Tuulivoimalla päästövähennyksiä maankäyttöön

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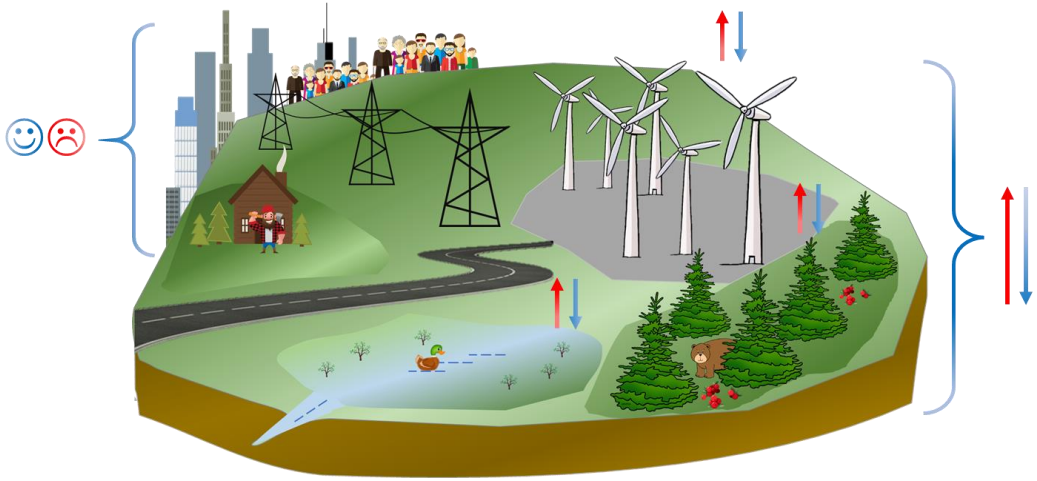
Nappaa hiilestä kiinni
MAANKÄYTTÖSEKTORIN ILMASTORATKAISUT

ILMASTOVIISAS HIILENKIERTO
LUKE

Sisältö

- Tuulivoimalla saavutettavat päästövähennykset
  - tähän asti ja tulevaisuudessa?

- Tuulivoimarakentamisen aiheuttama metsäkato
  - vaikutus nieluihin



Impact of Wind Power on GHG Emissions

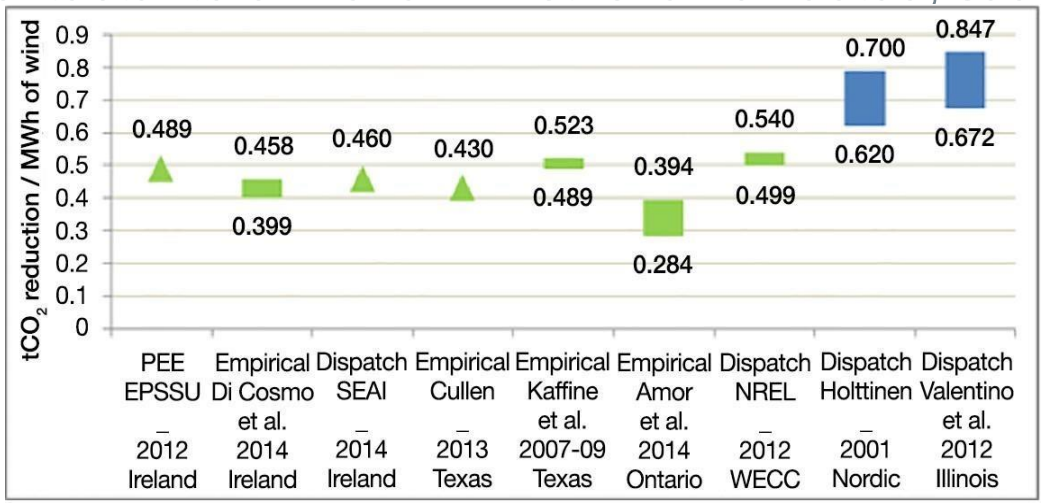
Tomi Lindroos, Antti Lehtilä VTT
Hannele Holttinen Recognis Oy

LandUseZero WP2

Tuulivoiman vaikutus kasvihuonekaasupäästöihin

Paljonko vähentää päästöjä?

