Every degree counts

Independent Danube water temperature measurement at MVM Paks NPP, project phase 1

Project documentation

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Study supported by

Wiener Umweltanwaltschaft / Vienna Ombuds Office for Environmental Protection

Vienna, 2021

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1 Summary

The MVM Paks nuclear power plant (NPP) in Hungary is situated about 100 km south of Budapest. It needs cooling water from the Danube for its four operating and two planned reactors.

In the past few years Hungary was facing several extreme weather occurrences. In 2018, as the temperature raised, the Hungarian NGO Energiaklub submitted a freedom of information request to the Hungarian National Atomic Agency to find out how the increased temperature influences the daily operation of MVM Paks NPP. Since the authority did not provide the information, Energiaklub travelled to Paks to measure the temperature of Danube and got the following results: The water temperature upstream from the NPP was 25-26 °C; downstream, however, the temperature rose to above 30 °C at several points. For the MVM Paks NPP, the cut-off is set at 30 °C.

Shortly after Energiaklub published these findings and an accompanying video, MVM Paks Nuclear Power Plant Ltd, the company running the NPP, sent its official water temperature data. On the day Energiaklub had measured over 30 °C, the official thermometer measured 28.42 °C. The NPP registered the highest water temperature, 29.88 °C, at the beginning of August 2018. This is only 0.12 °C lower than the temperature at which the NPP must be shutdown to protect life in the river. The Danube is a very important ecosystem for Europe and must be preserved all along its course.

This event did not only reveal differences in the temperature measurement results that need to be investigated, but also highlighted another important weakness of the system – the question of transparency.

Therefore, in the project *"Every degree counts"*, we want to establish an independent quality control of the Danube water temperature monitoring which should start in 2022. The report at hand summarises the results of the first part of the project on background research on legal aspects and measurement methods, and presents next steps.

In Hungary, the provisions on the water temperature in the Danube are laid down in *"Decree 15/2001 on radioactive discharges into the air and water during the use of nuclear energy and their control (VI. 6.). Environmental Ministerial Decree (15/2001. (VI. 6.)"*. In case of a priority facility, in order to protect surface waters and aquifers against thermal pollution, the receiving water shall receive water at any point of the section 500 m downstream whose temperature must not exceed 30 °C.

If according to the daily report of the National Watermarking Service the water temperature of the Danube reaches or exceeds 25 °C, then permit II.2 gets into force according to the permit of MVM Paks NPP. According to this permit, the following measurements have to be carried out:

- Point 2.3.4.: If, according to the daily report of the National Watermarking Service, the water temperature in the Danube reaches or exceeds 25 ˚C, the Government Office must be notified in writing within four hours of its detection.
- Point 2.3.5.: If the water temperature in the Danube reaches or exceeds 25 ˚C, the continuous compliance with the thermal limit of 30 ˚C must be checked with manual measurements from a measuring vessel in the reference section. The Government Office should be given the opportunity to participate in extraordinary measurements.

The measurement data of MVM Paks NPP on the water temperature of the Danube for 2018 and 2019 can be found on the company's websites and are presented in chapter 3.3. After 2019, the NPP has not yet uploaded water measurement data on their webpage

With regard to these measurement data, MVM Paks NPP emphasized in their response to our request for data of public interest, that if the Danube water temperature is below of 25 °C, the MVM Paks Nuclear Power Plant is not obliged to make official measurements. In this case it performs its measurements unofficially, for the purpose of exercising the personnel. These measurement data do not constitute official measurement data.

The measurement data available on the website for the year 2019 are not considered official measurement data because the temperature of the Danube did not reach 25 °C during this period. Moreover, the MVM Paks Nuclear Power Plant discontinued the measurements on 15 August 2019. In 2020 and 2021, the company was not obliged to perform official measurements, as the water temperature in the Danube did not reach the required 25 °C so there are no measurement data published for these years.

But even if MVM Paks NPP does not conduct continuously official measurements of the water temperature, it allows NGOs to measure the water temperature: According to the website of MVM Paks NPP, *"MVM Paks Nuclear Power Plant Ltd. - as it has done so far - is still ready to provide an opportunity for non-governmental organizations to perform water temperature measurements in its area."*[1]

[1] https://atomeromu.mvm.hu/hu-HU/Rolunk/Vizhomerseklet

Comparison to water temperature measurement of other NPPs showed that there is no standardized method. While in Hungary several laws determine how the measurements must take place, in the case of Krsko NPP/Slovenia we did not receive information on the legal background. The case of Dukovany NPP/Czech Republic was also different as the official representatives claimed that water monitoring methods are not publicly available information. In conclusion, not only a standardization of methods for temperature measurements for NPPs using cooling water from nearby rivers is missing but there is also an issue with transparency as the results of the temperature measurements and the method of the measurements vary in the studied countries. This confirms the need for independent scientists and NGOs to put a strong focus on transparency of data to allow independent control.

Continuing this project, we aim to take the following steps:

- Obtaining further offers for a water temperature measurement system
- Mapping out the financial background for the project
- Getting in touch with MVM Paks NPP and obtain permission for water measurements
- Negotiating and contracting preparation with the future partner who will undertake the measurements
- Setting up a website to inform about the methods and results of the temperature measurements
- Buying and installing a temperature measurement system
- Installing the regular upload of data to be displayed on the website

2 Introduction

The MVM Paks nuclear power plant (NPP) in Hungary is situated about 100 km south of Budapest. It needs cooling water from the Danube for its four operating and two planned reactors.

