COST-EFFICIENT REDUCTION OF POPULATION EXPOSURE TO PRIMARY $PM_{2.5}$ FROM RESIDENTIAL WOOD COMBUSTION IN FINLAND

Mikko Savolahti (1)

Niko Karvosenoja (1)

Ville-Veikko Paunu (1),

Kaarle Kupiainen (1),

(1) Finnish environment institute (SYKE)

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Outline

- Residential wood combustion (RWC) in Finland
- Finnish regional emission scenarios (FRES) model
- Studied reduction measures

- Results
  - Emission reductions by measure
  - Reductions in population exposure
  - Costs

- General observations about emission reduction goals & conclusions

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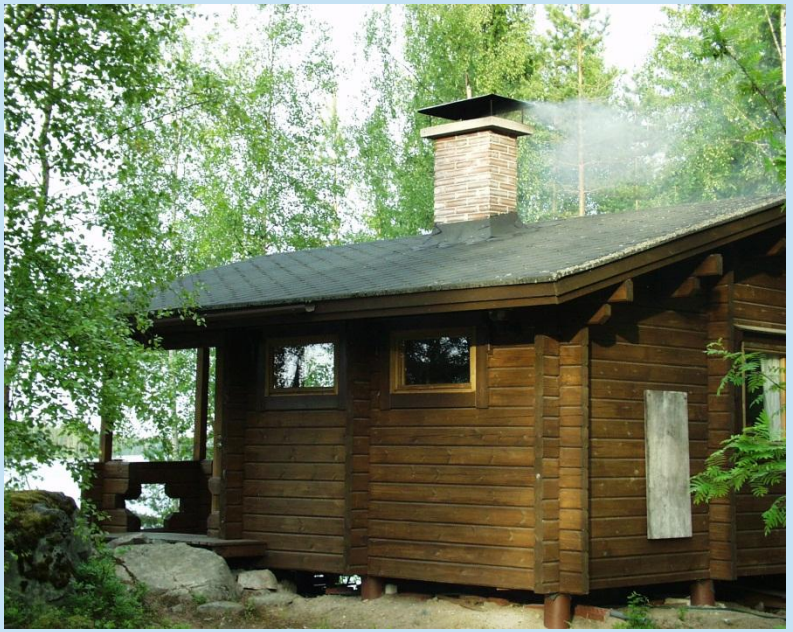
Residential wood combustion in Finland 1/3

- Approximately 2 million small-scale wood-burning devices + 1 million sauna stoves
- Masonry heaters and sauna stoves common
- Accounts for 40% of Finnish $PM_{2.5}$ emissions and 55% of BC emissions (2010)
- Currently no emission regulation



