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PART 5: ENERGY BALANCING AND CALCULATION OF ENERGY NEUTRALITY (DRAFT)

CLIENT

Ministry of Agriculture of the Czech
Republic



MINISTERSTVO ZEMĚDĚLSTVÍ

CONTRACTOR

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VYSOKÁ ŠKOLA
CHEMICKO-TECHNOLOGICKÁ
V PRAZE



SDRUŽENÍ OBORU VODOVODŮ A KANALIZACÍ ČR



National Implementation Programme for the Urban Wastewater Treatment Directive

Part 5: ENERGY BALANCING AND CALCULATION OF ENERGY NEUTRALITY

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1 Executive Summary

This part of the National Implementation Programme presents a proposed uniform procedure for balancing energy consumption and generation at urban wastewater treatment plants and for assessing achievement of the energy-neutrality target under Article 11 of Directive (EU) 2024/3019 of the European Parliament and of the Council.

The proposal is based on a complete annual energy balance that records separately the consumption of electricity, heat and fuels and the generation of energy from renewable sources. The balance includes energy generated directly on the treatment-plant site as well as renewable energy generated off-site by the WWTP owner or operator, or on their behalf, provided that its generation, quantity and allocation to a specific balancing unit can be demonstrated and no double counting occurs.

The proposed methodology defines the boundaries of the balancing unit, the rules for accounting for individual energy flows, the treatment of biogas, biomethane, sludge, waste heat and energy generated by heat pumps, and the minimum requirements for measurement, reporting and data retention.

For practical implementation, the basic balancing period is the calendar year. Energy self-sufficiency is determined as the ratio of total energy generation from renewable sources to the total energy consumption of the WWTPs included. The proposal also lays down conditions for the joint balancing of several treatment plants and for accounting for generation occurring outside the physical boundaries of a WWTP.

The proposed legal provisions constitute a working draft of a future legal and methodological framework. During the further preparation of the National Implementation Programme, it will be necessary in particular to clarify institutional responsibility for maintaining the balances, the method for aggregating results at national level, and the link to energy audits of wastewater treatment plants and their associated collecting systems.

2 Introduction and Purpose of the Document

This document presents draft legal provisions for the legal and technical regulation of energy balancing at urban wastewater treatment plants. Its purpose is to translate the requirements of Article 11 of Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment into a uniform and practically applicable national procedure.

The proposal focuses primarily on defining the boundaries of the balancing unit, determining total energy consumption and generation, accounting for renewable energy generated both on and off the WWTP site, rules for the joint balancing of several treatment plants, and requirements for measuring, documenting and reporting energy flows.

The draft legal provisions are supplemented by a technical annex setting out the calculation procedures, recommended units, the minimum scope of monitored data and the method for calculating energy self-sufficiency. The document is a technical proposal for further legislative and methodological development; it does not constitute the final text of a legal instrument. Decree on the methodology for energy balancing at wastewater treatment plants

3 Draft Legal Provisions

§ 1

Subject Matter

- (1) This Decree lays down the methodology for energy balancing at wastewater treatment plants (hereinafter “WWTPs”), including the method for defining the system, calculating energy inputs and outputs, and accounting for off-site generation.
- (2) The purpose of this Decree is to ensure a uniform and transparent procedure for monitoring, reporting and assessing the energy self-sufficiency of WWTPs in accordance with Article 11 of Directive (EU) 2024/3019.

§ 2

Definitions

For the purposes of this Decree, the following definitions apply:

- (a) **“balancing unit” (BU)** means the set of technological processes and equipment of a WWTP, or several WWTPs combined into a single unit, that is subject to the energy balance; the scope and precise boundaries of the balancing unit are defined as part of the WWTP energy assessment.
- (b) **“balancing period”** means the calendar year; the assessment period for evaluating compliance with the balancing milestones consists of the four most recently completed calendar years; where four years of data are not available, all available completed calendar years shall be used.
- (c) **“total annual energy consumption of the balancing unit” (S)** means the sum of all energy inputs under Section 4 and energy generated within the balancing unit and consumed within that unit during the balancing period, expressed in kWh or an equivalent unit per balancing period.
- (d) **“total annual energy generation of the balancing unit” (V)** means the sum of all energy generated within the balancing unit or on its behalf under Section 7, irrespective of whether it is consumed within the balancing unit during the balancing period or exported from it, expressed in kWh or an equivalent unit per balancing period.
- (e) **“generation on behalf of”** means energy demonstrably generated on behalf of the WWTP operator or owner under a legal title and supported by measured data.