In the past few years Hungary was facing several extreme weather occurrences. In 2018, as the temperature raised, the Hungarian NGO Energiaklub submitted a freedom of information request to the Hungarian National Atomic Agency to find out how the increased temperature influences the daily operation of MVM Paks NPP. Since the authority did not provide the information, Energiaklub travelled to Paks to measure the temperature of Danube.

The results of measurements upstream from the nuclear plant showed the water temperature to be 25-26 °C. Downstream, however, the temperature rose to above 30 °C at several points. For MVM Paks NPP, the cut-off is set at 30 °C.

Shortly after Energiaklub published its findings and an accompanying video, MVM Paks Nuclear Power Plant Ltd, the company running the NPP, sent its official water temperature data. On the day Energiaklub has measured over 30 °C, the official thermometer measured 28.42 °C. MVM Paks NPP registered the highest water temperature, 29.88 °C, at the beginning of August. This is only 0.12 °C lower than the temperature at which the NPP must be stopped in order to protect life in the river. The Danube is a very important ecosystem for Europe and has to be preserved all along its course.

This event did not only reveal differences in the temperature measurement results that need to be investigated, but also highlighted another important weakness of the system – the question of transparency.

Therefore, in this project, we want to establish an independent quality control on the Danube water temperature monitoring during the next one or two years.

This report informs about our research on the legal provisions for water temperature measurements in Hungary, about measurement results, about comparison with selected other NPP in Europe, and about our next steps.

3 MVM Paks NPP related water legislations

In this chapter the legal requirements on Hungarian national and EU level on water legislation that are of relevance for the MVM Paks NPP are described with a focus on the regulation for water temperature measurement.

3.1 Hungarian regulations

There are several laws, governmental and ministerial decrees in Hungary that regulate water related issues and several that concerns water measurement issues at MVM Paks NPP. In this chapter they are all listed but only the ones that are related to MVM Paks NPP are summarized in more detail.

The general rules are laid down in *"Decree 220/2004 on the rules for the protection of surface water quality (VII. 21.)"* and *"Decree 28/2004 on limit values for emissions of water pollutants and certain rules of their application (XII. 25.)"* of the Ministry of Environment and Water. The limit value for the thermal load on the aquatic environment shall be established on the basis of an individual test, taking into account the sensitivity of the recipient, the load capacity of the recipient and the maintenance of good chemical and ecological status. *"10/2010 on surface water pollution limit values and rules for their application. (VIII. 18.) VM decree"* does not contain any restrictions on heat output or heat load.

"6/2002 on the limit values for the pollution of surface water used for the abstraction of drinking water or designated as a drinking water base, as well as for surface water designated for ensuring the living conditions of fish (XI. 5.) the Ministry of Environment and Water decree" contains the categorization of only a few surface waters. The Danube is not listed in this, so it does not belong to fish waters according to the law. The classification of the Danube and certain sections of it into different fish water categories can be based on ecological impact assessments.

"15/2001. (VI. 6.) Environmental Ministerial decree on radioactive releases into the air and water from the use of nuclear energy and their control": Priority rules for the protection of waters and aquifers against radioactive and thermal pollution:

§ 10. (1) In the case of a priority facility, to protect surface waters and aquifers against thermal pollution

(a) the difference between the temperature of the discharge and the temperature of the receiving water must not exceed 11 °C or 14 °C for the temperature of the receiving water below +4 °C;

(b) at any point in the section 500 m downstream of the point of discharge, the temperature of the receiving water shall not exceed 30 °C.

(2) * Other restrictions on heat load necessary in the interests of water quality protection are set out in Annex LIII of 1995 on general rules for the protection of the environment, pursuant to Section 66 (1) of the Act on the Permitting of Environmental Use.

"1991 XLV. Act on Measurement": This Act defines the requirements according to which the water temperature measurement must be performed with a calibrated measuring instrument checked with a use standard.

3.2 Measuring practice and transparency of data

As explained above, the receiving water shall receive water at any point of the section 500 m downstream its temperature must not exceed 30 °C.

In accordance with the above regulations, the detailed rules and regulations for heat load measurement were issued to MVM Nuclear Power Plant Ltd. by the Baranya County Government Office, Pécs District Office, issued on 9 June 2017.

According to the permit of MVM Paks NPP, if according to the daily report of the National Watermarking Service the water temperature of the Danube reaches or exceeds 25 °C, then the permit II.2. gets into force. Official measurements in accordance with points II.2.3.4 and II.2.3.5 of the Water Protection Section have to be carried out according to this permit:

- Point 2.3.4.: If, according to the daily report of the National Watermarking Service, the water temperature in the Danube reaches or exceeds 25 ˚C, the Government Office must be notified in writing within four hours of its detection.
- Point 2.3.5.: If the water temperature in the Danube reaches or exceeds 25 ˚C, the continuous compliance with the thermal limit of 30 ˚C must be checked by manual measurement from a measuring vessel in the reference section. The Government Office should be given the opportunity to participate in extraordinary measurements.

As the relevant subpage of MVM Paks NPP's website[2] summarizes:

- The water temperature in the measurement reference section is determined from a measuring vessel. The speed of the measuring vessel is about 0.5 m/s. The measurement shall be performed at two depths (0.5 m and 1.5 m). At both depths, at least five of the right bank of the Danube - heat jet border - right bank of the Danube measurement series must be performed in order to have a sufficient number of data.
- The GPS coordinates of the measuring points must be recorded. Efforts should be made to make the data set as uniform as possible in space and time (especially for ship turns). Measurements close to the background temperature of the Danube water should be filtered out (to avoid data that do not result from the thermal plume[3]), as well as multiple measurements within a short distance (read from GPS coordinates).
- The statistical evaluation of the measured values must be performed for the entire thermal plume. During the evaluation, the value corresponding to the 95% confidence level of the empirical distribution function interpreted on the elements of the reduced cross-section heat measurement series shall not exceed the thermal limit of 30 ˚C.