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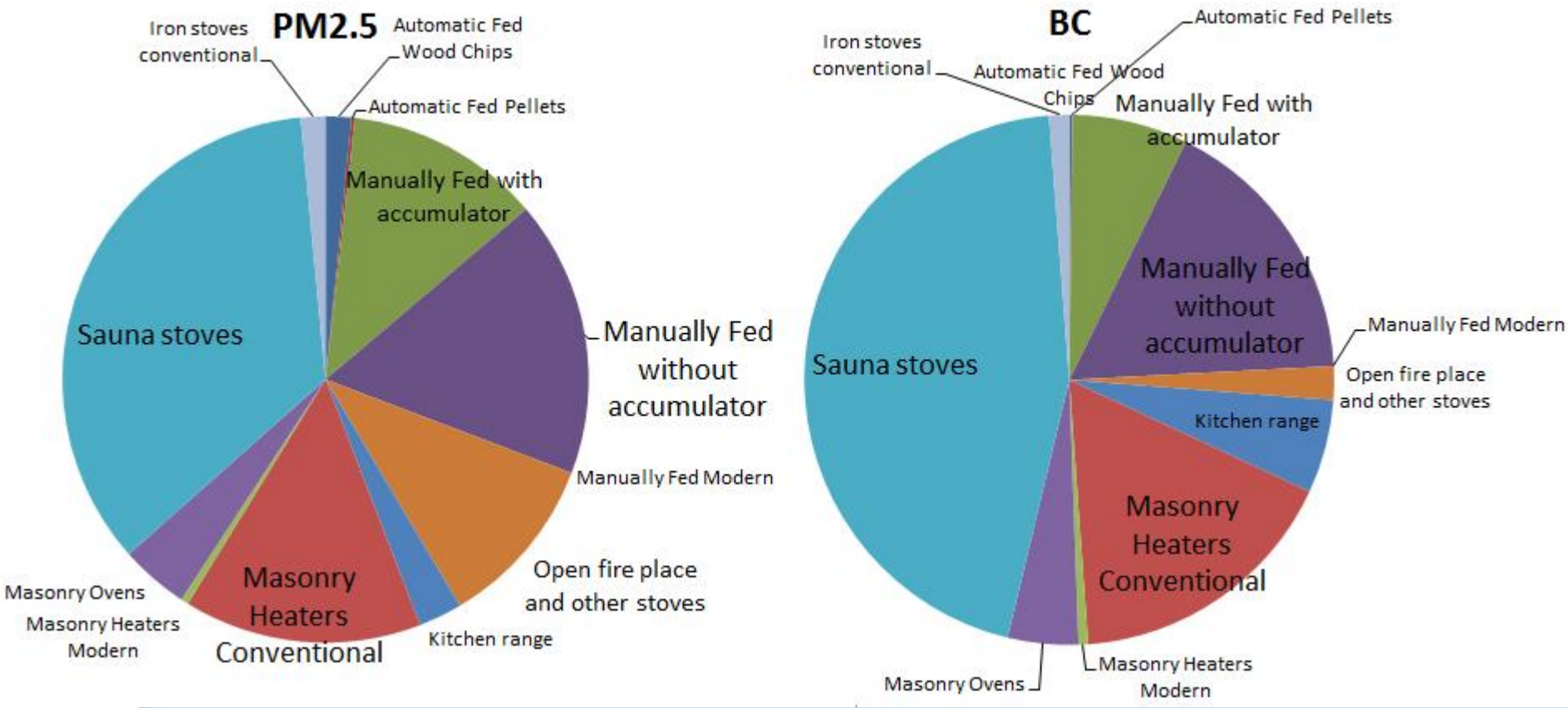
Residential wood combustion in Finland 2/3



Total emissions by subsector in 2010

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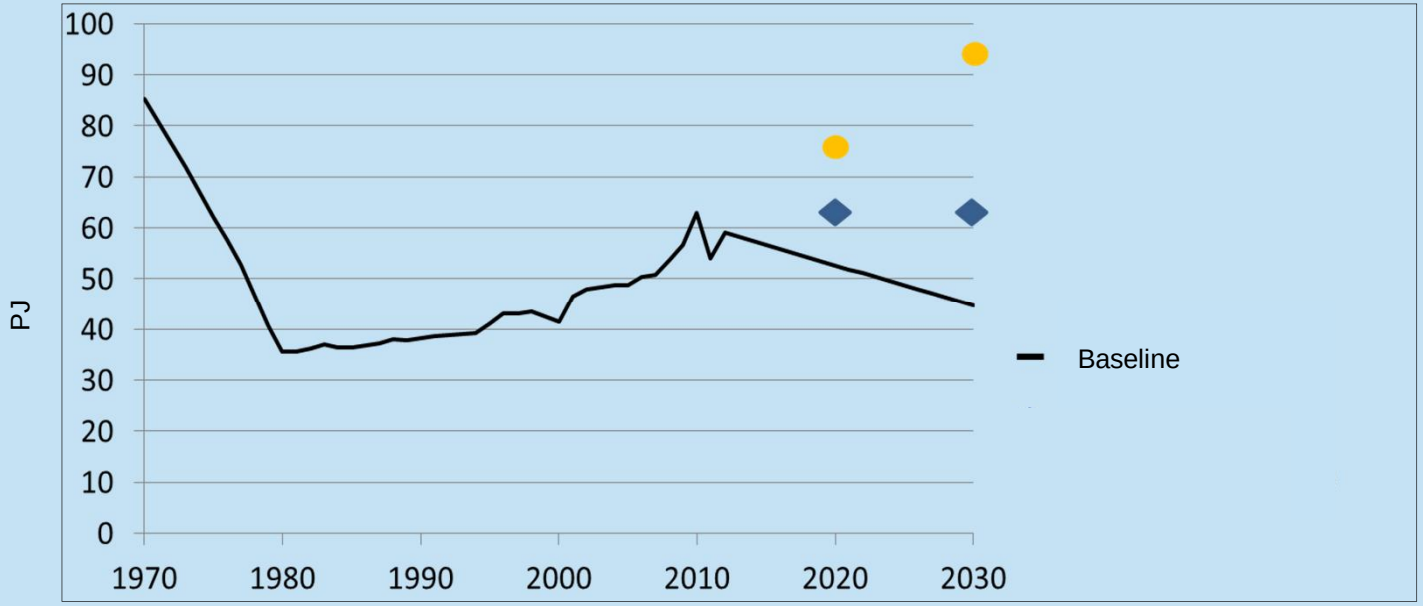
Residential wood combustion in Finland 3/3