- Yleensä on arvioitu paljonko tuulivoimalla tuotettu sähkö vähentää muuta sähköntuotantoa ja sähköntuotannon päästöjä
  - noin 300 g/kWh kun korvataan kaasuvoimaa ja noin 900 g/kWh kun korvataan hiilivoimaa
  - riippuen mikä sähköntuotanto on kunakin hetkenä korvautuu, saadaan laskettua päästösäästö

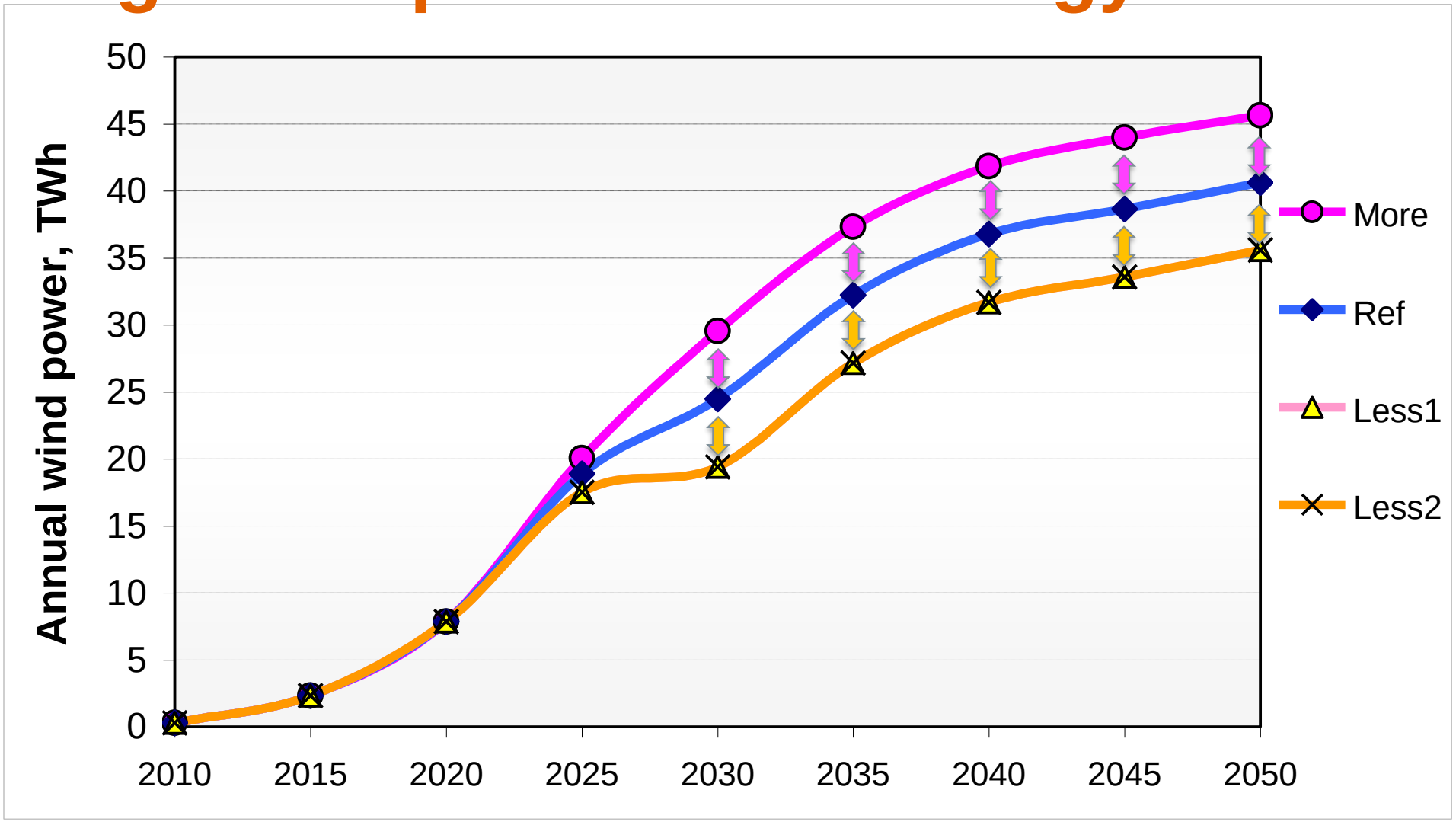


- Tulevaisuuden hiilivapaassa sähköjärjestelmässä tuulivoima korvaa sähköntuotannon sijaan sähköistymisen kautta tulevaa kulutusta
  - Tarkasteltava sähköjärjestelmän lisäksi kaikkia energiasektoreita, esim sähköautot/öljy.

