

## **INTRODUCING CIRCULAR ECONOMY IN SMALL MUNICIPALITIES: METHODOLOGY AND A CASE OF SEWAGE SLUDGE COMPOSTING**

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**Abstract.** The paper presents a new methodology that supports a transition of towns and villages to circular economy with reasonable costs for municipalities, businesses and households. A model showing analytical, decision-making and administrative actions that, step by step, lead from the first idea submitted to a public administration body via elaborating a draft project to its implementation phases is presented first. The case of sewage sludge composting combined with utilisation of compostable municipal organic waste with the production of compost shows a potential of efficient solution to this problem for municipalities when a massive subsidy is provided by a government.

*Keywords:* circular economy, sewage sludge, composting, municipality.

### **AIMS AND BACKGROUND**

Circular economy (CE) is an EU policy in the sphere of nature resource management<sup>1,2</sup> and is simultaneously a key component of Europe's progress towards climate neutrality<sup>3</sup>. It is also a part of the new municipal and urban development concept known as 'Smart City'<sup>4</sup>. CE is also an object of interest in the academic community. The body of expert and scientific literature on the topic has been growing in approximately the last five years. However, the definition of CE is not cohesive yet. Kircher et al.<sup>5</sup> compared the understanding of CE in 114 definitions and concluded that various authors perceive the term differently. The CE concept is also close to the concept of sustainable development, which has been evolving for some time. The most evident similarities and differences between both concepts can be found in Geissdoerfer et al.<sup>6</sup>, who analysed an extensive body of literature on the topic. The diverse notions of CE share sustaining value added in products in the economic system by a transition from rather linear economy to an economy with as closed material and energy flow cycles as possible. It builds on tradition-

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ally functioning natural systems. It goes together with reducing waste generation and negative impacts on the environment, including negative impacts on climate<sup>7</sup>.

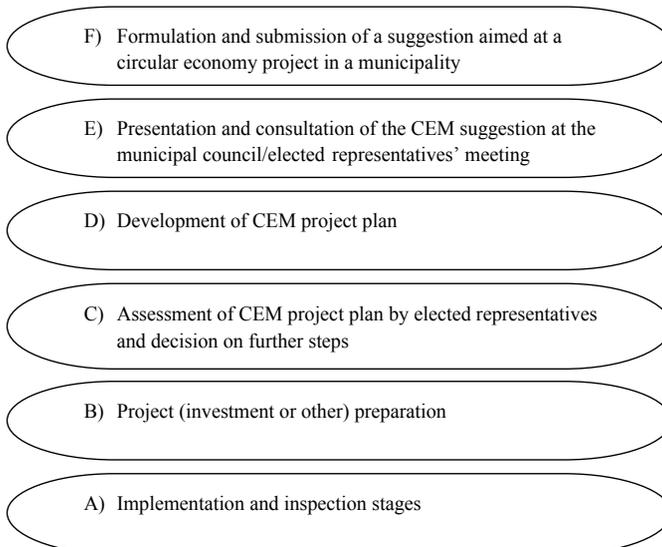
In this paper, we intend to present a new applied research project. Its goal is to create a tool that would support a transition of towns and villages to Circular economy in municipalities (CEM) with reasonable costs for municipalities, businesses and households.

The methodology is presented first. It builds on a model showing analytical, decision-making and administrative actions that, step by step, lead from the first idea submitted to a public administration body via elaborating a draft project to its implementation phases. Participative cooperation of citizens is one of the key issues in this process.

The model has been pilot-tested on several case studies. The case of sewage sludge composting combined with utilisation of compostable municipal organic waste and its utilisation is presented in this paper.

## EXPERIMENTAL

The diagram below (Fig. 1) presents a simplified model of the solution the decision-making processes regarding various options for CE project implementation in municipalities. The full model version in the diagram shows more explicitly what happens to a suggestion if decision is not made on the procedure towards its implementation within the steps outlined in this simplified diagram.



**Fig. 1.** Simplified decision-making model of introducing circular economy projects in municipalities

The following activities and decisions take place in the diagram steps. The paragraph letters correspond to the steps in the diagram. The diagram focuses on activities of municipalities. However, it can also be used by other entities for development of quality suggestions and for following the consultation and solution stages. It also serves as a kind of general public education tool on the public issue handling mechanism at the municipal level.

*Formulation and submission of a suggestion aimed at a circular economy project in a municipality.* A suggestion for a circular economy project in a municipality may be made by an entity existing in the municipality – a citizen, the mayor or an elected representative, a business whose activity is related to the municipality, a local non-profit/non-governmental organisation, particularly a citizens’ association, local group, political party, etc. The suggestion may also be made by entities outside the municipality, such as a ministry, regional authority, union of municipalities, non-profit/non-governmental organisation with a regional or broader jurisdiction, or another external entity. At present, the Ministry of the Environment in cooperation with the OECD is developing the strategic framework ‘Circular Czechia 2040’ and a comment proceedings is in progress on an amendment of the Waste Act, taking into account the principles of circular economy.

