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A European perspective on market potentials of modular wastewater treatment

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eawag
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eci
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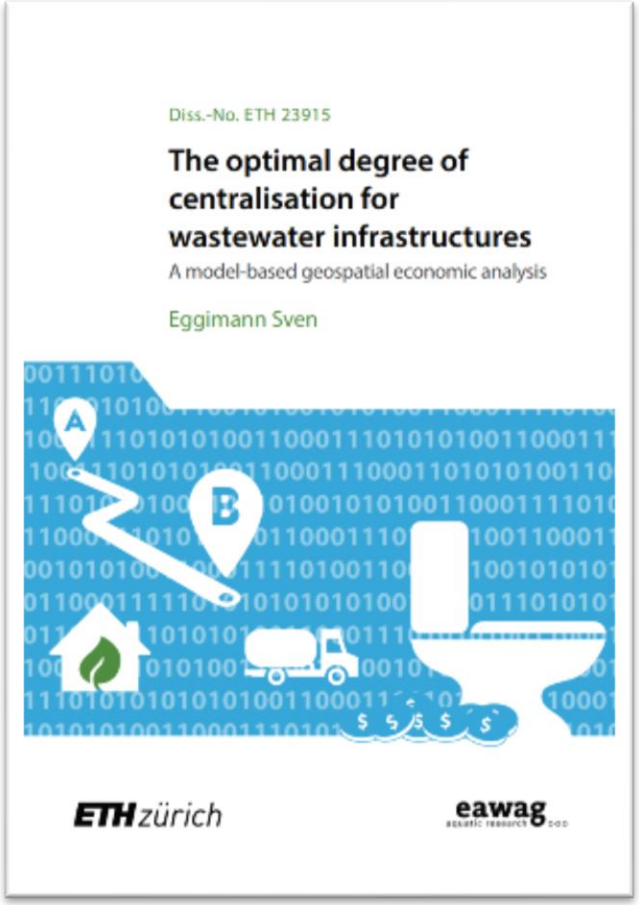

I The Swiss example
The history and challenges

II Geography and costs
Geospatial cost assessment

III Entry markets
Modular market potential

IV Concluding remarks

I: The Swiss example

History and challenges

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The Swiss Example

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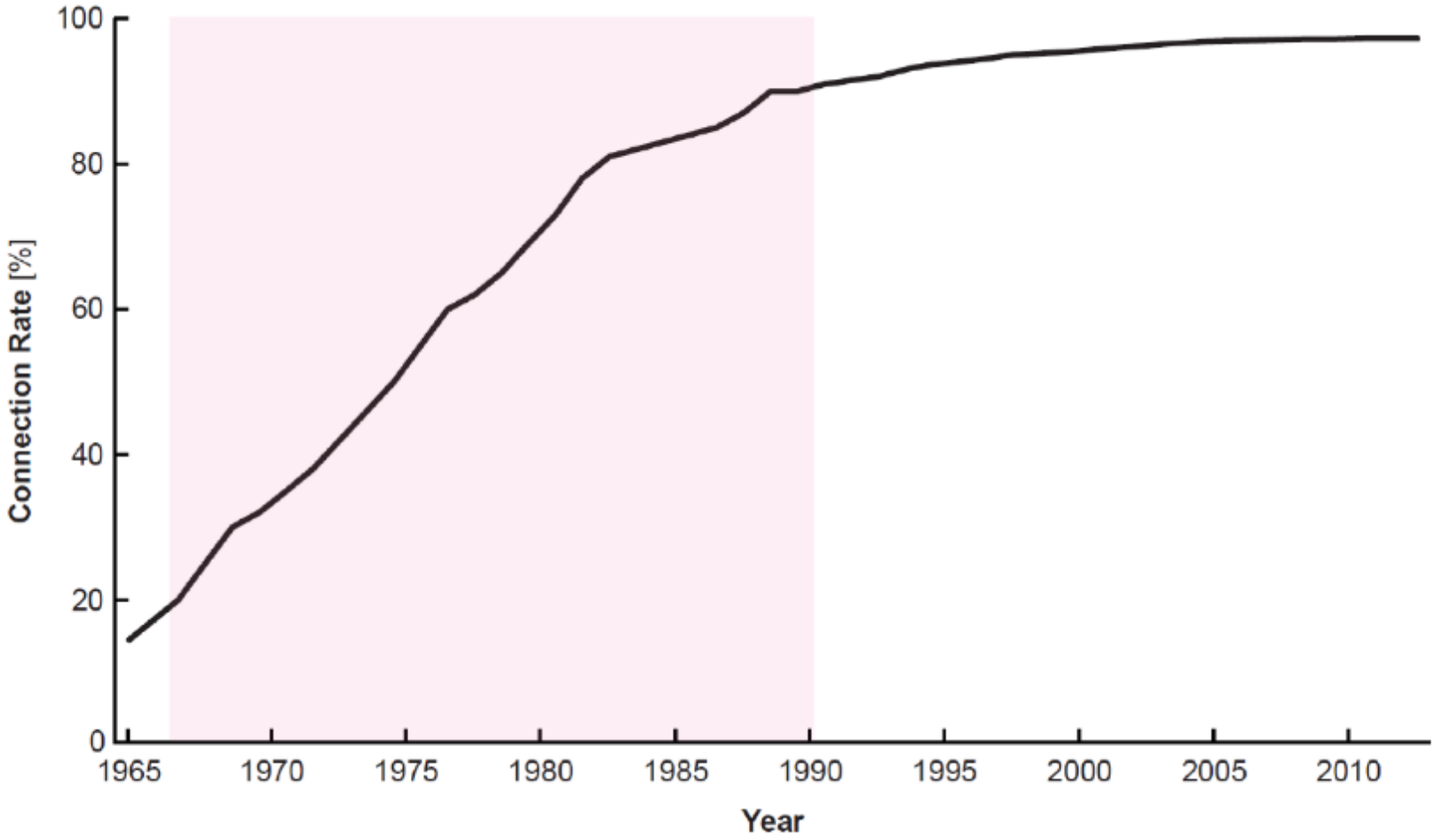
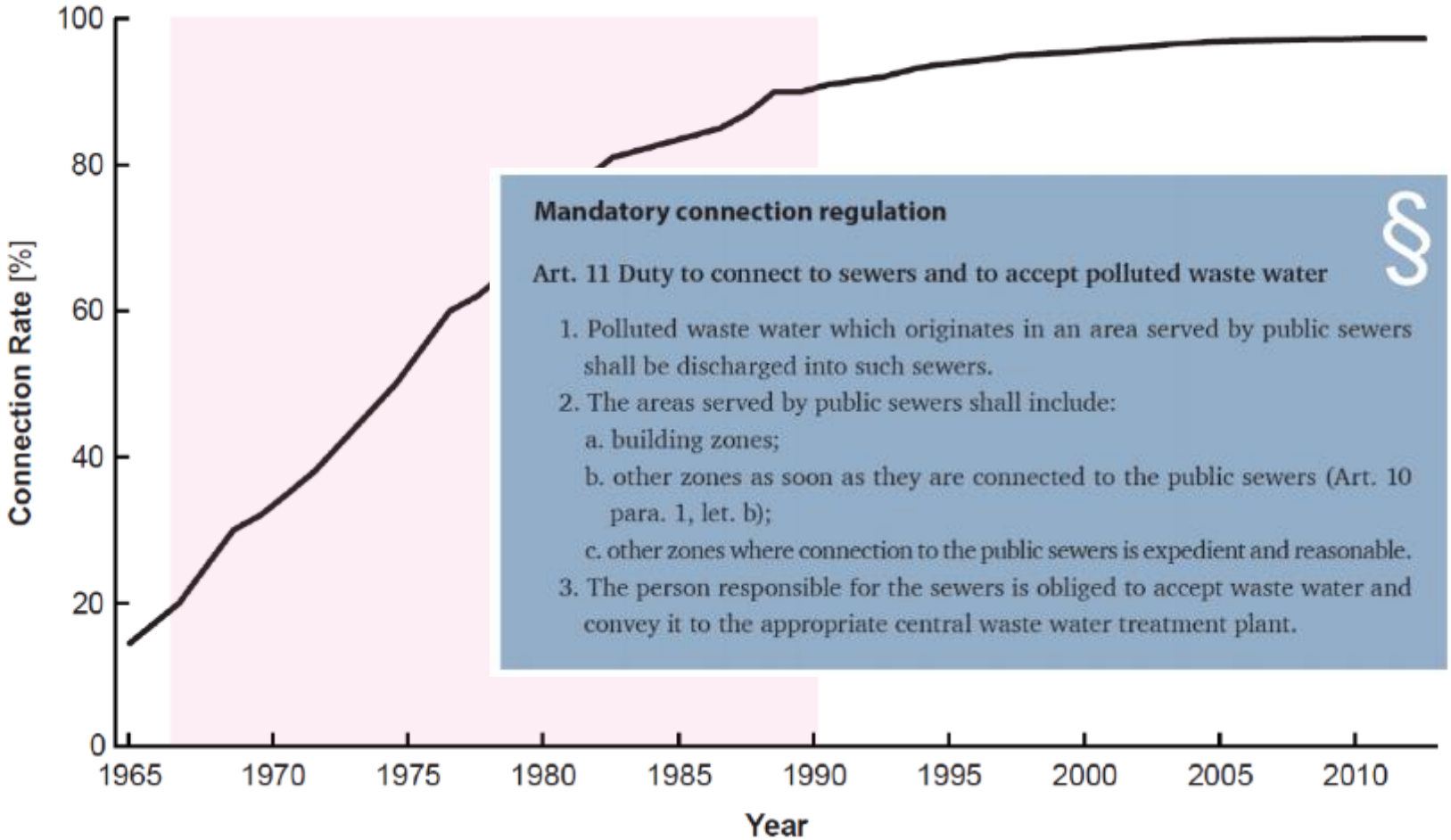
Degree of centralization



