance	Syntetic
K-1		0.1083	0.7317	0.0011	0.0999	0.7295	-0.7284
K-2		0.3007	1.9313	-1.5301	0.2998	1.9294	-3.4595
K-3		0.0000	-0.4437	0.0591	-0.0068	-0.4437	0.5028
V-1		-1.7682	-1.5143	0.7636	-1.7580	-1.5111	2.2747
V-2		0.1273	-0.8549	0.3528	0.1335	-0.8532	1.2060
V-3		-0.4089	-1.1859	1.0599	-0.4167	-1.1856	2.2455
A-1		-0.0862	-0.1479	0.5292	-0.0809	-0.1471	0.6763
A-2		1.7271	1.4837	-1.2356	1.7292	1.4819	-2.7175

Source: software HYPSE

4. Conclusions

- Energy recovery from wastewater systems using micro-hydro plants (MHPs) is an appropriate solution to improve the energy efficiency of the municipal water sector. Hoverer, it has seen no exploitation due to a number of technical and nontechnical issues in low-lying countries.

- The potential in lowland areas in terms of power capacity resulting from mostly low-head sites cannot be compared to that of elevated topography. For flat terrain, the selection field for turbines is relatively narrow; moreover, the low flow rates and small size of turbine units increase the unit price of turbines.

- A methodology was developed to quantify the potential and identify conduit hydropower sites in a lowland country's wastewater systems, including resource assessment, suitable tools to make a preliminary assessment of potential sites, and choice of turbines and their operating parameters in a harsh environment.

4. Conclusions (cont.)

- The lack of in-depth studies on wastewater quality's impact on hydro turbines, particularly the risk of clogging them in sewage networks upstream of WWTPs, can be a severe problem.

- A conventional multicriteria analysis (MCA) can help select the most appropriate site for constructing MHPs in urban water areas.

- There are plenty of MCA tools available on the market for solving any real-world issue. However, at least preliminary site assessments and design procedures must be accessible beforehand for this analysis.

Further information: Assessment of Hydropower Potential in Wastewater Systems and Application in a Lowland Country, Lithuania ***In Energies,*** Special Issue "*Hydropower in the East European Region: Challenges and Opportunities*"

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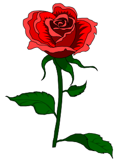
Thank you for attention
Ačiū.



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