TIMES model cases to study impact of 5 TWh/a wind energy

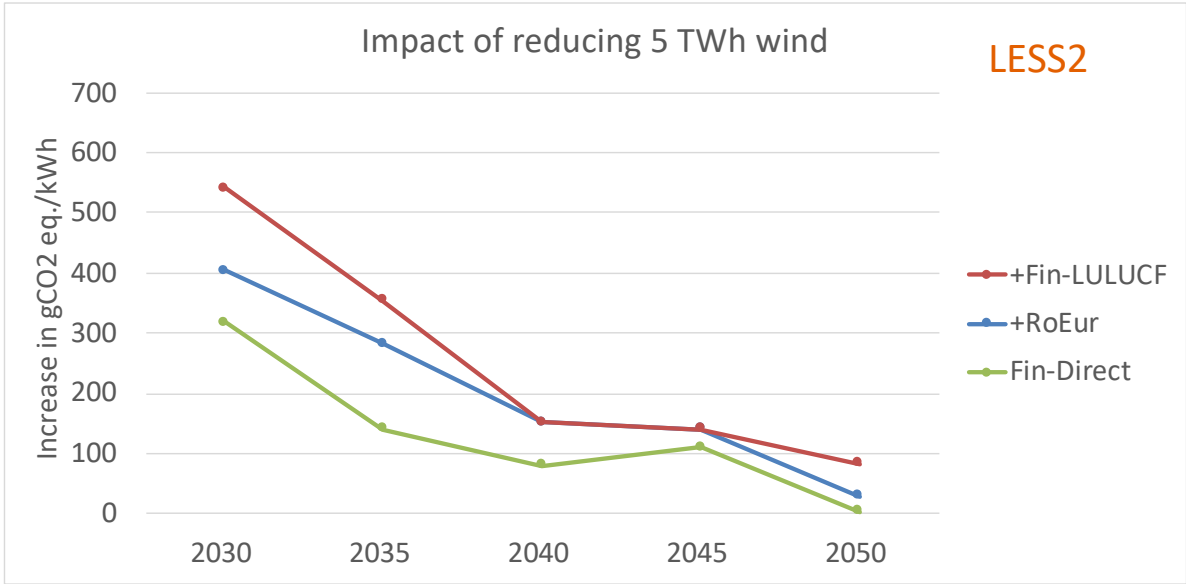
- Reference Case. 2030…2050:
  - Moderate EU-ETS price trajectory up to 80€ /tCO2 in 2050 no Hanhikivi nuclear plant
  - No binding emission targets for Finland or EU
- Case More: Same as Reference except for:
  - More wind power (5 TWh) for the studied 2030, 2035, 2040, 2045, 2050
  - Net exports of electricity limited to Reference levels
- Case Less1: Same as Reference except for:
  - Less wind power (5 TWh) for the studied 2030, 2035, 2040, 2045, 2050
  - No limit on electricity net imports (impacts may freely leak out of Finland)
- Case Less2: Same as Reference except for:
  - Less wind power (5 TWh) for the studied 2030, 2035, 2040, 2045, 2050
  - Net imports of electricity limited to reference