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

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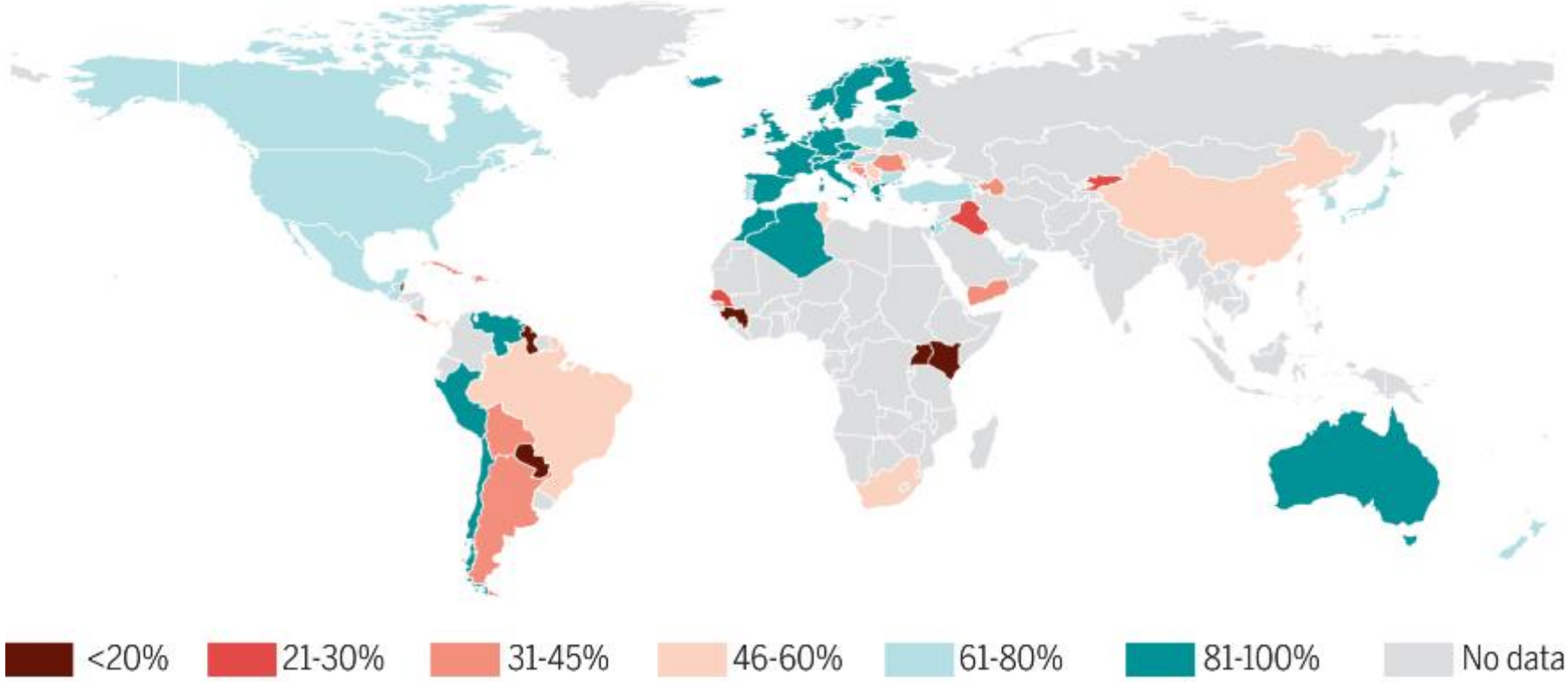
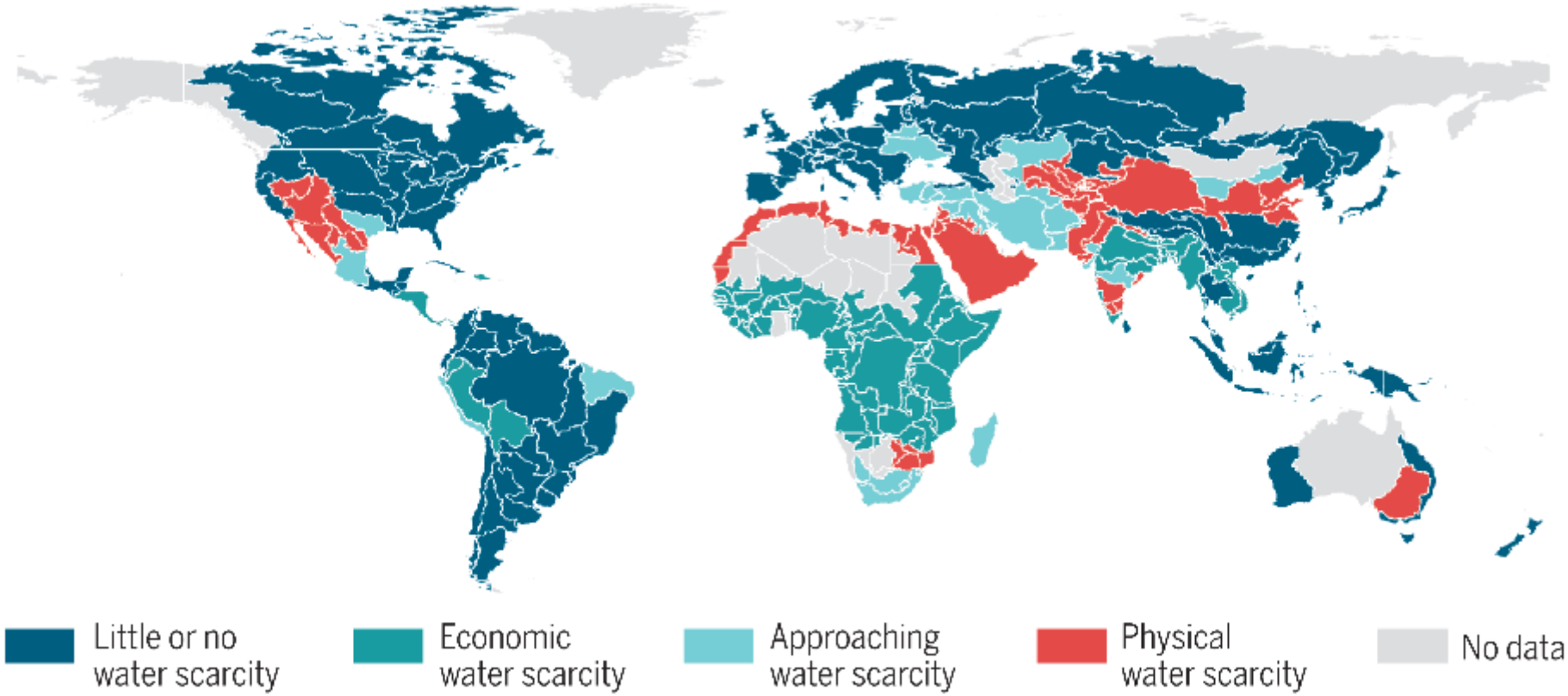
Centralized socio-technical system

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://www.royal.uk/sites/default/files/images/encyclopaedia/editrs571723_2105800-lpr.jpg

II: Geography and costs

Central or decentral?

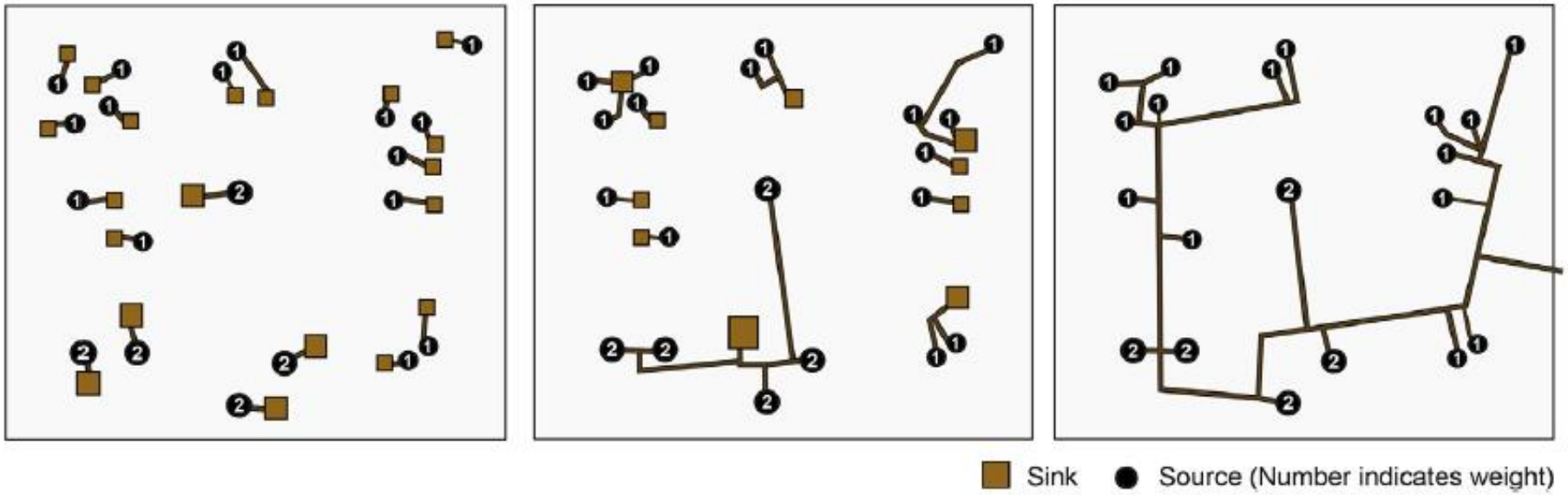
- **Not well understood economics**
  - Economies of scale
  - Diseconomies of scale
  - Network effects
  - Economics of a hybrid system
  - Geographic influence

https://d3n8a8pro7vhmx.cloudfront.net/votesustainable/pages/28/attachments/original/1455504148/Sustainability-diagram-enlarged.png?1455504148

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**



https://d3n8a8pro7vhmx.cloudfront.net/votesustainable/pages/28/attachments/original/1455504148/Sustainability-diagram-enlarged.png?1455504148