- Activity has been steadily increasing, and the rate has accelerated in the last decade
- It is assumed to start declining in the national Energy strategy, but the reality might be different



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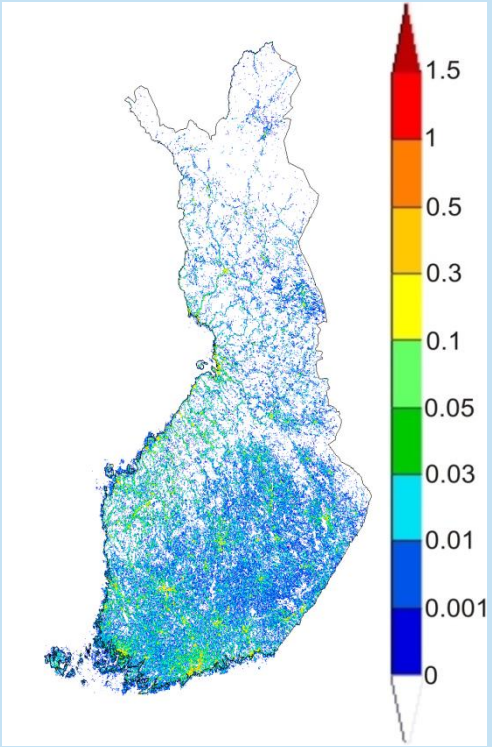
FRES (Finnish Regional Emission Scenarios) model

- **Comprehensive and congruent calculation for primary PM and gases**
- Aggregation: 154 sectors, 15 fuels (GAINS compatible)
- Large point sources (>200),
- Small point sources (> 200),
- Area emissions (1 × 1km2)
- Dispersion with s-r matrices (10 × 10km2 and 1 × 1km2)
- Several emission heights
- Databases of population and critical loads
- LRT from EMEP



BC emissions from RCW [ton/a]

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FRES model, RWC calculation parameters

- Emission factors (BC, OC, CO, CH4 & VOC) for different heaters
  - 9 stove categories, 5 boiler types
  - Reduction efficiencies of ESPs
- Average lifetime of appliances
- Costs (equipment, fuel, maintenance, education)
- Profile of combustion practices

	Share of profile	Share of SC
Accomplished user	25 %	0 %
Average user	60 %	5 %
Problem user	15 %	50 %
Average over profiles		**10.5%**

- Spatial allocation of emissions to 250m x 250m grid. Wood use in residential building according to
  - Primary heating method and residential area type
  - Latitude
  - Based on national housing register and questionnaires

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Ecodesign directive for RWC

- Proposed to be fully in force by 2022
- Sets emission factor limits for PM, OGC, CO and NOx emissions as well as requirements for energy efficiency
- Covers new appliances in the market
  - Solid fuel space heaters (<50kW) – Lot 20
  - Solid fuel boilers (<500kW) – Lot 15
- Doesn't cover (e.g.)
  - Heaters for non-woody biomass combustion
  - Heaters for outdoors
  - Stoves that are not factory assembled or provided as prefabricated components
  - Sauna stoves

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Other measures to reduce emissions

- National legislation for sauna stoves, similar to Ecodesign
  - Only modern sauna stoves sold from 2022
  - Assumed 50% fewer emissions
- Influencing the combustion habits of stove users by informational campaigns
  - Assumed 50% less poor combustion in all stoves
- Additional measures for boilers
  - End-of-pipe technologies – installing ESPs (80% removal efficiency)
  - Banning the use of existing inefficient appliances – installing accumulator tanks to old log boilers without one