The suggestion may aim at one CEM activity by its nature. For example, a citizen or another stakeholder comes up with an initiative that the municipality ought to support rainwater harvesting for irrigation of either public spaces or private land. The suggestion may be broader in scope (at first). For example, the municipality (mayor, elected representatives, etc.) may want the municipality to join those active in CEM or sustainable development. Thus, specific areas of CEM activity and projects will be defined later.

The model considers both suggestions made orally (such as a citizen’s contribution to the elected representatives’ meeting, sharing their idea with the mayor or the elected representatives, the mayor’s or an elected representative’s speech at a municipal or council meeting) and suggestions made in writing or by means of modern communication channels such as specialised applications. The important thing is that the municipality is the recipient of the suggestion and that the implementation of further steps is assumed by the mayor or person in charge of the respective agenda.

*Presentation and consultation of the CEM suggestion at the municipal council/elected representatives’ meeting.* The mayor, perhaps after consultation with the municipal council or available experts, makes a preliminary assessment of the suggestion and decides whether it is a CEM-type suggestion. If YES, the mayor accepts the suggestion and presents it as a point on the agenda of the municipal council or elected representatives’ meeting. The mayor may request a specification and resubmission of the suggestion.

If it is an interesting suggestion but is obviously not of a CEM type, it is moved to the standard consultation process in a different area. If it is a totally meaningless idea – regardless whether CEM or not – the mayor, perhaps after consultation with others in the municipal council, rejects the suggestion and replies to the suggester appropriately.

*Development of CEM project plan.* If the suggestion passes successfully the municipal council and elected representatives' meeting, a decision on development of the so-called CEM Project Design is typically made. If the suggestion is not approved, the suggester has two options: either withdraw it or resubmitted in a better-prepared form.

The model recommends the following parts in the CEM project design:

The technical part describes: (i) the exact purpose, (ii) the positive and negative environmental impacts, and (iii) the technical and process implementation options.

The economic-financial part makes qualified estimates of: (i) PCEM implementation investment costs, (ii) operating costs, (iii) revenues, (iv) profit/loss if any and return on investment. Moreover, this part specifies the CEM project financing method, i.e. (i) the contribution of the municipality, state, citizens and businesses, and (ii) applicable subsidy brackets for this type of project and requirements for applications for the subsidy. If any profit is expected, the design specifies its recipient.

The legal analysis makes an assessment whether the design can be implemented from the legal point of view and under what conditions, particularly whether the CEM project implementation is in accordance with the current legislation in force. If the CEM project implementation is not in contravention of legislation, the author shall make explicit reference to the legal standards under which the design can be implemented. If the CEM project implementation is in contravention, the report states that the design cannot be implemented (and the reasons). The municipality may show legislative initiative.

The Project design shall also contain an outline of further managerial steps, i.e. a description of the character of the project and its expected requirements for management of further steps, particularly in case the implementation will be an investment project.

*Assessment of CEM project plan by elected representatives and decision on further steps.* The outcome of the (expert) assessment is particularly the following clearly formulated conclusions:

- whether the project can be implemented in process (factual) terms;
- whether the project is efficient, i.e. meets the efficiency and effectiveness criterion (pursuant to the Czech Act on Municipalities<sup>8</sup>);
- whether provision of funds for the project is realistic;
- whether the CEM project implementation is in accordance with current legislation in force.

In the case of a negative conclusion in any of the above points, the assessment may contain suggestions for resolving the situation. If technological advancement or price decrease, and particularly the opening of a subsidy bracket for the given project type, is expected soon, the conclusion shall be that the Project design will be modified and resubmitted for consultation and decision on implementation.

If the decision is positive, the standard implementation stages follow. They may include purchase of equipment subject to standard requirements for contractor selection. Implementation of projects in the form of capital investment is a frequent case. A standard procedure exists for that under the legislation (project documentation development, environmental impact assessment, zoning proceeding, building permit proceeding, construction, operation, inspection).

## RESULTS

The above model has been pilot-tested on a case of reuse of sewage sludge in a municipal composting plant. It is a case implemented in an actual municipality with a population around 1600 inhabitants in Central Bohemia. The municipality is of a suburban type with predominant single-family housing. There are only small-scale entrepreneurs: business and services in haulage, hairdressers, locksmiths and tinsmiths as well as small-scale construction production. The land-use plan assumes construction of approximately 150 single-family houses. The land-use plan also sets a part of the territory for development of business activities.

(A) The project was initiated by one of the municipality citizens, who came to the municipal authority with the oral information that a call has been opened for public funds for building composting plants. One of the elected representatives assessed the suggestion and proposed that the subsidy could be used for building a facility for reuse of biodegradable waste by means of composting. The solution would involve both reuse of wastewater treatment plant sludge and selected biodegradable waste collected within the municipality's territory. The suggestion was then included on the elected representatives' meeting agenda.