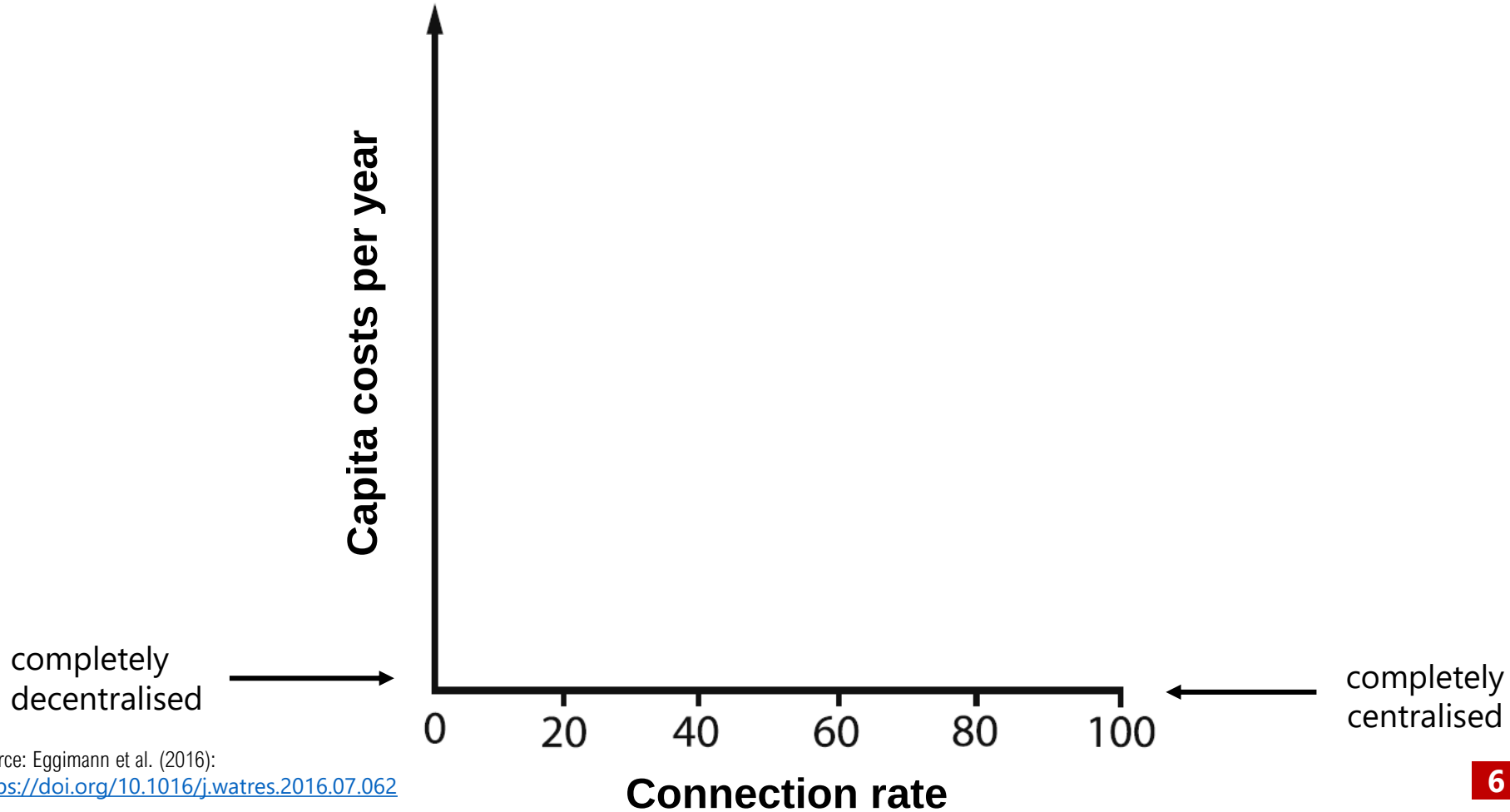
Economics of a hybrid system

total central				total decentral				system costs
Treatment	+	Transport	+	Treatment	+	Transport	=	Total

Source: Eggimann et al. 2016b

Economics of a hybrid system

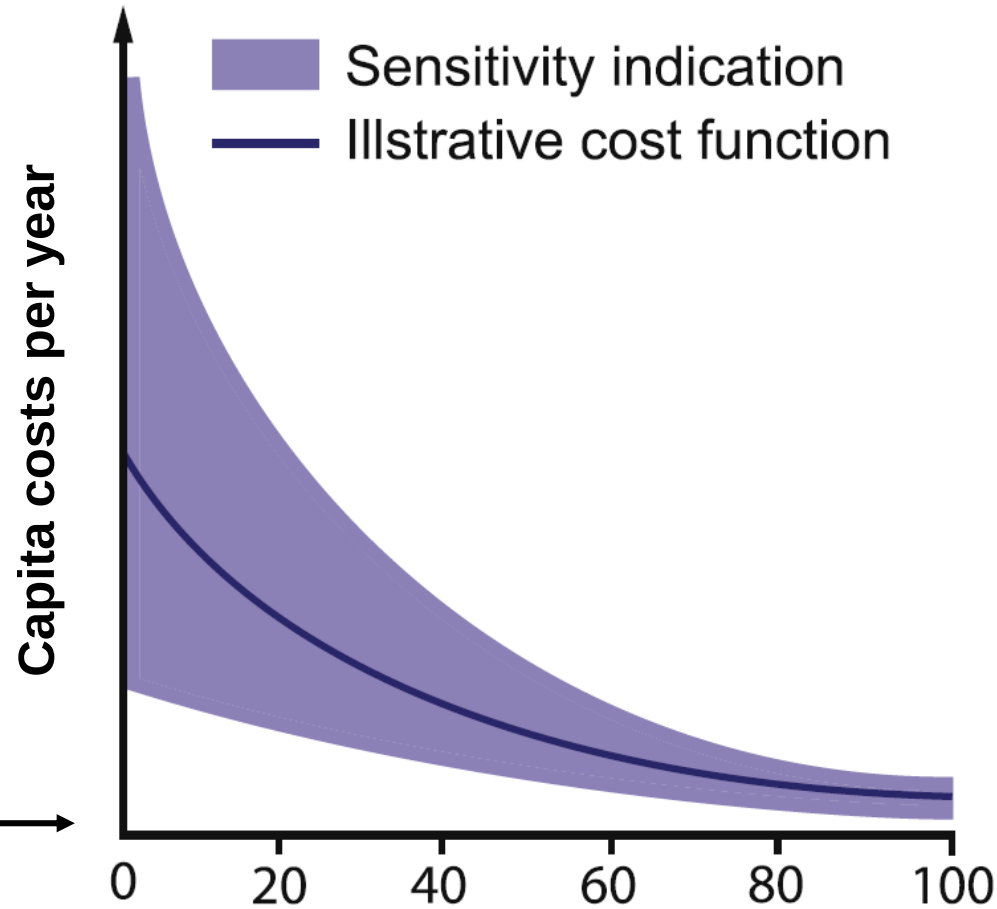
total central			total decentral			system costs
Treatment	+ Transport	+	Treatment	+ Transport	=	Total



Source: Eggimann et al. (2016): https://doi.org/10.1016/j.watres.2016.07.062

Economics of a hybrid system

total central: **Treatment** + **Transport**
+
total decentral: **Treatment** + **Transport**
=
system costs: **Total**



completely decentralised

completely centralised

Source: Eggimann et al. (2016):
https://doi.org/10.1016/j.watres.2016.07.062

Economics of a hybrid system

total central				total decentral				system costs
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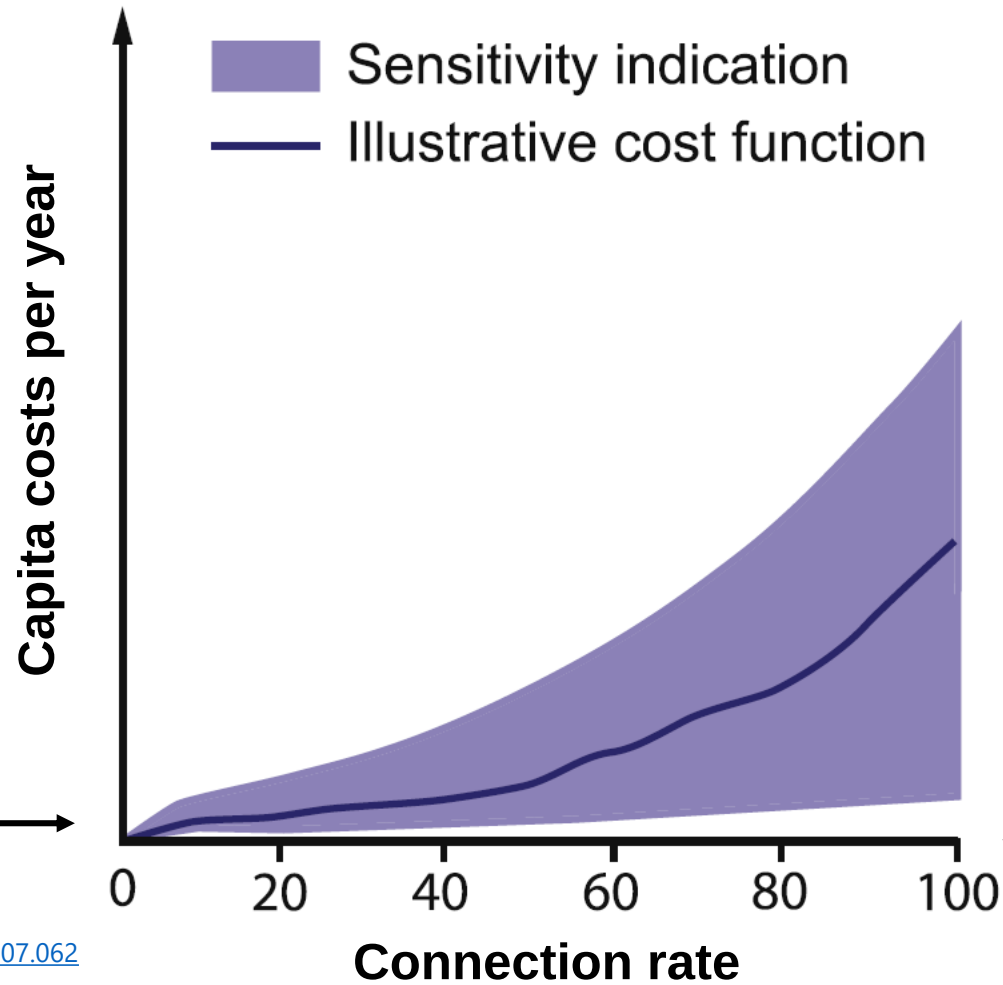