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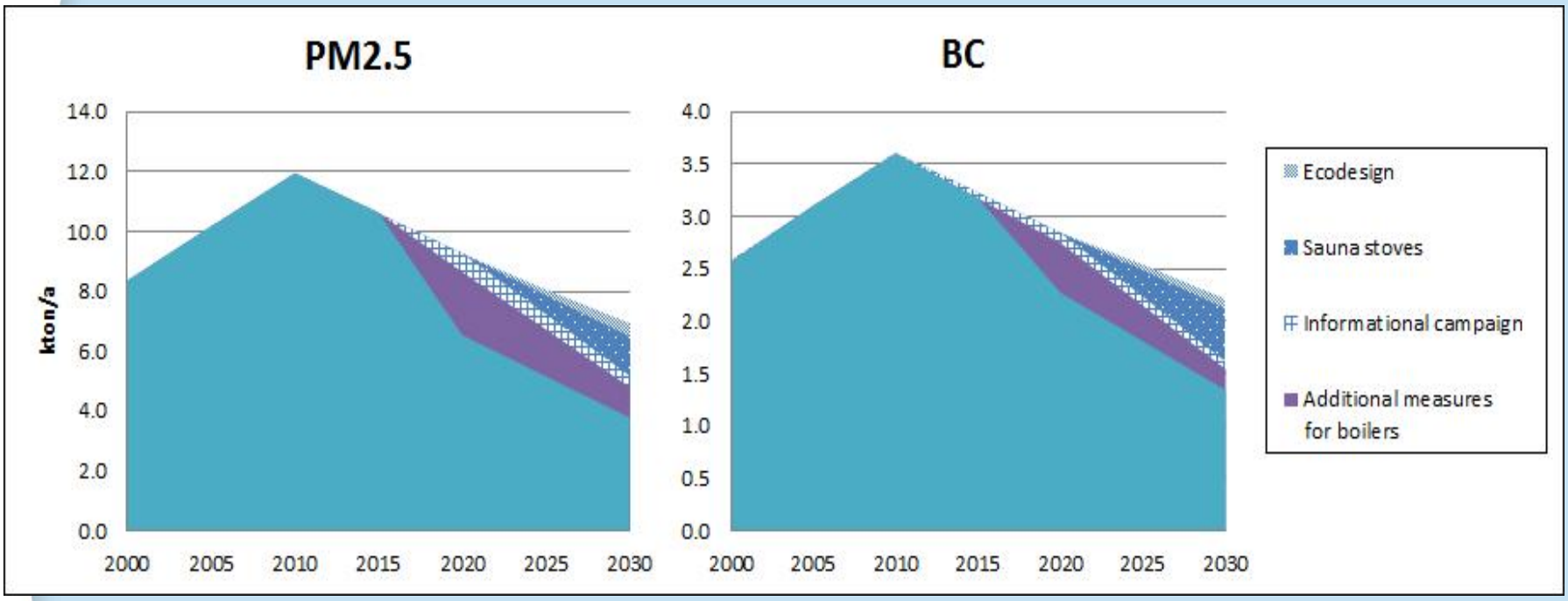
RWC emission reductions in 2030 (baseline wood consumption)



- 6/4% reductions with Ecodesign, 45/40% reductions with MFR
- 60% emission reduction in RWC, should the appliance stock modernization be complete by 2030
- MFR reductions would account for 17% and 31% of total estimated PM2.5 and BC emissions in Finland