The measurement data of MVM Paks NPP on the water temperature of the Danube for 2018 and 2019 can be found on the company's websites. After 2019 the NPP has not yet uploaded water measurement data on their webpage.

[2] https://atomeromu.mvm.hu/hu-HU/Rolunk/Vizhomerseklet

[3] A thermal plume involves a part of a particular substance such as **water or atmosphere which is of a different temperature**, usually an elevated temperature which is proceeding from a source and has not yet dissipated into the surrounding substance and equalized temperature. Source: https://www.safeopedia.com/definition/3035/thermal-plume

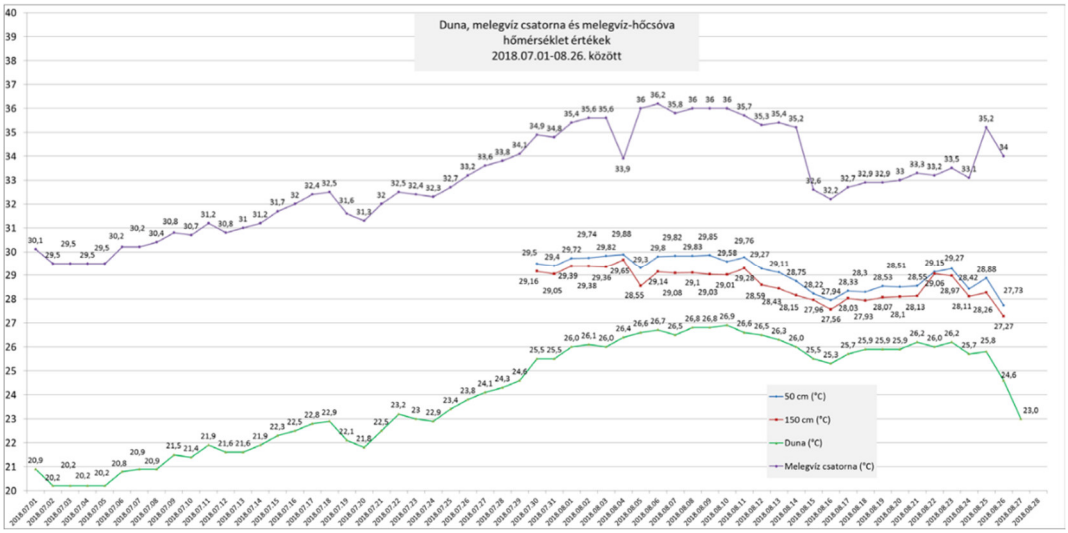

Figure 1: Danube, hot water channel and hot water heat plume temperature values July 1-August 26, 2018. Source: [https://atomeromu.mvm.hu/-/media/PAZrtSite/Documents/Rolunk/Vizhomerseklet/Duna-hocsova-meresi-eredmenyek-2018-Duna-es-melegvizcsatorna-hofokkal.pdf?la=hu-HU.](https://atomeromu.mvm.hu/-/media/PAZrtSite/Documents/Rolunk/Vizhomerseklet/Duna-hocsova-meresi-eredmenyek-2018-Duna-es-melegvizcsatorna-hofokkal.pdf?la=hu-HU)