completely decentralised

completely centralised

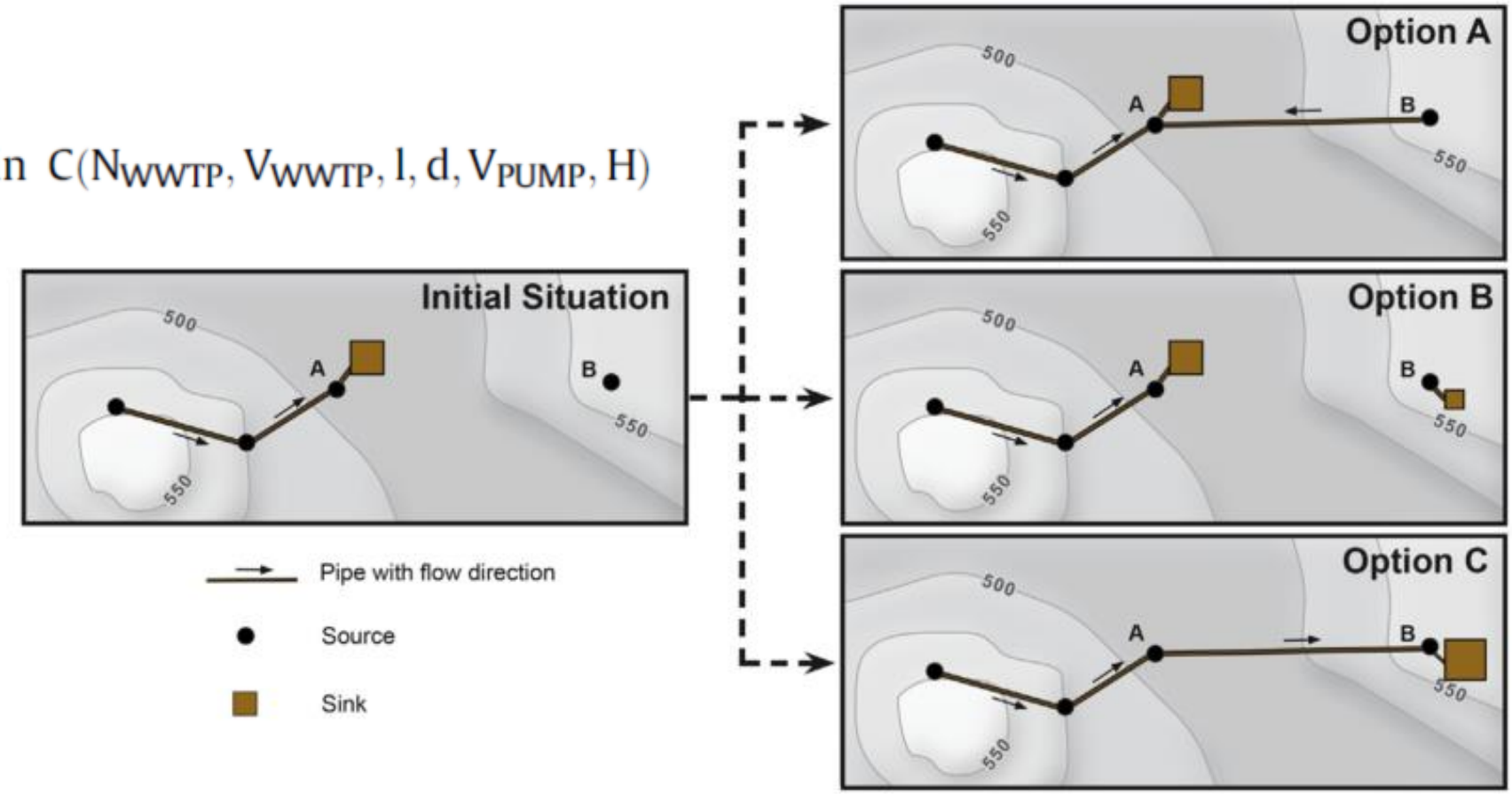
Source: Eggimann et al. (2016): https://doi.org/10.1016/j.watres.2016.07.062

SNIP: Geospatial modelling approach

Heuristic geospatial cost optimisation

Shortest path finding, agglomerative hierarchical clustering…

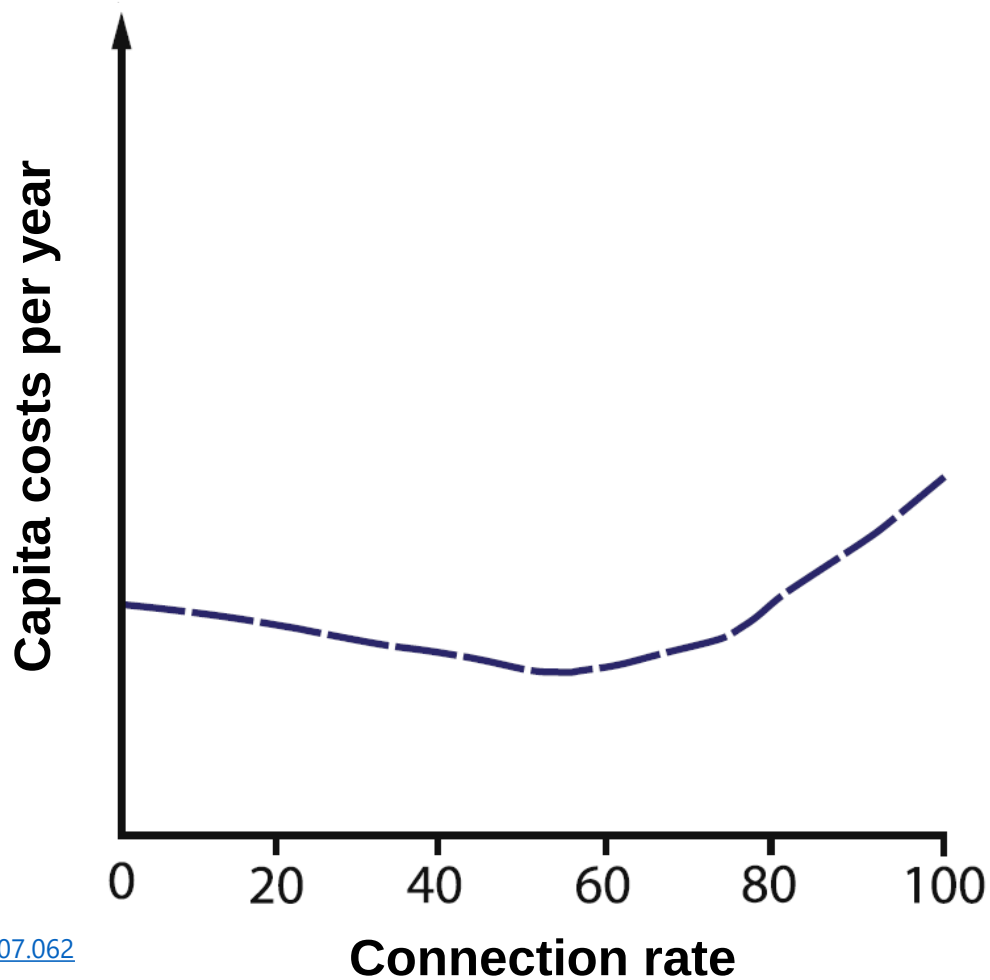
$$\text{Min } C(N_{WWTP}, V_{WWTP}, l, d, V_{PUMP}, H)$$



Source: Eggimann et al. (2015):
https://doi.org/10.1016/j.watres.2015.07.004

Towards a full cost assessment

total central				total decentral				system costs
Treatment	+	Transport	+	Treatment	+	Transport	=	Total



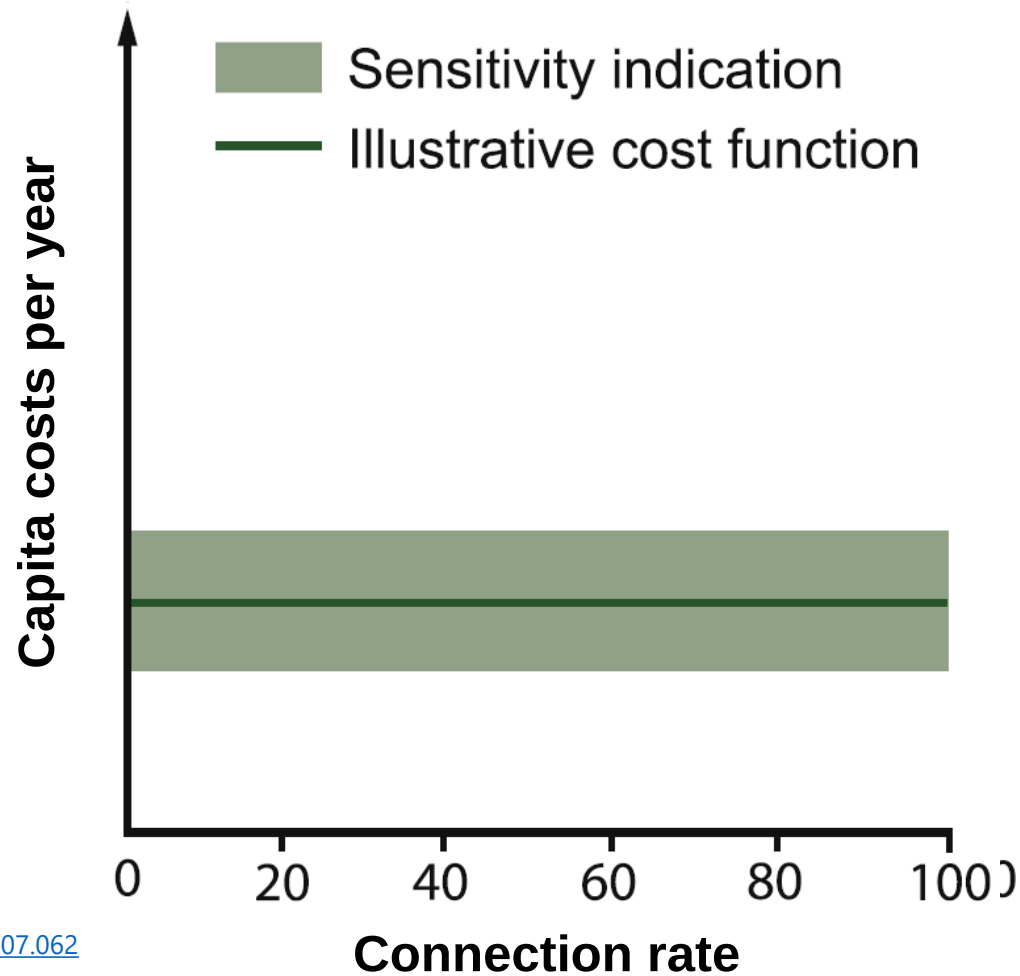
Source: Eggimann et al. (2016):
https://doi.org/10.1016/j.watres.2016.07.062

Towards a full cost assessment

total central: Treatment + Transport

total decentral: Treatment + Transport

= Total (system costs)