(f) **“WWTP energy community” (WEC)** means an association of two or more WWTPs that consolidate energy generation and consumption as one common balancing unit.

(g) **“chemical energy of a fuel”** means the product of the lower heating value of the fuel and its quantity, expressed in kWh;

(h) **“wastewater treatment plant” (WWTP)** means a technological unit intended for wastewater treatment, comprising equipment in which the physical, chemical or biological properties of wastewater are modified and sludge is separated or transformed. A WWTP is distinguished from sewerage infrastructure; its scope does not include structures used exclusively for wastewater conveyance that are not part of the treatment process, i.e. between the first and last treatment stage. For energy-balancing purposes, the operator shall define the WWTP boundary so as to identify unambiguously whether sludge-treatment equipment is included in the balancing unit. This definition shall be made as part of the energy assessment.

(i) **“energy self-sufficiency of the balancing unit” (P_{SOB})** means the ratio of the total annual energy generation of the balancing unit V to the total annual energy consumption of the balancing unit S, expressed as a percentage.

§ 3

Definition of System Boundaries

(1) The energy balance shall be drawn across the boundary of the balancing unit (BU), comprising all physical energy flows entering or leaving a WWTP or, where applicable, a combined unit of several WWTPs.

(2) Generation shall also include energy from renewable sources generated outside the WWTP site by the WWTP owner or operator, or on their behalf, irrespective of where it is used, provided that it is demonstrably allocated to the balancing unit and is not counted twice.

(3) Internal energy conversions within the balancing unit shall not be counted again as inputs or outputs, in order to prevent double counting.

(4) Where several WWTPs are balanced jointly, the internal and external boundaries of the balancing unit shall be defined so as to prevent double counting of energy.

(5) The WWTP shall define the scope of the balancing framework; the minimum scope is specified in subsections (1) and (2). The owner may delegate this obligation to the operator, a representative of the WWTP energy community, or another person.

§ 4

Energy Inputs

(1) Energy inputs shall include only:

(a) electricity supplied to the balancing unit from the distribution system or other sources;

(b) heat or cooling supplied to the balancing unit from external sources;

(c) fuels supplied to the balancing unit, converted to chemical energy in accordance with Annex 1.

(d) Fuels may be included in the balance either as chemical-energy inputs or through the measured energy outputs produced from those fuels (electricity and heat), provided that no double counting occurs.

(2) Inputs shall not include:

(a) fuels used for road transport;

(b) chemicals, imported sludge and external substrates.

§ 5

Energy Outputs

(1) Energy outputs shall include:

- (a) electricity supplied to the distribution system or another entity;
- (b) heat or cooling supplied to another entity;
- (c) fuels transferred outside the balancing unit, in particular biogas, biomethane and sludge intended for energy recovery;
- (d) energy used to charge electric vehicles (this energy shall always be balanced as an output);
- (e) usefully utilised heat or electricity generated on the WWTP site for purposes unrelated to wastewater treatment or conveyance within the WWTP treatment train.

(2) Unused energy, for example energy dissipated in heat dump systems or residual gas flares, may not be counted as an energy output and shall not be included among energy outputs.

(3) Dewatered sludge may be included in the energy balance as an output where its use for energy purposes is documented.

§ 6

Balancing Energy from Fuels and Biogas

(1) Where energy is generated from purchased fuels, the calculation shall be based either on the chemical energy of the fuel, converted using its lower heating value, or on the measured quantity of electricity and heat generated.

(2) Where several types of fuel are used simultaneously, outputs shall be allocated according to their energy shares. Where several fuels are used in parallel, outputs shall be allocated according to the shares of the LHV inputs or verified measurements.

(3) Biogas and biomethane shall be included in energy outputs on the basis of their measured volume and lower heating value where they are transferred outside the balancing unit. The calculation methodology is set out in Annex 1.

(4) Wet or dried sludge shall be regarded as fuel where it is demonstrably used for energy purposes and transferred outside the balancing unit. Its energy value shall be determined by calculation or laboratory measurement; laboratory determination shall be carried out in accordance with Section 10(4) and (5).

(5) Heat generated by heat pumps within the balancing unit shall be regarded as internally generated; the electricity used by the heat pump is an input under Section 4. Where this heat is transferred beyond the boundary of the balancing unit, it shall be reported as an output under Section 5.