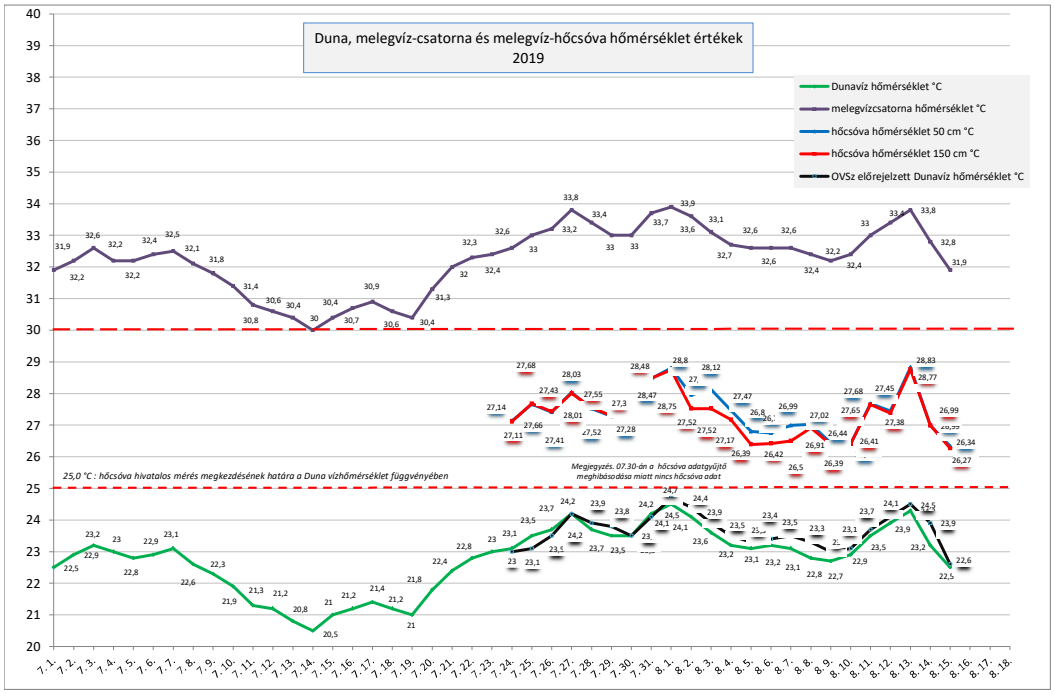

Figure 2: Danube, hot water channel and hot water heat plume temperature values 2019. Source: [*https://atomeromu.mvm.hu/-/media/PAZrtSite/Documents/Rolunk/Vizhomerseklet/TLK-Hocsova-meresi-eredmenyek-20190815ig.pdf?la=hu-HU*](https://atomeromu.mvm.hu/-/media/PAZrtSite/Documents/Rolunk/Vizhomerseklet/TLK-Hocsova-meresi-eredmenyek-20190815ig.pdf?la=hu-HU)

[Translation of the legend:

- green: Danube water temperature
- purple: hot water channel temperature
- blue: thermal plume temperature at 50 cm
- red: thermal plume temperature at 150 cm
- black: National Water Marking Service forecasts on Danube water temperature]

Regarding the measurement data, MVM Paks NPP emphasized in their response to our request for data of public interest, that if the Danube water temperature is below of 25 °C, the MVM Paks Nuclear Power Plant is not obliged to make official measurements. In this case it performs its measurements unofficially, for the purpose of exercising the personnel. These measurement data do not constitute official measurement data.

The measurement data available on the website for the year 2019 are not considered official measurement data as the temperature of the Danube did not reach 25 °C during this period. Moreover, the MVM Paks Nuclear Power Plant discontinued the measurements on 15 August 2019. In 2020 and 2021, the company was not obliged to perform official measurements, as the water temperature in the Danube did not reach the required 25 °C so there are no measurement data published for these years.

But even if MVM Paks NPP does not conduct continuously official measurements of the water temperature, it allows NGOs to measure the water temperature: According to the website of MVM Paks NPP, *"MVM Paks Nuclear Power Plant Ltd. - as it has done so far - is still ready to provide an opportunity for non-governmental organizations to perform water temperature measurements in its area."*

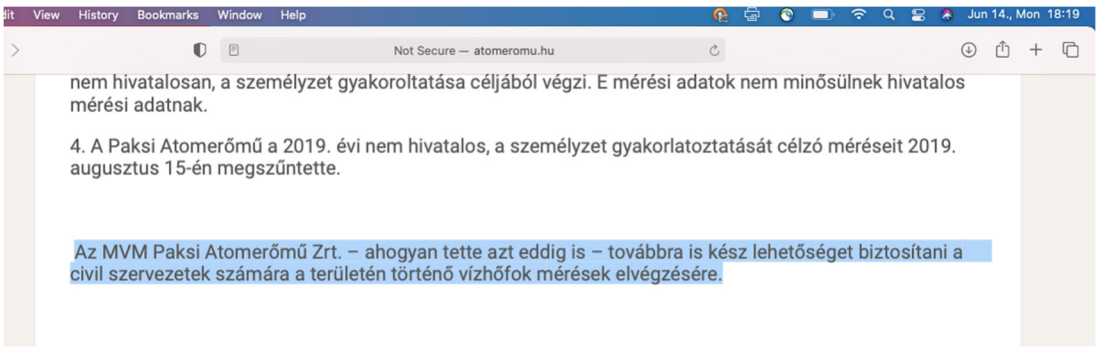

Figure 3: Print screen of the quotation in Hungarian, source: https://atomeromu.mvm.hu/hu-HU/Rolunk/Vizhomerseklet

3.3 Licensing practice

According to the MVM Paks II environmental impact study[4], when approving conventional power plants, the inspectorates determine the permissible difference between the temperature of the extracted and returned water (ΔTmax), the maximum permissible temperature of the discharged water (Tmax), the temperature increase after mixing (ΔT) and the place of inspection.

3.4 Issues related to Natura 2000 and MVM Paks II

Literally quoting the above mentioned MVM Paks II environmental impact study, *"In terms of natural impacts, the northern branch is also more favorable because there is only a narrow range of Natura 2000 sites affected, which is a significant advantage over the southern tributary."*

The study also emphasizes that *"[b]ased on the performed studies, the northern branch from the existing hot water channel was selected for the introduction of hot water into the Danube, taking into account technical, economic, environmental and nature protection aspects. With this, the northern branching of the area enclosed by the existing cold-water channel and the existing hot water channel and the use of a new hot water introductory structure (e.g. recuperation power plant) can improve the mixing of the introduced hot water in the Danube while minimizing the impact on Natura 2000 sites."*

MVM Paks II directly affects a Natura 2000 site, the Tolna-Danube. The narrow coastal strip affected by the planned recuperation power plant and energy-breaking structure is a floodplain grove heavily affected by flooding and a secondary degraded grassland with no conservation value on the side of the dam. There are no protected and marking plant species in the Natura 2000 area.

Therefore, it is of high importance to not only minimize the impacts on Natura 2000 areas but also to monitor the actual thermal load of the Danube due to the Paks waste water.