(B) The suggestion was discussed at the elected representatives' meeting. It decided on development of a Project design. It was stated already at this stage that the implementation will only be possible in the case of a successful subsidy application. It resulted from the meeting that the elected representatives are ready to approve the project if the municipality does not have to expend more than 15% of the total investment and that the municipality had the amount available.

(C) The Project design was developed by an external consultant:

*Technical part.* The main project objective is reuse of wastewater treatment sludge and selected biodegradable waste in the municipality. The sludge is currently not reused but handed over to an authorised entity for disposal. The dry matter content

in the sludge is about 20% (i.e. it contains approx. 80% water). The system of separate collection of biodegradable waste in the municipality will be modified.

Technically, the project objective will be achieved by constructing a municipal composting plant, which will reuse, based on an approved recipe, reuse biodegradable waste to produce land reclamation substrate and technical compost. The resulting products will be offered for sale for the purposes of technical land reclamation and landscaping.

*Economic-financial part.* The project implementation investment costs were estimated to be CZK 3,000 thousand (EUR 115 thousand).

The composting plant equipment operating costs were estimated to be CZK 300 thousand a year (EUR 11.5 thousand) with the project sustainability of 5 years and expected equipment service life of 10–15 years.

The municipality's current costs of WWTP sludge handling are approx. CZK 650 thousand a year (EUR 25 thousand). The project will thus bring a cost saving of CZK 350 thousand a year (EUR 13.5 thousand). The estimated benefits do not include revenues from sales of land reclamation substrate and technical compost at CZK 300–400/t (EUR 11–15), totalling approx. CZK 50 thousand (EUR 2 thousand).

The rate of return on investment was estimated to be approx. 4 years.

Since the municipality will be the future owner of the newly built movable and immovable property, the municipality will also obtain any profit and cover any loss resulting from the facility operation.

The municipality will contribute 15% to the investment project funding, and 85% of the costs will be covered by a state subsidy<sup>9</sup>.

*Environmental part.* The limit for successful reuse of biodegradable waste in the municipality is the contents of hazardous substances. They become a part of the wastewater treatment sludge during the treatment process. Their sources are associated, among other things, with consumption of everyday products, including foodstuffs, as well as business activities, vegetation care, etc.

The Project design assessment answered yes to all the key questions:

*Can the project be implemented technically, i.e. does it meet the efficiency requirement?* Yes, the proposed composting plant project is standard. The composting plant operator has the obligation to monitor quality of input waste, the composting process and the land reclamation substrate/technical compost. The waste processing/composting work procedure has to be observed.

*Is the project efficient in terms of costs and benefits?* Yes, the return on investment is only 4 years for the municipality.

*Is the project implementation realistic in terms of securing funds?* Yes, but only in the case of approved subsidy.

*Is the project implementation in accordance with current legislation in force?* The project complies with legislation in force.

The municipal elected representatives subsequently decided that the project would be implemented in case the subsidy is obtained. The design involves municipality's investment – therefore, it will follow standard regulations like any other investment project. After the implementation, the project is expected to function on its own, including necessary inspections and repairs.

## CONCLUSIONS

On the whole, it can be concluded that the pilot testing has shown that the methodology developed is applicable at the level of even smaller municipalities for supporting decision-making on circular economy projects, in this case for the area of WWTP sludge reuse. It has also demonstrated clarity of the methodology for smaller municipalities, which is of a more general validity.

As suggested above, reuse of sewage sludge for composting (particularly for agricultural use) may be a problematic point due to the environmental risks (contents of heavy metals, antibiotics, EDTA, NTA, PAH, etc.)<sup>10-12</sup>. The literature does not rule out the option, but drying and energy reuse of such sludge is considered above all<sup>13</sup>. If WWTP sludge is reused for composting in the municipality, the collection of other biodegradable waste in the municipality has to be modified so that it is easily reusable for the composting<sup>14</sup>. The EU is also striving for a policy promoting eco-design of products not containing substances that are difficult to break down in WWTP, thus enabling safer reuse of the sludge<sup>1</sup>. An example of such a procedure is substitution of hazardous substances in commonly used everyday products, including foodstuffs, with original natural substances or reduction of their consumption (e.g. replacement of EDTA with citric acid, reducing the consumption of antibiotics, etc.).

The paper focuses primarily on the role of municipalities in promoting circular economy within their territories. More successful functioning of CE will be aided by activity of manufacturers in the area of eco-design, enabling better recycling. In specific cases, there is a possibility of efficient cooperation of municipalities and larger local businesses in safe wastewater treatment, thus safe reuse of sludge<sup>15</sup>.

The pilot methodology testing has also shown that the solution is demanding in terms of subsidies from public resources (85% of the investment costs in our case). Since these are enormous amount of money, the importance of research 'justifying' these expenditures by assessing the social benefits increases<sup>16,17</sup>. At the academic level at least, we can discuss alternative methods of subsidy allocation, such as by negotiation under information asymmetry between the applicant and the provider. The effectiveness of such negotiations has been authenticated experimentally on the case of shared municipal WWTP<sup>18</sup>.

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