Source: Eggimann et al. (2016):
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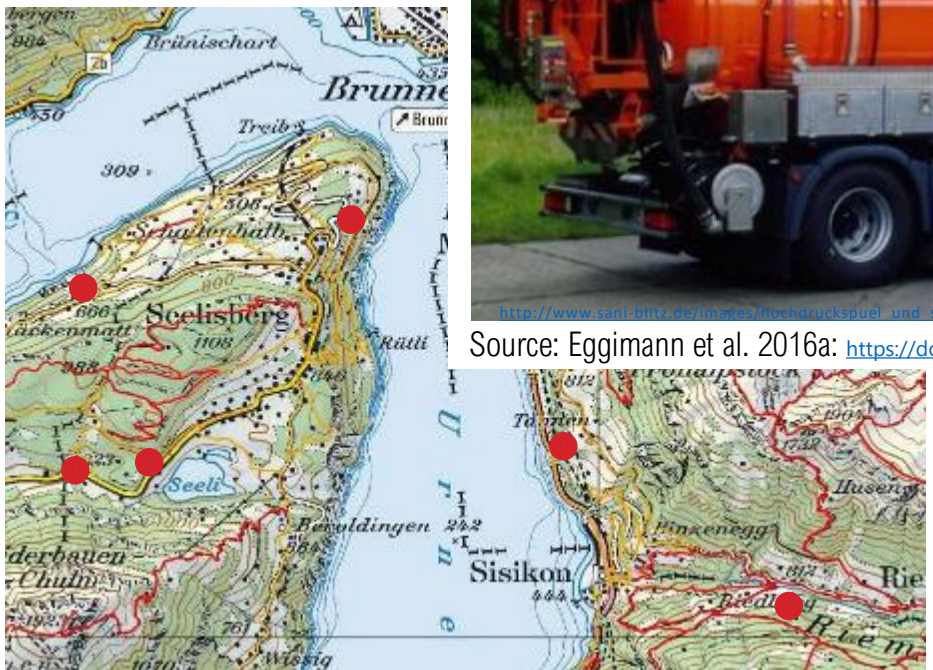
Economies of density

total central				total decentral				system costs
Treatment	+	Transport	+	Treatment	+	Transport	=	Total

Geospatial analysis on operation and maintenance

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

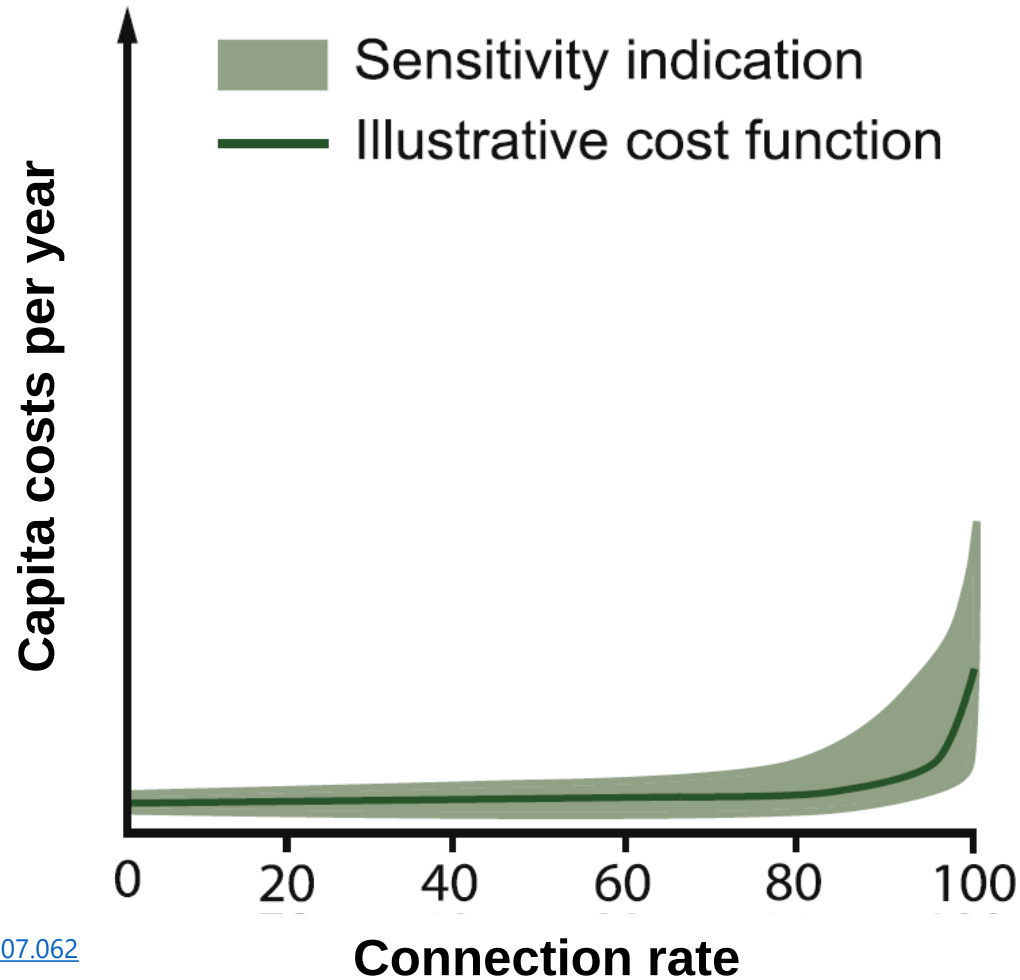


Towards a full cost assessment

total central: Treatment + Transport

total decentral: Treatment + Transport

system costs: = Total



Source: Eggimann et al. (2016): https://doi.org/10.1016/j.watres.2016.07.062

Towards a full cost assessment

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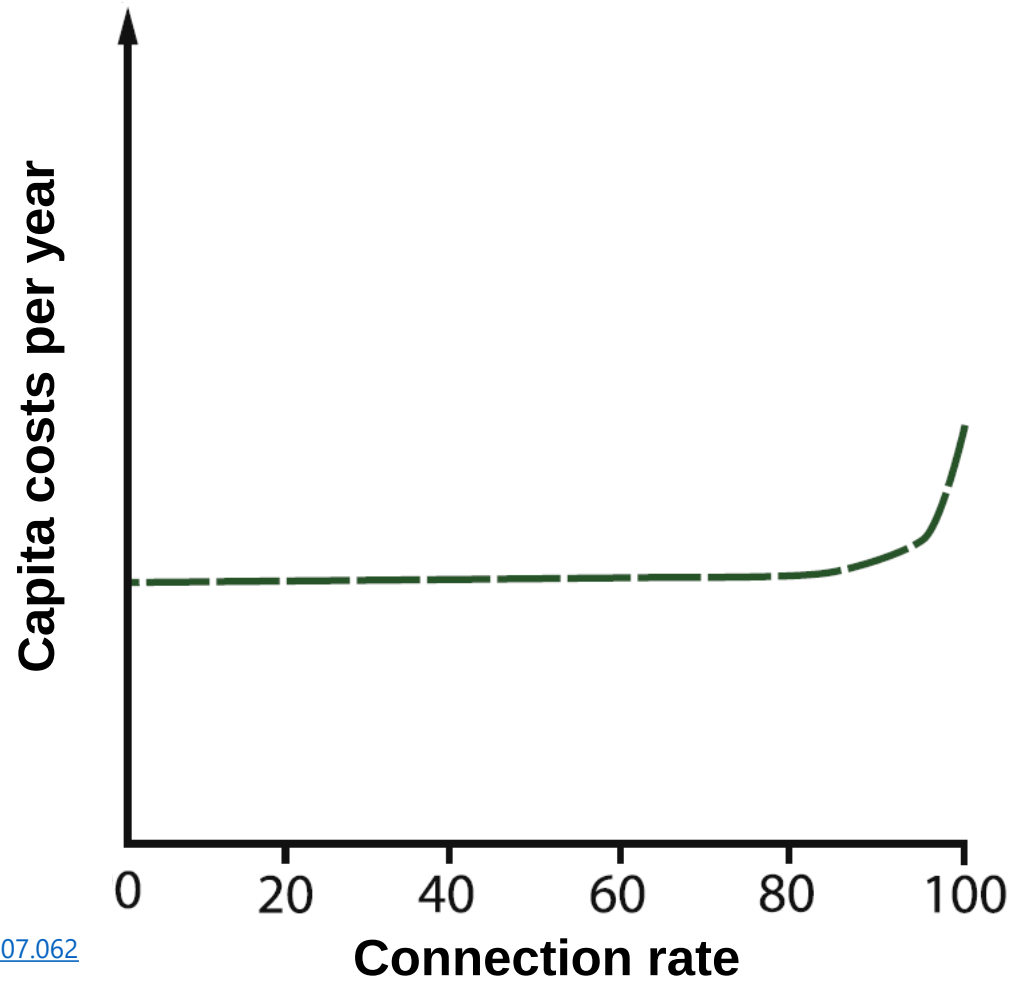

Source: Eggimann et al. (2016):
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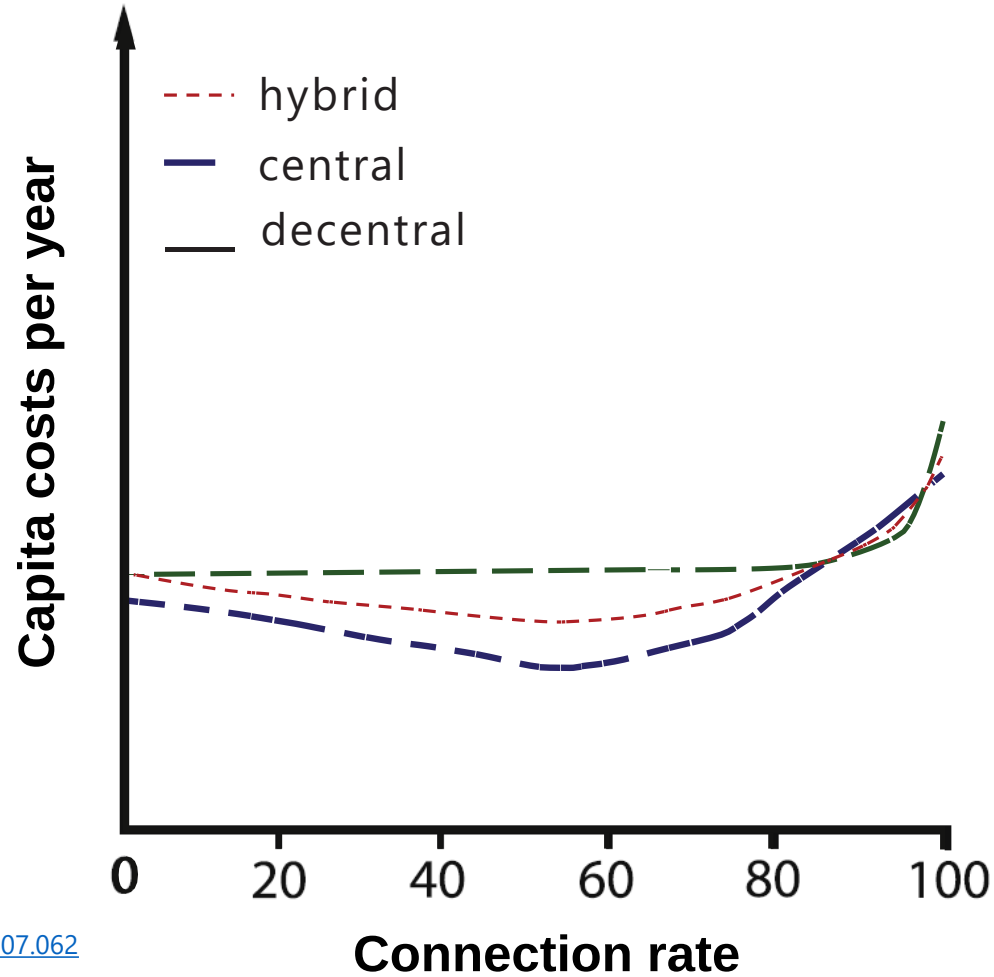
Optimal degree of centralization

total central			total decentral			system costs
Treatment	+ Transport	+	Treatment	+ Transport	=	Total



