A European perspective on market potentials of modular wastewater treatment

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The optimal degree of centralisation for wastewater infrastructures
A model-based geospatial economic analysis

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eawag aquatic research
I The Swiss example
   The history and challenges

II Geography and costs
   Geospatial cost assessment

III Entry markets
   Modular market potential

IV Concluding remarks
I: The Swiss example

History and challenges
The Swiss Example
Degree of centralization

Data Source: BAFU 2016
Degree of centralization

Mandatory connection regulation

Art. 11 Duty to connect to sewers and to accept polluted waste water

1. Polluted waste water which originates in an area served by public sewers shall be discharged into such sewers.
2. The areas served by public sewers shall include:
   a. building zones;
   b. other zones as soon as they are connected to the public sewers (Art. 10 para. 1, let. b);
   c. other zones where connection to the public sewers is expedient and reasonable.
3. The person responsible for the sewers is obliged to accept waste water and convey it to the appropriate central waste water treatment plant.

Data Source: BAFU 2016
Centralized socio-technical system

Proportion of population connected to sewers

Source: Larsen et al. (2016): https://doi.org/10.0.4.102/science.aad8641
Global challenges and drivers of change

- **Global Environmental Change**
  *Water scarcity...*

- **Ageing infrastructure**
  *Financing, leaking pipes....*

- **Socio-demographic change**
  *Infrastructure flexibility...*

- **Innovation deficit**
  *Lock-in, path-dependency...*

Source: Larsen et al. (2016): [https://doi.org/10.0.4.102/science.aad8641](https://doi.org/10.0.4.102/science.aad8641)
The Swiss Example
II: Geography and costs
Central or decentral?

- **Not well understood economics**
  - Economies of scale
  - Diseconomies of scale
  - Network effects
  - Economics of a hybrid system
  - Geographic influence
Central or decentral?

- **Not well understood economics**
  - Economies of scale
  - Diseconomies of scale
  - Network effects
  - Economics of a hybrid system
  - Geographic influence

Fully decentral | Hybrid system | Fully central
Economics of a hybrid system

Treatment + Transport + Treatment + Transport = Total
Economics of a hybrid system

Capita costs per year

Connection rate

Economics of a hybrid system

Economics of a hybrid system

Total central: Treatment + Transport + Total
Total decentral: Treatment + Transport = Total

Capita costs per year

Sensitivity indication
Illustrative cost function

SNIP: Geospatial modelling approach

Heuristic geospatial cost optimisation
Shortest path finding, agglomerative hierarchical clustering...

Towards a full cost assessment

Towards a full cost assessment

Economies of density

Geospatial analysis on operation and maintenance

Source: Eggimann et al. 2016a: https://doi.org/10.1016/j.watres.2016.06.011
Towards a full cost assessment

Source: Eggimann et al. (2016):
https://doi.org/10.1016/j.watres.2016.07.062
Towards a full cost assessment

Optimal degree of centralization

Optimal degree of centralization

Optimal connection rate
- Different tariff structures
- Monopolistic service provision
- Professional competencies
- Households cannot choose freely
- Regulate central operator

II: Entry markets

Modular market potential
Screening analysis for estimating markets

- Deriving proxy to screen for optimal degree
  Population density (urban, peri-urban, rural)

- Geospatial analysis for Switzerland
  Raster-cell based optimisation

European market potentials for modular treatment

Market potential of modular infrastructure concepts on a European scale

European market potentials for modular treatment

Market potential of modular infrastructure concepts on a European scale

# European market potentials for modular treatment

Table 4

<table>
<thead>
<tr>
<th>Country</th>
<th>Extrapolated small modular market potential</th>
<th>Currently no central treatment</th>
<th>Annual number of small modular treatment units with Swiss plant distribution (88% category A, 12% category B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Population [%]</td>
<td>Population [PE]</td>
<td>Population [%]</td>
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<tr>
<td>France</td>
<td>10</td>
<td>5,689,000</td>
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<td>5,050,000</td>
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<tr>
<td>Poland</td>
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<tr>
<td>United Kingdom</td>
<td>4</td>
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</tr>
<tr>
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<td>5</td>
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<td>618,000</td>
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<td>Iceland</td>
<td>7</td>
<td>18,000</td>
<td>9</td>
</tr>
<tr>
<td>Malta</td>
<td>2</td>
<td>7,000</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>–</td>
<td>35,234,000</td>
<td>–</td>
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</table>

Where are possible entry markets?

- Germany: 5.1 million PE
- Poland: 3.9 million PE
- France: 5.7 million PE
- Italy: 3.4 million PE

Approximately 100,000 modular treatment units per year
Concluding remarks
Concluding remarks

- Increasing spatial price differentiation fosters decentral treatment
- Leapfrog age of fully centralised systems
- Spatial economic analysis revealed promising entry markets for modular systems
- Socio-technical challenges remain (demographic, regulations, automation...)
- European context differs
  - Some countries (e.g. Switzerland) should reconsider mandatory connection rule
  - Some countries (e.g. UK, Germany) could focus on technological upgrading of existing decentral treatment system with more sustainable alternatives
  - Some countries (e.g. Hungary, Portugal) should invest in «system hybridization»
Transition towards new degrees of centralization

Economies of learning, cost of packaged treatment plants, SBR membranes...

Falling costs for batteries for electricity vehicles

Transition towards new degrees of centralization
Literature


Fig. 6. Average treatment cost data for on-site WMS.