[4] https://www.paks2.hu/documents/20124/60046/Környezeti+hatástanulmány+-+Közérthető+összefoglaló.pdf/5ea368ee-fa34-f276-0c78-eff7f369f2ef; an English version can be found here: https://www.umweltbundesamt.at/fileadmin/site/themen/energie/kernenergie/verfahren/ungarn/uvp_paksii/uve/02_paks%202_npp_eia_report_eng/paks2_npp_eia_report_11_danube_modelling_en.pdf

3.5 EU general regulations on the temperature load on the Aquatic Environment

In the formerly valid *"Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life",* limits on heat emissions are set in Annex I.:

a) the increase in temperature measured from the point of entry of a thermal discharge downstream (at the edge of the mixing zone) for carp waters (cyprinid waters) may be 3 °C higher than the temperature in the unaffected area
b) the temperature measured in the flow direction (at the edge of the mixing zone) from the heat release point as a result of the discharge must not exceed 28 °C for carp waters.

Due to the uneven mixing of the inlet water in the receiver, higher temperature zones may be formed within the mixing zone. The main factors influencing the mixing zone are temperature, speed and the amount of water introduced.

Directive 2006/44/EC is no longer in force, its validity ended on 21/12/2013 by being implicitly repealed by *"Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy"* or, for short, the EU Water Framework Directive (WFD).

The WFD no longer includes water temperature limits nor discusses carp water issues.

3.6 Conclusions

In summary of this chapter, we can state that the temperature limit is set to 30 °C according to the *"15/2001. (VI. 6.) Environmental Ministerial decree on radioactive releases into the air and water from the use of nuclear energy and their control"*. If the water temperature in the Danube reaches or exceeds 25 ˚C, the continuous compliance with the thermal limit of 30 ˚C must be checked by manual measurement from a measuring vessel in the reference section. The details of the measurements are explained in the chapter. Regulations on EU level do not set a temperature limit.

Although the measurement data on the water temperature of the Danube for 2018 and 2019 can be found on MVM Paks NPP's websites, after 2019 the NPP have not uploaded water measurement data due to their claim of lower temperature data. MVM Paks II directly affects a Natura 2000 site, the

Tolna-Danube, therefore, it is of high importance to not only minimise the impacts on Natura 2000 areas but also to monitor the actual thermal load of the Danube due to the MVM Paks wastewater. According to the website of MVM Paks NPP, non-governmental organisations have the opportunity to perform water temperature measurements in its area.

4 International outlook and quality assurance

In this chapter we look at the water temperature measurements of other NPP to compare not only methods but also transparency regimes.

Furthermore, we discussed the temperature methods with an expert from the Austrian Federal Agency for Environment to find out which temperature measurement system would be best suited.

4.1 Krško Nuclear Power Plant, Slovenia

Data on the flows and temperatures of the rivers in Slovenia are published on the website of the Slovenian Agency for Environmental Protection:

https://www.arso.gov.si/vode/podatki/stanje_voda_samodejne.html .

The Krsko Nuclear Power Plant lies at Sava River, between two Hydro Power Plants (HPP Krsko and HPP Brezice), therefore NPP Krsko uses and compares a variety of data (i.e. NPP measurements and external measurements). NPP Krsko internal measurements consists of a multiple Resistance Temperature Detector (RTD) sensors, normally type Pt100 probes for open or closed cooling processes with nominal temperature of 50 °C or less. Pt100 probes are robust and covered with polished stainless steel for higher corrosion resistance.

Nuclear Power Plant Krsko measures water temperatures at:

- Inlets and outlets in all open-cycle cooling systems, that use Sava river as medium (Condenser and Safety Equipment Cooling Systems, Cooling Towers System, etc.)
- Inlets and outlets of Heat Exchangers at Systems, that use Sava river as medium
- Additionally at several points of interest in Systems, mentioned above.

Main points of interest are shown in the simplified figure below:

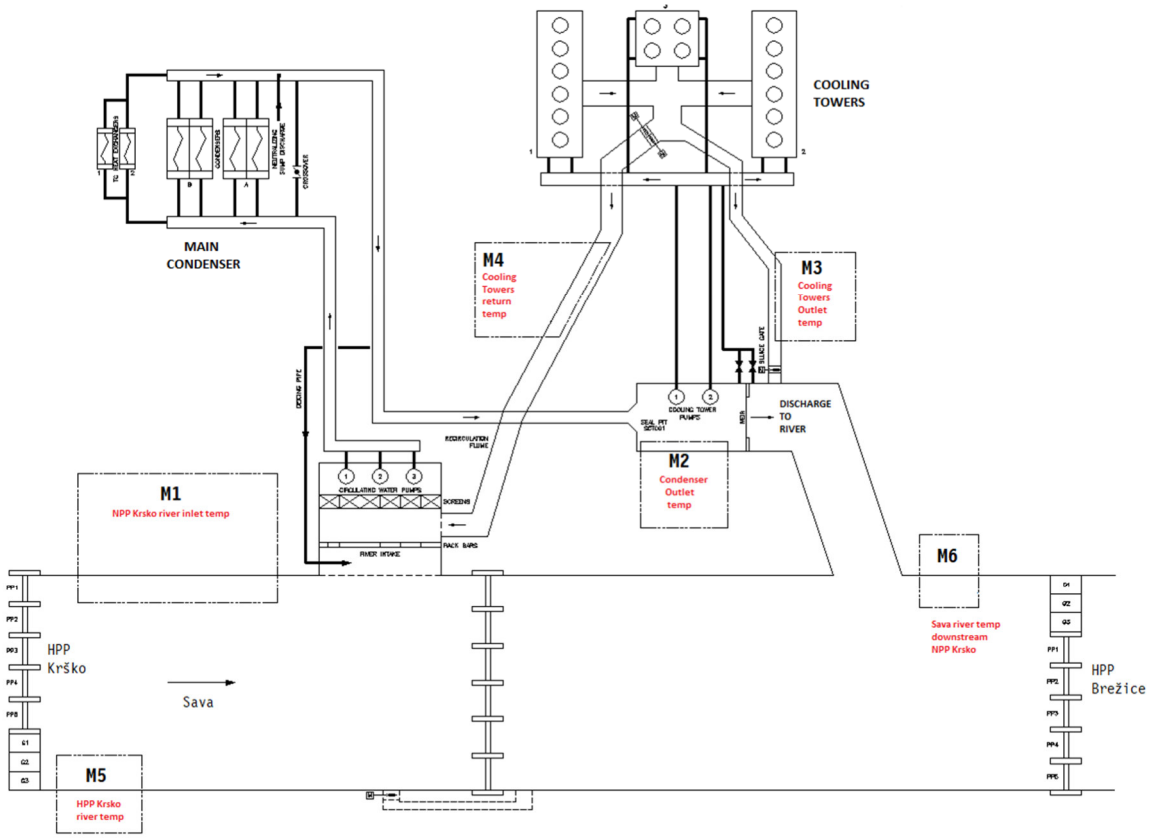

Figure 4: Krško Nuclear Power Plant Measurements, source: Nuklearna elektrarna Krško, Public Relations

The Krsko NPP water measurement system slightly differs from MVM Paks NPP as they operate with cooling towers. Some data that the power plant provided are not comparable with the case of Paks as the Hungarian measurement system is more elaborated and detailed (for example in contrary to Krsko, MVM Paks NPP provides exact coordinates of the inlets and outlets).

4.2 Dukovany Nuclear Power Plant, Czech Republic

So far, the authorities (Povodí Moravy) have not gotten back to us with their answers on how Dukovany NPP is monitoring water temperature in Jihlava River. We only found data about chemicals and radioactive issues in the river, and in the EIA documentation for the new Dukovany NPP only some models with predictions if there will be enough water for new nuclear blocks.

In the statement from the EIA procedure for new nuclear blocks in Dukovany there are conditions (monitoring of waters) which have to be fulfilled by the operator CEZ. These conditions will be part of the construction permission – now they are in the phase of the side construction procedure, which has not been finished yet. The authority which will control this monitoring will be the Building Authority in Třebíč or the Ministry of Trade and Industry.

Supposedly the same conditions which must be respected by CEZ were part of the construction permission of the old four blocks in Dukovany, but we have no evidence for this. The authority which can control this monitoring is the Building Authority in Třebíč or the Ministry of Trade and Industry. There was no EIA procedure at that period, only side construction and construction proceedings.

We sent an information request to CEZ via a Czech NGO concerning water temperature measurement methods and data. In its answer, CEZ wrote that this information was not publicly available. Therefore, information pursuant to Act 106/99 Coll., Concerning "water monitoring methods" cannot be granted. We are going to continue to get information on how the water temperature is measured by contacting the Ministry of Environment. This might take longer than the project duration.

4.3 Loviisa NPP, Finland

During our project period the Environmental Impact Assessment of Loviisa 1&2 Lifetime Extension was published. Even though it does not strictly fit to river water temperature measurements (Loviisa is situated at the coast of the Gulf of Finland) it serves as a great example for us in several cases. It provides several water-and air temperature measurement systems, such as satellite measures that could be considered in the river water measurements cases. This could be important especially if we consider the future impact of climate change on the flow and elevation of the rivers in our region. The EIA also examines several weather conditions that could be useful in our case, such as air movement- and circulation.

4.4 Results of the water expert consultation

We consulted a surface water expert of Umweltbundesamt (Environment Agency Austria) to gain information on methods of temperature measurement in rivers at sewage outlets. We also asked for recommendations for a temperature measurement system to be established by us later in the next project phase. As the expert explained, Umweltbundesamt does not have any specific methods for temperature measurements. According to the expert, nowadays there are many companies on the market that can offer a complete solution: a suitable measuring probe and controller in one, that means a suitable sensor (in our case temperature sensor) and a controller that evaluates and saves the data.

4.5 Conclusions

It is clear from the international outlook that when it comes to water temperature measurements at nuclear power plants, there is no general rule. While in Hungary several laws determine how the measurements must take place, in the case of Krsko NPP we did not receive information on the legal background. The case of Dukovany was also different as the official representatives claimed that water monitoring methods are not public information. In conclusion, not only the standardized method for temperature measurements is missing but there is also an issue with transparency as the results of the temperature measurements and the method of the measurements vary in the studied countries. This confirms the need for independent scientists and NGOs to put a strong focus on transparency of data to allow independent control.

5 Preparation of the next project phase

In this chapter we present offers for water temperature measurement systems that might be installed in the Danube near Paks in the next project phase. Furthermore, necessary next steps to implement and operate the future system are presented, including reflection on publication of the data.

5.1 Water measurement systems

To improve the development of a new regime of transparency and public quality control together with the MVM Paks NPP (and later perhaps with Krsko and/or Dukovany NPP) we requested price offers for a water measurement system for our project that may be suitable for the continuous monitoring of the water temperature of the Danube in this certain area. The measuring instrument we will need shall be able to store and transmit temperature data for data processing. In accordance with the Hungarian law, the instruments should be calibrated measuring instruments checked with a standard of use and the gauge should operate at two depths (0.5 m and 1.5 m).