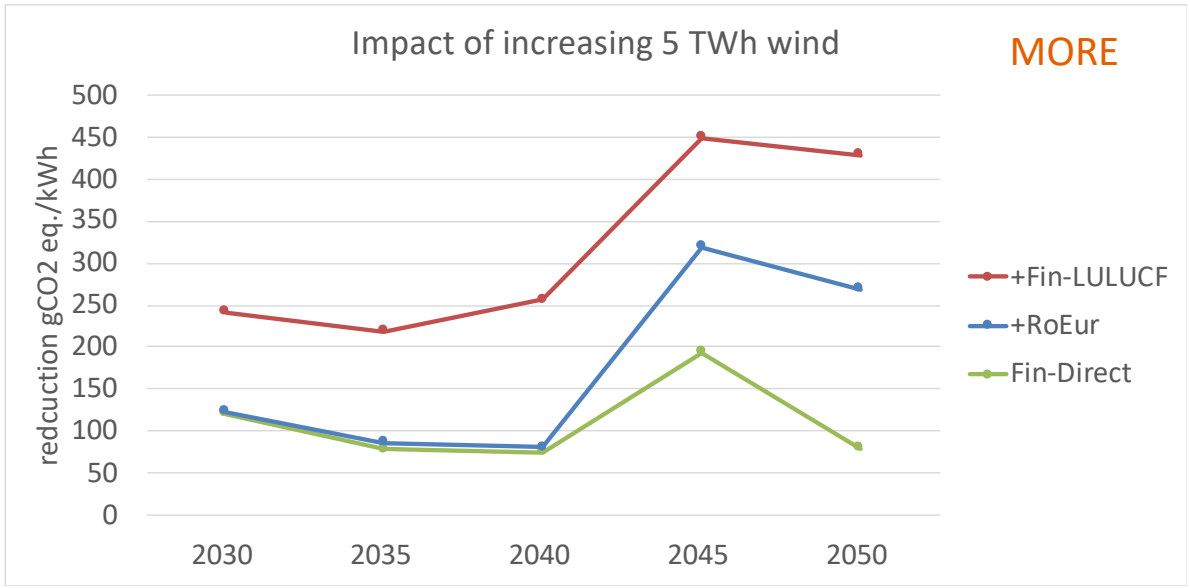
Marginal impact of wind energy assessed



NOTE – reference scenario has quite much wind – this positive impact is not included. Having less wind in Ref would give higher impacts for wind. Having more wind in Ref would give less benefits.

Wind impacts on emissions: FIN, RoEUR and LULUCF (through replacing wood chips)