§ 7

Off-site Energy Generation and Energy Communities

(1) Energy generated outside the balancing unit shall be counted as generation only where:

- (a) there is a legal title (contract or agreement) demonstrating that the generation was carried out on behalf of the WWTP operator or owner;
- (b) measured data on generation and allocation are available;
- (c) the same generated energy is not counted twice;
- (d) it is not merely a purchase of energy.

(2) A WWTP energy community may consolidate the generation and consumption of several WWTPs as one balancing unit where it has:

- (a) a founding agreement (owners' agreement) defining its members, boundaries and shared facilities;



- (b) a demonstrable allocation of generation “on behalf of the community”;
- (c) defined internal and external energy flows;
- (d) safeguards ensuring that no double counting occurs.

(3) Energy and fuel flows between members of the energy community (electricity, heat/cooling, biogas/biomethane and sludge) shall be regarded as internal and shall not be included in the community’s inputs or outputs.

§ 8

Balancing Milestones

- (1) Each balancing unit under Section 2(a), consisting of a wastewater treatment plant with a load of at least 10,000 PE, or a WWTP energy community under Section 2(f), shall ensure that the energy self-sufficiency of the balancing unit (P_SOB) reaches, by no later than:
 - a) 40% by 31 December 2035;
 - b) 70% by 31 December 2040;
 - c) 100% by 31 December 2045.
- (2) For the purpose of determining energy self-sufficiency, counted own generation shall not include energy that is merely purchased, even where it originates from renewable sources.
- (3) In the case of an energy community, the obligation under subsection (1) shall be determined using the sum of the loads of all participating WWTPs, expressed in PE.

§ 9

Measurement, Reporting and Verification

- (1) The WWTP operator or owner shall maintain and retain records of all measured energy flows under Annex 1 for a period of five years. Records may be kept in paper form, on electronic media or in data repositories.
- (2) The balance shall be prepared on the basis of actually measured values or energy contents demonstrably determined using an accredited laboratory method.
- (3) Balance results shall be reported in an annual summary stating all inputs and outputs, the total annual energy consumption of the balancing unit S, the energy self-sufficiency of the balancing unit P_SOB, and the calculation formulae used.
- (4) Measurement and reporting shall comply with the requirements of Article 11 of Directive (EU) 2024/3019.

§ 10

Meters and Metrological Requirements

- (1) All energy inputs and outputs under this Decree shall be measured using instruments that comply with Directive 2014/32/EU on measuring instruments (MID), its Czech transposition in Government Regulation No. 120/2016 Coll., as amended, and the relevant harmonised standards.
- (2) In particular, the following shall be used for the respective types of measurement:
 - (a) active electrical-energy meters in accordance with Annex MI-003 (for DC metering and electric-vehicle charging equipment, the requirements shall apply from the effective date of the relevant amendment);
 - (b) thermal-energy meters in accordance with MI-004 (EN 1434); the requirements for cooling shall apply from the effective date of the relevant amendment;

(c) gas meters in accordance with MI-002; conversion to energy shall be calculated as volume $\times$ lower heating value, with the lower heating value determined in a metrologically traceable manner (traceability of measuring instruments under Act No. 505/1990 Coll. and ČSN EN ISO/IEC 17025).

(3) Until the relevant amendments referred to in subsection (2) enter into force, measuring instruments having legal metrological conformity under the Metrology Act and Government Regulation No. 120/2016 Coll. may be used where they are intended for the relevant purpose.

(4) Where laboratory-determined fuel lower heating values are used instead of the tabulated values in Annex 1, the determination shall be carried out by a testing laboratory accredited under ČSN EN ISO/IEC 17025 for the relevant test method, with accreditation granted by a national accreditation body under Regulation (EC) No. 765/2008 (including accreditation in other EU Member States). The laboratory shall ensure the metrological traceability of the results and state the measurement uncertainty.

(5) The relevant technical standards shall be used to determine lower heating values, in particular:

(a) EN ISO 18125 (solid biofuels);

(b) ISO 1928 (solid fossil fuels – coal/coke);

(c) EN ISO 6976 (gaseous fuels – calculation of calorific values from composition).

The currently valid edition or an equivalent European/international standard shall be used.