Source: Eggimann et al. (2016):
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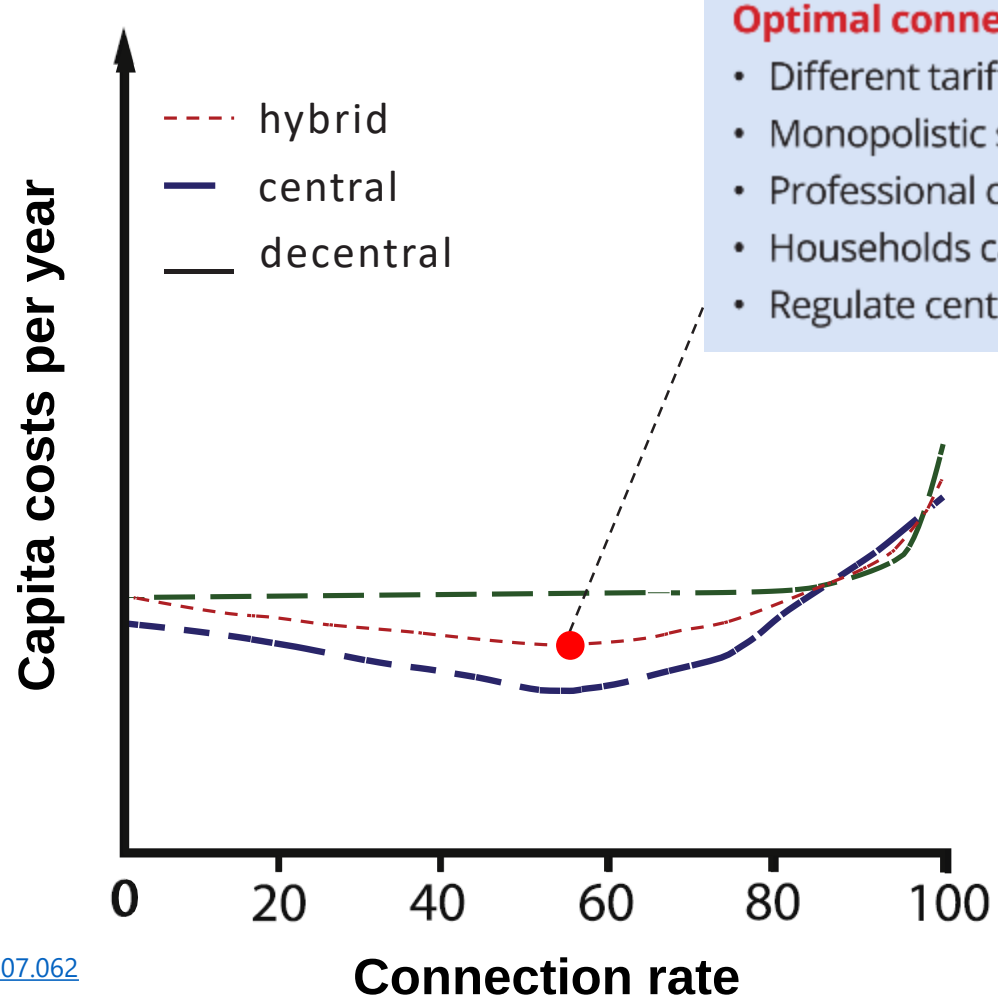


Optimal connection rate

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

Source: Eggimann et al. (2016): https://doi.org/10.1016/j.watres.2016.07.062

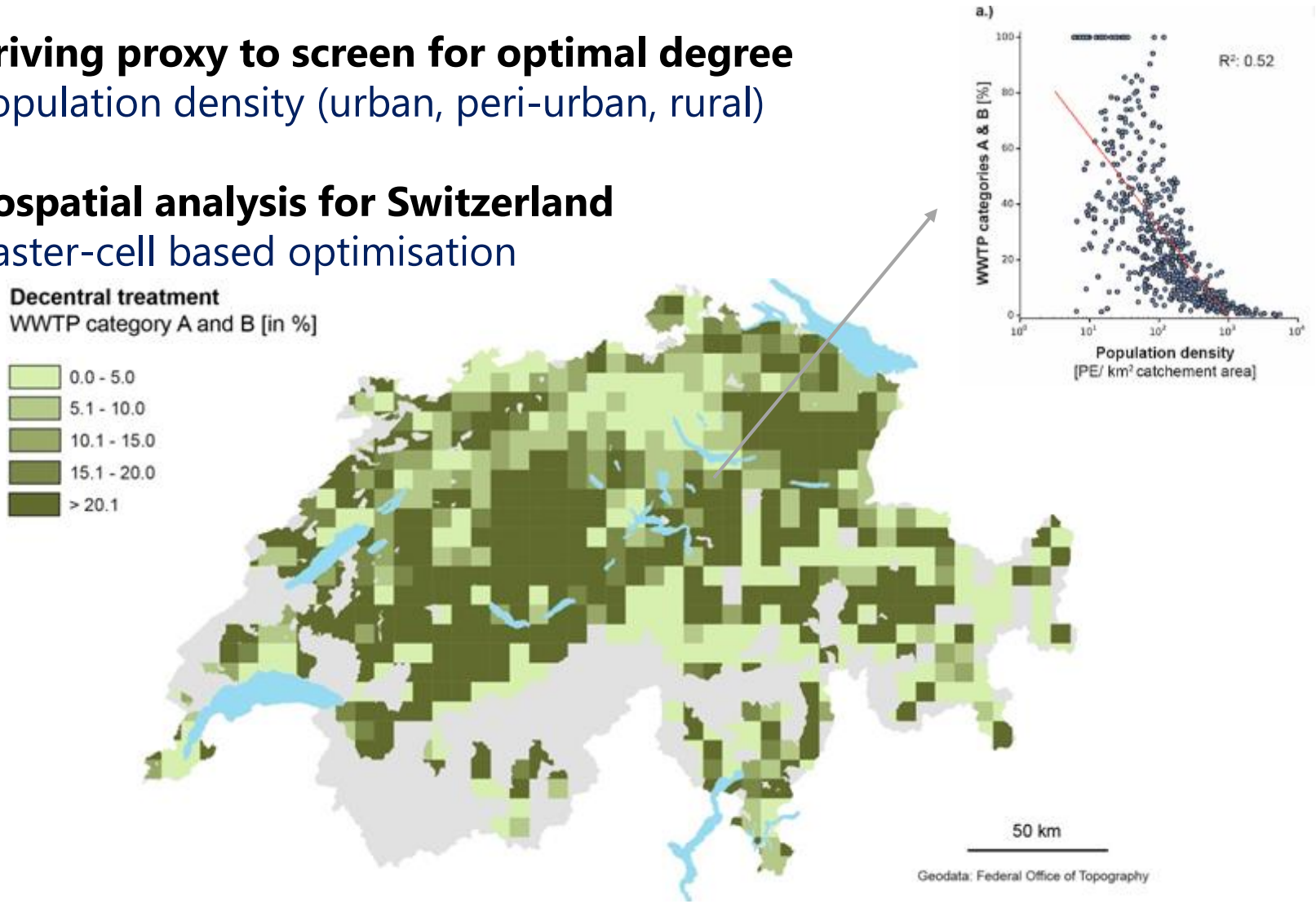
II: Entry markets

Modular market potential

Screening analysis for estimating markets

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

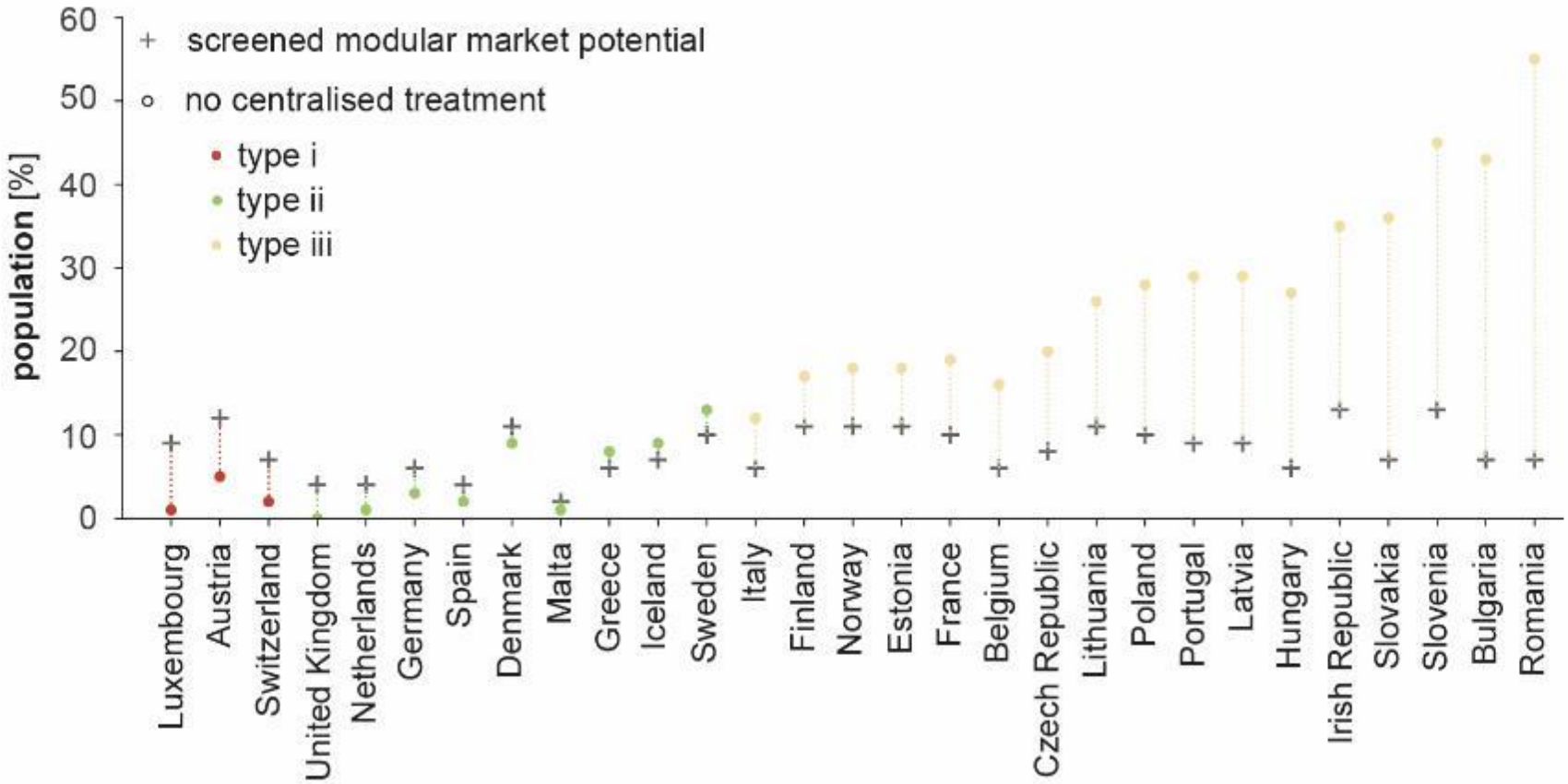
- **Geospatial analysis for Switzerland**
  Raster-cell based optimisation