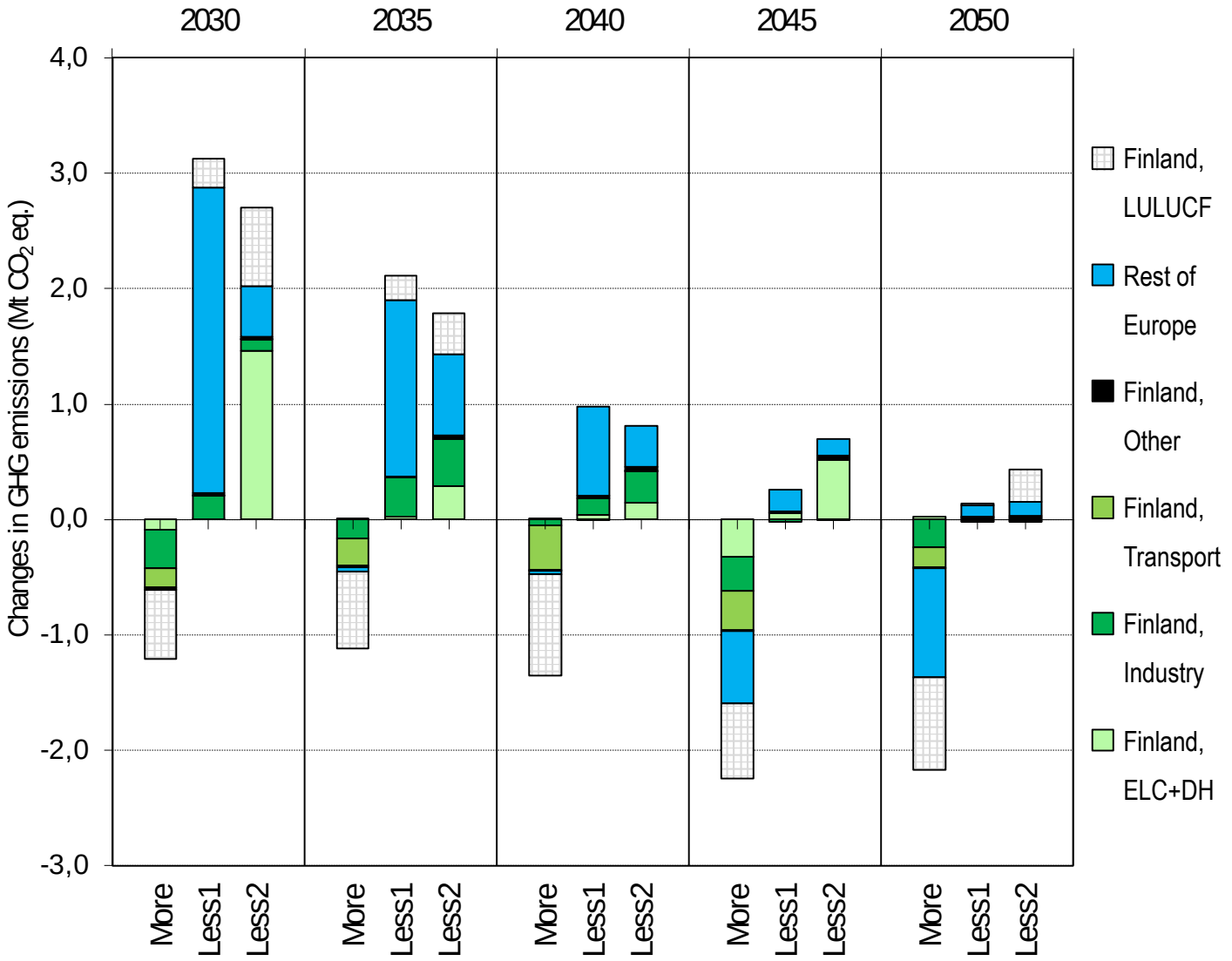


- More and Less scenarios are not symmetrical. Modest fossil use and electrification in reference: can use extra wind to electrify but not take away electrification when less wind; can increase fossils when taking away wind but little fossils to replace in generation when adding wind
- Effect on emissions reduction due to additional electrification appears in 2045 (industry and transports, More scenario)

- Fin-LULUCF is the wood chip use impact on carbon sink, estimated with 55 g/MJ (50% of direct wood CO2 emission 110 g/MJ)

- Some impacts in Rest of Europe (RoEur) even when limiting net electricity trade to Reference levels (the limits were on the annual level only)

TIMES model results on changes in emissions for demand sectors



What number to use as wind impact gCO2equivalent/kWh wind?

At first – reduction in electricity generation: 350-610

With electrification 430-450

gCO2eq./kWh wind	2030	2035	2040	2045	2050	Average 2030-2050
More = adding 5TWh/a	120 (+120=240)	90 (+130 =220)	80 (+170=260)	320 (+130=450)	270 (+160=430)	**180 (+140=320)**
Less 2 = reducing 5 TWh/a	400 (+140=540)	280 (+70=350)	150 (+0=150)	140 (+0=140)	30 (+50=80)	**230 (+20=250)**
Less 1= benefits Rest of EU	560 (+50=610)	380 (+40=420)	190 (+0=190)	50 (+0=50)	20 (+0=20)	**240 (+20= 260)**