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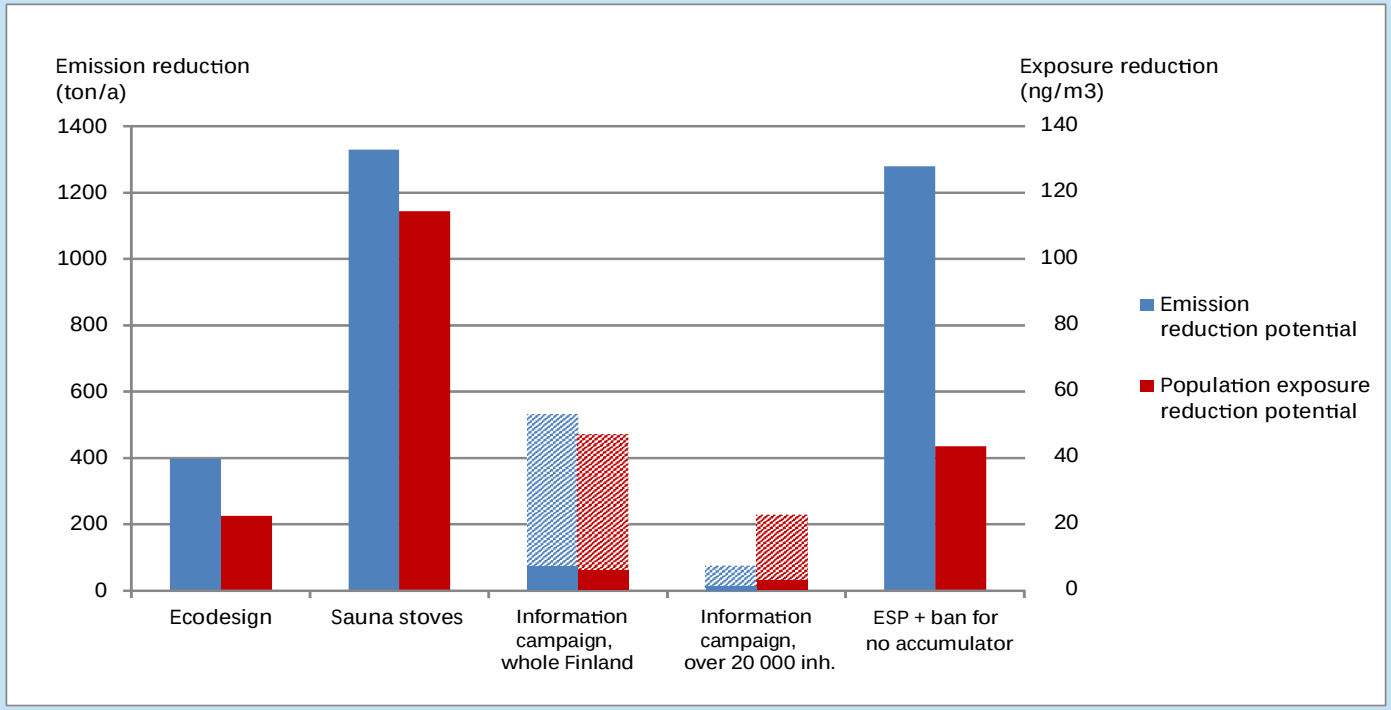
Reduction of population exposure with RWC measures



- Measures for sauna stoves reduce efficiently both emissions and population exposure
- Information campaigns efficient for population exposure reduction, especially when targeted to urban areas
- Measures for boilers inefficient in population exposure reduction

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Cost efficiency of PM2.5 reductions

Measures, PM2.5 reduction potentials and costs in 2030

Measure	Reduction potential (of total RWC emissions)	Cost M€/a	Cost efficiency (reduced emissions) [k€/ton]	Cost efficiency (reduced health impacts) [k€/(ng/m3)]
Ecodesign	- 6 %	14	35	620
Legislation for sauna stoves	- 20 %	22	17	190
Informational campaign	< - 8 %	0.3	< 6	< 64
ESPs to boilers and banning the use of log boilers without an accumulator tank	- 17 %	44	29	850

- Legislation on new appliances slow to effect, but it's a step into the right direction

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Cost efficiency of BC reductions

Measures, PM2.5 reduction potentials and costs in 2030

Measure	Reduction potential (of total RWC emissions)	Cost M€/a	Cost efficiency (reduced emissions) [k€/ton]	Cost efficiency (reduced climate impact) [€/t CO2 –eq]
Ecodesign	- 4%	14	150	175
Legislation for sauna stoves	- 23 %	22	43	53
Informational campaign	< - 3 %	0.3	< 37	4
ESPs to boilers and banning the use of log boilers without an accumulator tank	- 9 %	44	150	275

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General observations about emission reduction goals

- Priority in reducing the impacts instead of just emissions
  - Spatial assessment of emission sources
  - Finnish BC emissions matter mostly in winter, according to recent studies
  - Reducing summertime emissions in sparsely populated areas not effective for achieving environmental or health benefits

- This needs to be taken into account when deciding the most feasible and effective measures

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Conclusions

- RWC is the major source of PM2.5 and BC emissions in Finland, and is currently unregulated
- Although challenges remain, Ecodesign is definitely a step into the right direction
- Slow to effect because of the long lifetime of typical appliances
- Sauna stoves the biggest source, needs to be addressed
- Increasing stove users' awareness of the negative environmental impacts of RWC is the most cost-effective and readily-usable measure
- Reduction of impacts needs more research

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Thanks for your interest

- Contact Info
  - Mikko Savolahti
  - mikko.savolahti@ymparisto.fi
  - Finnish Environment Institute
  - Helsinki

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