The expert of Umweltbundesamt recommended four companies which have developed various online sensors for monitoring process water and surface water. We sent out our price offer requests to the following companies:

Siemens

Temperaturmessung | Prozessinstrumentierung | Siemens Deutschland

Enders und Hauser

Temperaturmesstechnik | Endress+Hauser

Hach-Lange

produktsuche, tempera, 8350 ph kombinations-sensor, 3/4", analog, pt100, für hohe temperaturen, orbisphere wasserstoff/helium tc sensor, luftspülung, ext. temperatursensor (20 bar), orbisphere wasserstoff (h_2) tc sensor, stickstoff-spülung, ext. temperatursensor (170 ba, Hach Österreich Suchergebnisse – Produkte

WTW

Xylem Analytics | Prozess-Messtechnik für pH/Redox, Leitfähigkeit und Sauerstoff

Up to now we received a price offer from Hach-Lange and Enders und Hauser in Hungarian language, the translation of the offer is below.

1. Price offer by Hach-Lange

	Item	Piece	Price	Discount	Total Price (HUF)	Euro (estimated. 1 Euro today is 363,75 HUF)
1.1	SC4200c transmitter for mobile sensor management (MSM), 2 digital sc universal sensor connector, 3G / 4G mobile internet SIM with card, 2 x M12 Ethernet connectors, USB, 5 x 4-20 mA output, 2xrelay, IP66, 100 - 240 V 50/60 Hz	1	734,616.00 HUF	15%	624,423.60	1717
1.2	3798-S sc inductive conductivity probe; 250 µS / cm ... 2.5 S / cm; max. 60 ° C; 1 "NPT; 10 m cable	2	228,245.00 HUF	15%	388,016.50	1066
1.3	Chain mounting unit for railing, pool edge; 1 "NPT E-chem for probe, V4A stainless steel (1200 mm horizontal, with 600 mm vertical tube, 5 m chain)	2	127,349.00 HUF	15%	216,493.30	595
2.1	SC 4200c controller installation, remote control function online interface design, parameterization. The fee includes: • Commissioning, training of operating personnel • Disembarkation costs	1	173,629.00 HUF		173,629.00	477
2.2	Commissioning 3798 The Hach commissioning service with instruments for use provide optimal performance from the start. It's not just operating personnel consists of training but also with Start-Up Service 24 We provide a one month factory warranty for commissioning and not delivery from the date of The fee includes: • Startup • Travel costs	2	75,455.00 HUF	10%	135,819.00	373
3.1	MSM connected sensor annual fee; 1 db	2	41,250.00 HUF		82,500.00	227
3.2	Claros basic package, annual fee for Claros access	1	53,460.00 HUF		53,460.00	147
			Without VAT	1,674,341.40		4603
			27% VAT	452,072.18		1243
			Total Price	**2,126,413.58**		**5845**

2. Price offer by Enders und Hauser

Item	Piece	Unit Price (EUR)	Net price (EUR)
Modular thermometer with resistance sensor or thermocouple. Metrical version with exchangeable insert for demanding applications in the chemical, oil/gas and power industry. With thermowell or to be installed into thermowell. Measuring range: -200...+1.100oC/ -328...2.012oF (depending on the configuration). ::Fastest response times for optimal process control through iTHERM QuickSens insert and fast response thermowell options. ::Maximum robustness for highest process safety through iTHERM StrongSens insert. ::Cost savings with recalibrations through iTHERM QuickNeck coupling ::Material selection for a wide range of applications. Additional specifications: Low range value Upper range value dual-sensor configuration 50,000- 50,000 PV = CH1; CH2 not °C °C AA Approval: Non-hazardous area B Thermowell: Thermometer with thermowell, continuous, similar DIN43772 Form 2 G/F , 3 G/F E Thermometer Design: Removeable neck D12mm acc. to DIN43772 CE Process/Thermowell Connection; Material: G1 male thread; 316L/316Ti	1	820,09	820,09
Paperless recorder with color graphic display. TFT 7 "display, front IP65, NEMA tip. 4 Encl. Operation with explanatory texts. With PC and web server. 6x digital input, 6x relay. 24 V transmitter power supply. Ethernet, 4x USB, RS485 / 232. FDA 21 CFR 11 compliant. AA Certificate: Non-hazardous area 1 Power supply: 100-230 V AC (+/- 10%) B Expansion slot 1: 4x universal U, I, TC, RTD, pulse / frequency input 10kHz Expansion Slot 2: Not used Expansion Slot 3: Not used Expansion Slot 4: Not used Expansion Slot 5: Not used Front panel: Zinc diecast, powder coated, clear gray, interfaces + SD card front page, instrument panel design 149x195mm, IP65, NEMA type 4 Encl. 1 Communication Master Function: None The Communication Slave Function: None 3 Application package: Remote alarm + math	1	2.756,54	2.756,54
Fieldgate FXA42 Compact gateway for data capture of field devices, without antenna. Embedded web server, alarm / event handling. Application: remote monitoring, inventroy data monitoring, web enabled field interface. Field device interfaces 4-20mA, Modbus RTU, digital inputs/outputs. :: Meets NAMUR NE43 requirements. :: Data transition into SupplyCare. Communication: Ethernet + 2G/3G modem	1	1.440,69	1.440,69
	TOTAL NET PRICE	5.017,32	
	Transportation	167,24	
	TOTAL PRICE	5.184,56	

Siemens and WTW have not yet reported back to us by November 16, 2021.