Source: Eggimann et al. (2018): https://doi.org/10.1016/j.landusepol.2018.07.031

European market potentials for modular treatment

Market potential of modular infrastructure concepts on a European scale



Source: Eggimann et al. (2018): https://doi.org/10.1016/j.landusepol.2018.07.031

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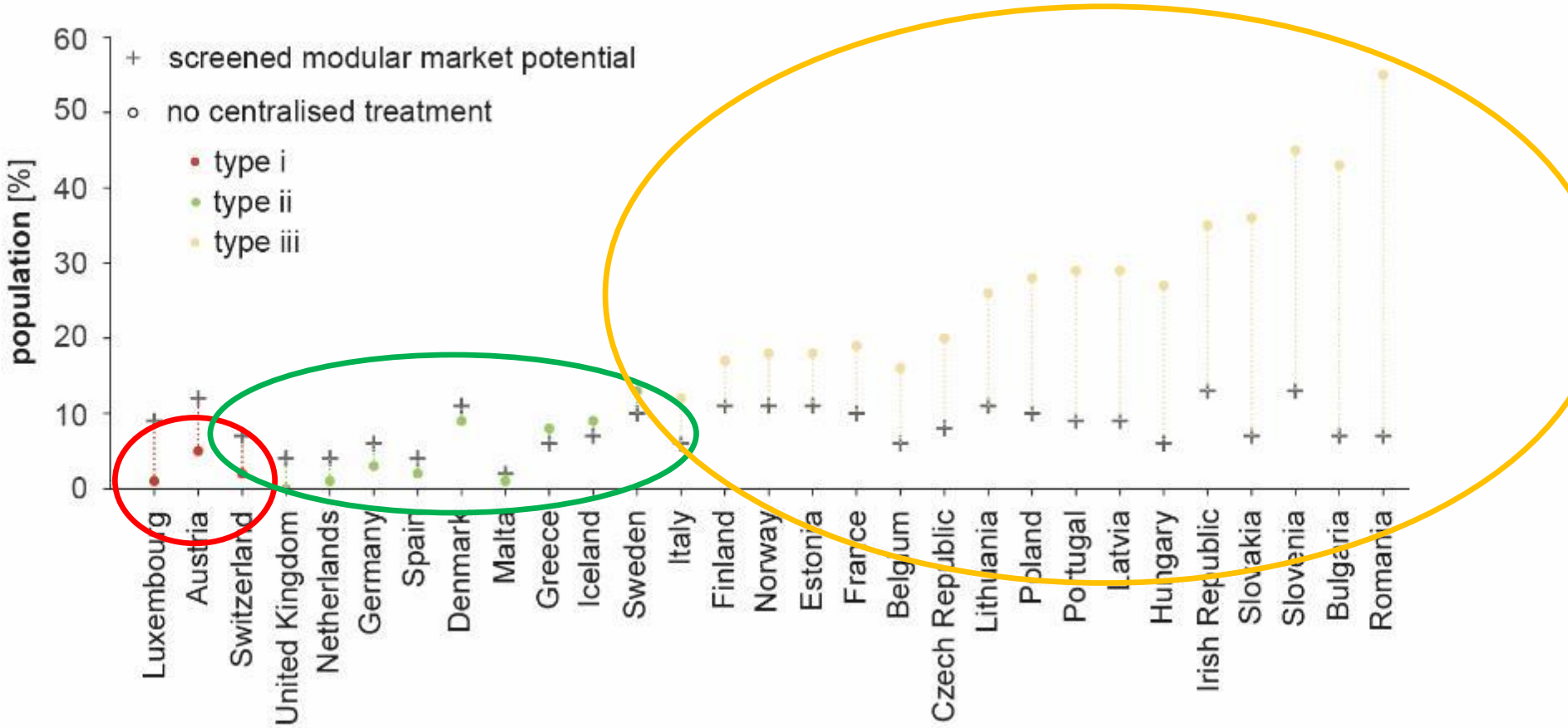

Source: Eggimann et al. (2018): https://doi.org/10.1016/j.landusepol.2018.07.031

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European market potentials for modular treatment

Table 4
Population density-based screened market potential for small modular wastewater management systems in Europe and current population percentages without central treatment (Eurostat, 2017).

	Extrapolated small modular market potential		Currently no central treatment	Annual number of small modular treatment units with Swiss plant distribution (88% category A, 12% category B)		
Country	*Population [%]*	*Population [PE]*	*Population [%]*	*10 PE [#]*	*110 PE [#]*	*Total [#]*
France	10	5,689,000	19	15,219	2,064	17,284
Germany	6	5,050,000	3	13,510	1,832	15,343
Poland	10	3,858,000	28	10,321	1,400	11,721
Italy	6	3,428,000	12	9,170	1,244	10,414
United Kingdom	4	2,703,000	0	7,230	980	8,211
Spain	4	2,098,000	2	5,613	761	6,375
Romania	7	1,510,000	55	4,040	548	4,588
Czech Republic	8	891,000	20	2,384	323	2,708
Sweden	10	887,000	13	2,374	322	2,696
Portugal	9	851,000	29	2,276	309	2,584
Austria	12	846,000	5	2,264	307	2,571
Netherlands	4	722,000	1	1,930	262	2,192
Hungary	6	698,000	27	1,867	253	2,120
Belgium	6	668,000	16	1,787	242	2,029
Greece	6	664,000	8	1,776	241	2,017
Finland	11	618,000	17	1,654	224	1,879
Irish Republic	13	561,000	35	1,500	203	1,703
Denmark	11	527,000	9	1,411	191	1,602
Switzerland	7	525,000	2	1,405	191	1,596
Norway	11	520,000	18	1,391	189	1,580
Bulgaria	7	511,000	43	1,368	186	1,553
Slovakia	7	408,000	36	1,091	148	1,239
Lithuania	11	345,000	26	922	125	1,047
Slovenia	13	270,000	45	723	98	821
Latvia	9	191,000	29	511	69	580
Estonia	11	128,000	18	342	46	388
Luxembourg	9	42,000	1	113	15	129
Iceland	7	18,000	9	47	6	54
Malta	2	7,000	1	19	3	22
Total	–	**35,234,000**	–	**94,260**	**12,785**	**107,045**

Source: Eggimann et al. (2018): https://doi.org/10.1016/j.landusepol.2018.07.031

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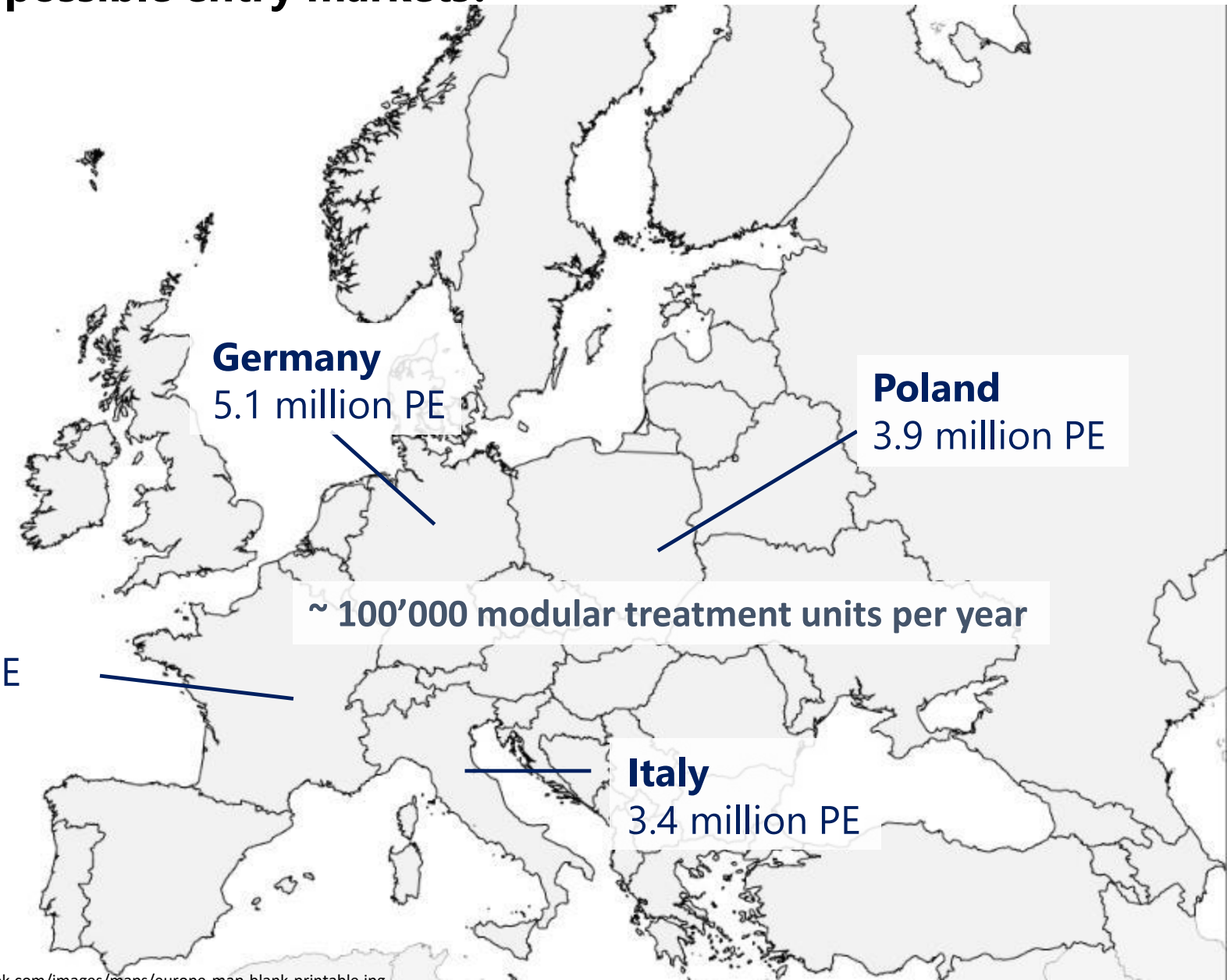
Where are possible entry markets?