Annex 1: Technical Methodology for WWTP Energy Balancing

Article 1 – Basic Principles of the Balance

- (1) The energy balance shall be prepared for the balancing unit (BU) under Section 3 of the Decree as a complete energy balance separately recording all energy inputs, all energy outputs and all energy generated within the balancing unit, including a breakdown by origin and method of use.
- (2) Internal energy conversions within the BU shall not be counted repeatedly; energy entering equipment (for example combined heat and power units or heat pumps) shall be reported as an input, and energy leaving such equipment as generation or an output under this Decree.
- (3) The balance may be prepared for one WWTP or for several WWTPs associated in an energy community, provided that the conditions of Section 7 of the Decree are met.
- (4) All energy quantities shall be expressed in [kWh] or converted equivalents.
- (5) The balance shall be based on actually measured or demonstrably determined data.

Article 2 – Calculation of Energy Inputs

1. Inputs shall include the items specified in Section 4(1) of the Decree:
 - (a) electricity supplied to the balancing unit;
 - (b) heat or cooling supplied to the balancing unit;
 - (c) fuels supplied to the balancing unit.

$$E_{in} = Electricity_{in} + Heat/cooling_{in} + \sum_i (LHV_i \cdot m_i)$$

2. The chemical energy of a fuel shall be determined using the following equation:

$$E_{fuel} = LHV \cdot m$$

where:

- (E_{fuel}) – chemical energy of the fuel [kWh];
- (LHV) – lower heating value of the fuel [kWh·kg⁻¹ or kWh·m⁻³];
- (m) – quantity of fuel [kg or m³].

3. The lower heating value shall be determined by laboratory analysis in accordance with Section 10(4) and (5), from the tabulated values and calculations specified in this Decree, or using a value declared by the fuel manufacturer or supplier.
4. Inputs shall not include the fuels and materials specified in Section 4(2) of the Decree.

Article 3 – Calculation of Energy Outputs

1. Energy outputs shall include the items specified in Section 5 of the Decree.
2. Each output shall be reported separately: electricity, heat/cooling, biogas, biomethane, sludge and other energy products.
3. Usefully utilised on-site energy shall be included in outputs only where its actual use outside the treatment process defined in Section 2(h) is documented.

4. For the final balance, all outputs shall be summed:

$$E_{out} = Electricity_{export} + Heat/cooling_{export} + \sum_i (LHV_i \cdot m_i)$$

Article 4 – Calculation of Energy in Biogas and Biomethane

1. The energy content of biogas or biomethane shall be determined using the following equation:

$$E_{biogas} = V_{biogas} \cdot LHV_{CH_4} \cdot x_{CH_4}$$

where:

(E_{biogas}) – energy contained in biogas or biomethane [kWh];
 (V_{bio}) – gas volume [Nm^3];
 (x_{CH_4}) – volumetric fraction of methane [–];
 (LHV_{CH_4}) – lower heating value of methane (10 kWh·m⁻³).

2. Where the methane content is not measured, the standard value (x_{CH_4}) = 0.60 shall be used.
3. Only gas intended for energy use (combustion, combined heat and power generation, upgrading to biomethane, etc.) shall be included in the calculation of the energy output in the form of biogas.

Article 5 – Calculation of Energy in Sludge

1. The energy contained in sludge shall be determined from its mass, dry-solids content, volatile-solids fraction and the lower heating value of the volatile solids.
2. Calculation equation:

$$E_{sludge} = m_{sludge} \cdot (VL_{VS} \cdot LHV_{VLVS} - (1 - VL_{105}) \cdot H_{evap})$$

where:

(E_{sludge}) – energy content of the sludge [kWh];
 (m_{sludge}) – sludge mass [kg];
 (VL_{105}) – mass fraction of dry solids in the sludge [g/g];
 (VL_{VS}) – mass fraction of volatile solids in the sludge [g/g];
 (LHV_{VS}) – lower heating value of the volatile solids [kWh·kg⁻¹ of sludge volatile solids];
 (H_{evap}) – specific heat of vaporisation of water [kWh·kg⁻¹ H₂O].

3. (LHV_{VS}) shall be determined by laboratory analysis or from the tabulated values below.
4. (H_{evap}) = 0.72 kWh/kg of evaporated water
5. The calculation applies to sludge leaving the balanced system.