5.2 Next steps – preparation of project phase 2

In the second project phase, the measurement system shall be implemented and operation shall start. This will be done with a partner near the site, if possible. The data will be published regularly on a website.

Possible partner organization for the next project phase: Greenpeace Hungary, Nuclear Transparency Watch, Department of Environmental Sciences of Central European University

Possible partners for the website for publication of the data: Nuclear Transparency Watch, Department of Environmental Sciences of Central European University

Continuing this project, we aim to take the following steps:

- Obtaining further offers for a water temperature measurement system
- Mapping out the financial background for the project
- Getting in touch with MVM Paks NPP and obtain permission for water measurements
- Negotiating and contracting preparation with the future partner who will undertake the measurements
- Setting up a website to inform about the methods and results of the temperature measurements
- Buying and installing a temperature measurement system
- Installing the regular upload of data to be displayed on the website

6 Annex: Hungarian legal background

6.1 Laws

- Act XLV of 1991 on measurement
- Act LVII of 1995 on water management
- Act LIII of 1995 on the general rules of environmental protection
- Act LIII of 2006 on the acceleration and simplification of the implementation of investments of special importance from the point of view of the national economy
- Act CXXIX of 2007 on the protection of agricultural land
- Act CCIX of 2011 on Water Utilities
- Act CXXXIV of 2013 on the Provision of Certain Public Services and Related Amendments to the Act
- Act CLXV of 2013 on Complaints and Notices of Public Interest
- Act CXXXIX of 2018 on the Spatial Planning Plan of Hungary and some of its priority areas

6.2 Government decrees

- 72/1996. (V.22.) On the exercise of water management authority
- 121/1996. (VII. 24.) On the establishment and operation of public baths
- 123/1997. (VII. 18.) On the protection of water bases, long-term water bases and water facilities for drinking water supply
- 120/1999 (VII.6.) On tasks related to the maintenance of waters and public water facilities
- 239/2000. (XII. 23.) On the rights and obligations related to the utilization of mining lakes
- 50/2001. (IV.3.) On the rules for the agricultural use and treatment of sewage and sewage sludge
- 220/2004. (VII.21.) On the rules for the protection of surface water quality
- 219/2004. (VII.21.) On the protection of groundwater
- 314/2005. (XII. 25.) On the environmental impact assessment and the unified environmental use permitting procedure
- 27/2006. (II. 7.) On the protection of waters against nitrate pollution of agricultural origin
- 90/2007. (IV.26.) On the procedure for the prevention and remedying of environmental damage

- 147/2010. (IV. 29.) On the rules for activities and facilities for the utilization, protection, and remediation of water
- 58/2013. (II. 27.) of the CCIX of 2011 on water utility services. implementing certain provisions of the Act
- 455/2013. (XI. 29.) On the detailed rules of public service activities for the collection of domestic wastewaters collected by non-public utilities
- 83/2014. (III. 14.) On the use and utilization of areas endangered by large riverbeds, coastal strips, watercourses, and flood waters, and in the case of rivers, the rules on the procedure and content of the preparation of large riverbed management plans
- 223/2014. (IX. 4.) On the designation of bodies performing water management and water management and water protection authority tasks
- 71/2015. (III. 30.) On the designation of bodies performing environmental and nature protection authority and administrative tasks
- 366/2015. (XII. 2.) On the designation of performing water protection administrative tasks and amending certain government decrees on water issues
- 378/2015. (XII. 8.) On non-regular public services for the collection of domestic sewage not collected by public utilities
- 531/2017. (XII. 29.) On the designation of competent authorities acting on the basis of certain overriding reasons in the public interest

6.3 Ministerial decrees

- 12/1997. (VIII.29.) On the degassing of produced and supplied waters
- 23/1998. (XI. 6.) On the water management register of the water management organization
- 43/1999 (XII.26.) On the calculation of the water resources contribution
- 15/2001 (VI. 6.) On radioactive discharges into the air and water during the use of nuclear energy and their control, Environmental Ministerial Decree
- 6/2002 (XI.5.) of the Ministry of Environment and Water, the pollution limits and their control at the surface waters assigned for drinking water and ensuring life conditions of fish
- 27/2004. (XII.25.) On the classification of settlements in areas sensitive to groundwater status
- 28/2004 (XII.25.) On emission limit values for water pollutants and certain rules for their application
- 27/2005 (XII.6.) On detailed rules for self-monitoring of discharges of used and wastewater
- 18/2007. (V.10.) On the provision of data on the groundwater and geological environment environmental registration system

- 101/2007. (XII. 23.) On the professional requirements for the intervention in groundwater resources and water well drilling
- 30/2008. (XII. 31.) On technical rules for activities and facilities for the utilization, protection, and remediation of water
- 59/2008. (IV. 29.) On the detailed rules of the action program for the protection of waters against nitrate pollution of agricultural origin, as well as on the procedure for data provision and registration
- 6/2009. Regulation on limit values and measurements of pollution of the geological environment and groundwater against pollution
- 10/2010 (VIII. 18.) VM of the Ministry of Rural Development providing limit values for water pollutants in surface waters and rules of application
- 13/2015. (III. 31.) On administrative service fees for water management and water protection authority procedures
- 16/2016. (V. 12.) On the professional requirements for water management and water protection, the scope of inspections and the content of data provision to be fulfilled during the operation of public drinking water plants and public sewage disposal and treatment plants
- 41/2017. (XII. 29.) On the content of the documentation required for the water rights permitting procedure