http://www.worldatlasbook.com/images/maps/europe-map-blank-printable.jpg

Concluding remarks

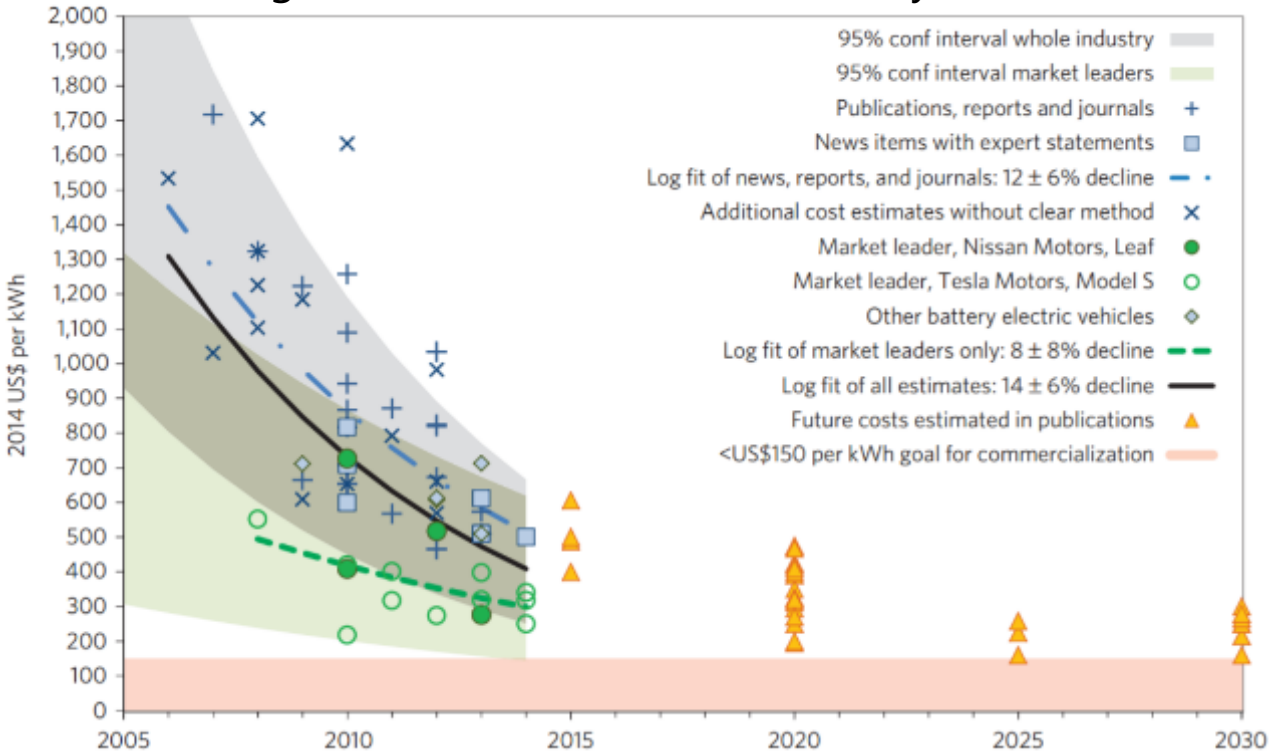
Concluding remarks

- 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 countires (e.g UK, Germany) could focus on technological upgrading of existing decentral treatment system with more sustainble alternatives
  - Some countries (e.g. Hungary, Portugal) should invest in «system hybridization»

Transition towards new degrees of centralization

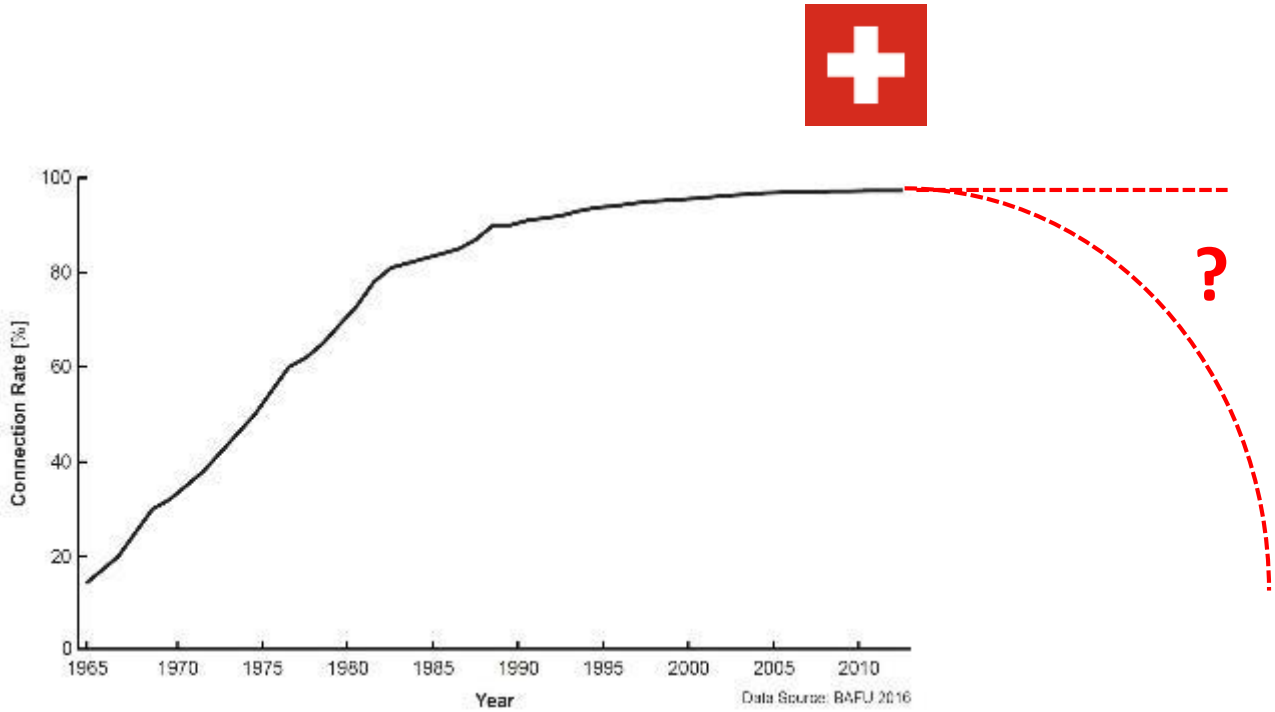
Economies of learning, cost of packaged treatment plants, SBR membranes…

Falling costs for batteries for electricity vehicles



Source: Nykvist and Nilsson (2015)

Transition towards new degrees of centralization



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- Larsen, T., Hoffmann, S., Lüthi, C., Truffer, B., Maurer, M. 2016. Emerging solutions to the urban water challenges of an urbanizing world. *Science* 352, (6288) 928 - 933. https://doi.org/10.0.4.102/science.aad8641

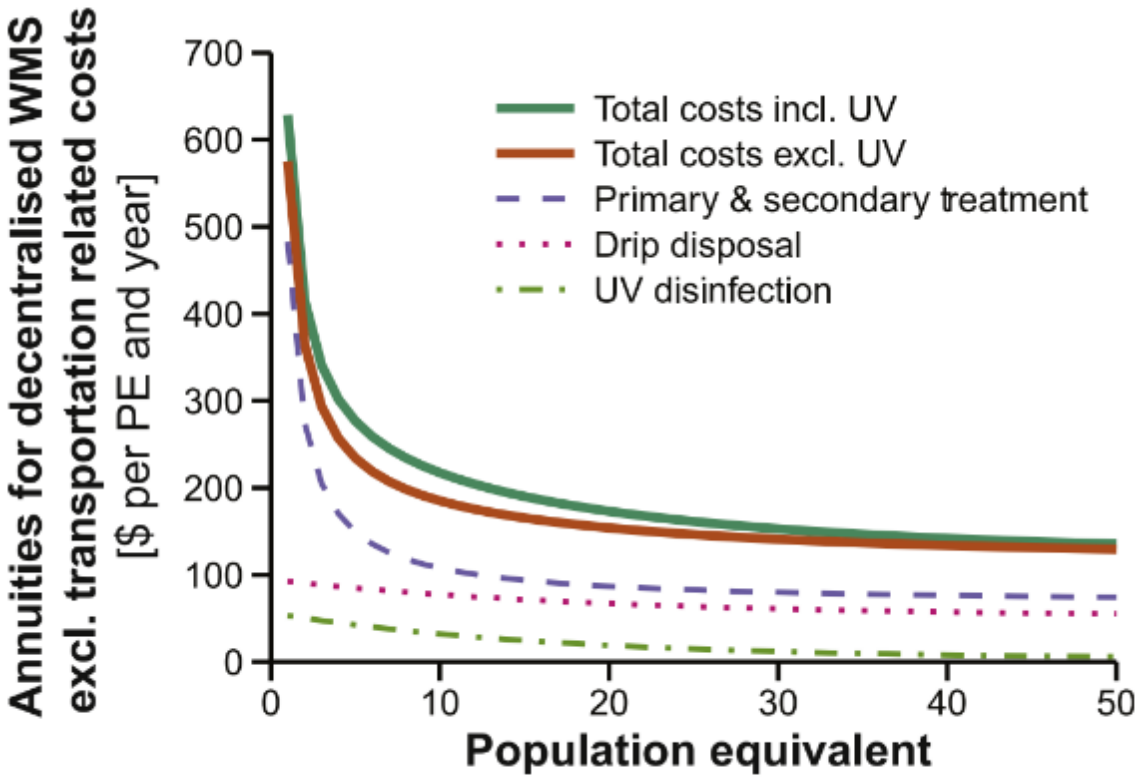

Fig. 6. Average treatment cost data for on-site WMS.

Eggimann et al. (2016b): https://doi.org/10.1016/j.watres.2016.07.062