Article 6 – Minimum Scope of Measurement and Reporting

1. The minimum set of measured data shall include:

Inputs:

- electricity supplied to the balancing unit [kWh];
- heat or cooling supplied to the balancing unit [kWh];



- fuel quantities and lower heating values [kg, m³, kWh];
- energy generated off-site “on behalf of” the operator [kWh].

Outputs:

- electricity supplied to the grid [kWh];
 - heat or cooling transferred to other entities [kWh];
 - biogas, biomethane and sludge intended for energy recovery [kWh];
 - usefully utilised heat or electricity for other purposes [kWh].
- Measurements shall be traceable, archived and included in the annual balance under Section 9 of the Decree.
 - The period for which the balance is prepared is the calendar year.
 - Measurements shall be carried out using appropriate measuring instruments and laboratory determinations.
 - The measured data shall make it possible to determine:
 - the sum of all energy inputs under Section 4;
 - the sum of all energy outputs under Section 5;
 - the quantity of energy generated within the balancing unit, broken down by source and method of use (own consumption or export).
 The measurement and reporting method shall be selected so that the total annual energy consumption and energy self-sufficiency of the balancing unit can be calculated in accordance with Article 7 of this Annex.

Table 1: Standard lower heating values for gaseous fuels

Fuel	LHV [kWh·m ⁻³]
Methane (CH ₄) [biomethane, natural gas]	10
Hydrogen (H ₂)	3

Table 2: Standard lower heating values for solid and liquid fuels

Fuel / component	LHV [kWh·kg ⁻¹]
Sludge volatile solids	6
Brown coal (lignite)	3.8
Hard coal (bituminous)	7.5
Light fuel oil (LFO)	11.3

Article 7 – Calculation of Total Energy Consumption and Energy Self-Sufficiency

- The total annual energy consumption of the balancing unit S [kWh/year] shall be determined as the quantity defined in Section 2(c), using the energy-input data under Article 2 and data

on energy generated within the balancing unit and consumed within that unit during the balancing period.

- (2) The total annual energy generation of the balancing unit V [kWh/year] shall be determined as the quantity defined in Section 2(d), using data on all energy generated within the balancing unit and energy generated outside the balancing unit “on behalf of” the operator or owner under Section 7 of the Decree and allocated to the balancing unit.
- (3) The energy self-sufficiency of the balancing unit P_SOB [%] shall be calculated as follows:
$$P_SOB = 100 \times (V / S).$$
- (4) For the purpose of meeting the balancing milestones under Section 8, total annual energy generation V shall not include energy that is merely purchased, even where it originates from renewable sources.

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4 Final Explanatory Notes and Relationship to European Guidance

The proposed procedure is based directly on Article 11 of Directive (EU) 2024/3019, under which energy-neutrality targets are assessed at Member State level and include renewable energy generated on or off the WWTP site by treatment-plant owners or operators, or on their behalf. The decisive factor is therefore not the physical use of each unit of generated energy directly at a specific WWTP, but the ability to demonstrate its generation, allocate it unambiguously to the balance and prevent double counting.

Generation “on behalf of” a WWTP owner or operator must be based on a legal title, supported by measured data and assigned to a specific balancing unit or energy community. The mere purchase of energy, including energy declared to be renewable, shall not be regarded as generation on behalf of a WWTP.

For example, where a WWTP owner operates an external photovoltaic power plant, its demonstrable generation may be allocated to the WWTP energy balance even where the electricity is supplied to the distribution system and sold. Sale is a method of using the generated energy, not a second accounting of that energy. For a generation facility owned by a third party, only the contractually defined share of generation carried out on behalf of the WWTP owner or operator may be counted.

In some respects, the proposed Czech methodology is more detailed than the technical interpretative materials being prepared at European level. It differs from recommendations based primarily on individual WWTPs in particular by retaining a complete energy balance and by allowing use of the flexibility expressly provided by the Directive for meeting the target at national level. This approach must, however, be accompanied by transparent records, unambiguous balancing boundaries and rules preventing the double counting of energy.

The 20% milestone for 2030 is not addressed separately in the proposed legal provisions because, according to the available national data, this level of energy self-sufficiency is already being achieved; the proposal therefore focuses on the subsequent binding milestones from 2035 onwards.

5 Sources and References

- Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment.
- Directive (EU) 2023/1791 of the European Parliament and of the Council on energy efficiency – definitions and requirements for energy audits.
- Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.
- JRC: technical materials under preparation or available for the implementation of Article 11 of the UWWTD.