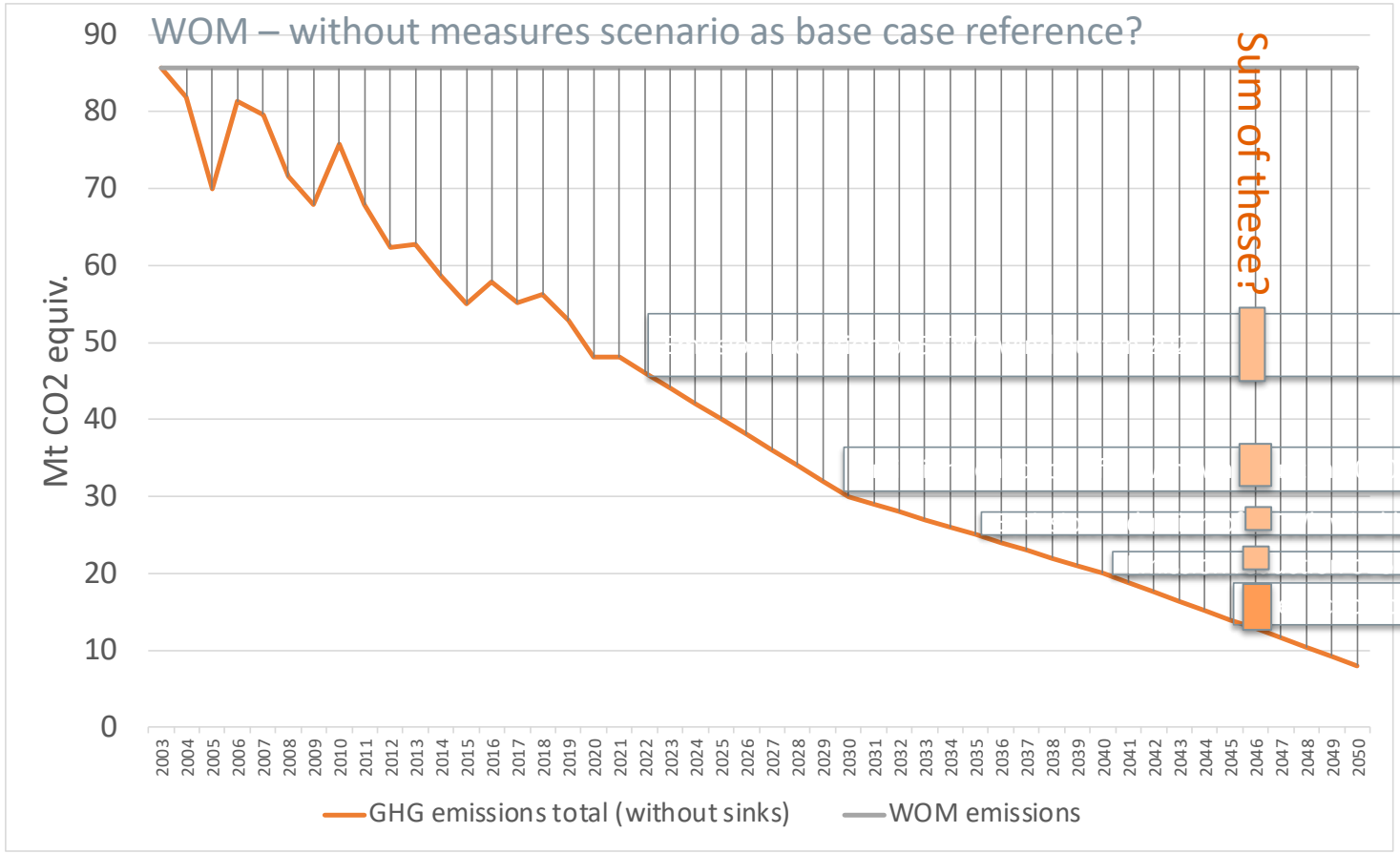
Impact on LULUCF estimated with penalty for biomass use (in parenthesis)

Average 250-320

Conclusions

- CO2 reductions in the electricity generation give first higher impact ('Less' scenarios results for 2030-35) reducing to less than 50 g/kWh in 2050.
  - Many other countries will have a gas back up for longer, giving more benefits up to 2040 - the European wide results ('Less1').
- Reducing emissions through electrification will increase the benefit of wind energy ('More' scenario results for years 2045-50).
- Impact on carbon sinks when wind energy replaces wood chips is considerable
  - Finland a special case here, other countries would not see impact on bioenergy

Discussion: what emission reduction should we use for impact of wind power built now –marginal impact or impact cumulated over years?



- New wind built each year will have a reduction impact – first decreasing and then increasing due to electrification (that could start already before 2045)
- cumulative impact from previous wind is also seen, and will be needed to keep the downward trend of emissions

WOM would be hard to calculate, a totally theoretical scenario stopping all wind power to today's levels

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Tuulivoiman vaikutus maankäytön nieluihin

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Photo: Erkki Oksanen/ Luke

Tuulivoiman vaikutus kasvihuonekaasupäästöihin

Paljonko aiheuttaa päästöjä?

- Tuulivoimaloiden rakentaminen aiheuttaa päästöjä
  - LCA analyysin perusteella noin 7 g/kWh – tämä ottaa huomioon että suuri osa rakenteista kierrätetään, esim kaikki metallit (terästorni, konehuone,..)
  - Kun sähkö- ja energiajärjestelmän päästöt pienenevät, myös tämä vaikutus pienenee
- Tuulivoimaloiden alta kaadetaan metsää
  - rakennusaikaisen vaikutuksen jälkeen jää noin 0,4 ha /voimala alue metsäkatoon
- Tuulivoimaloiden verkkoonliitäntä
  - liityntäjohto lähimpään 110/220/400kV verkkoon
  - jos useampia tuulipuistoja, voidaan käyttää samaa johtolinjaa

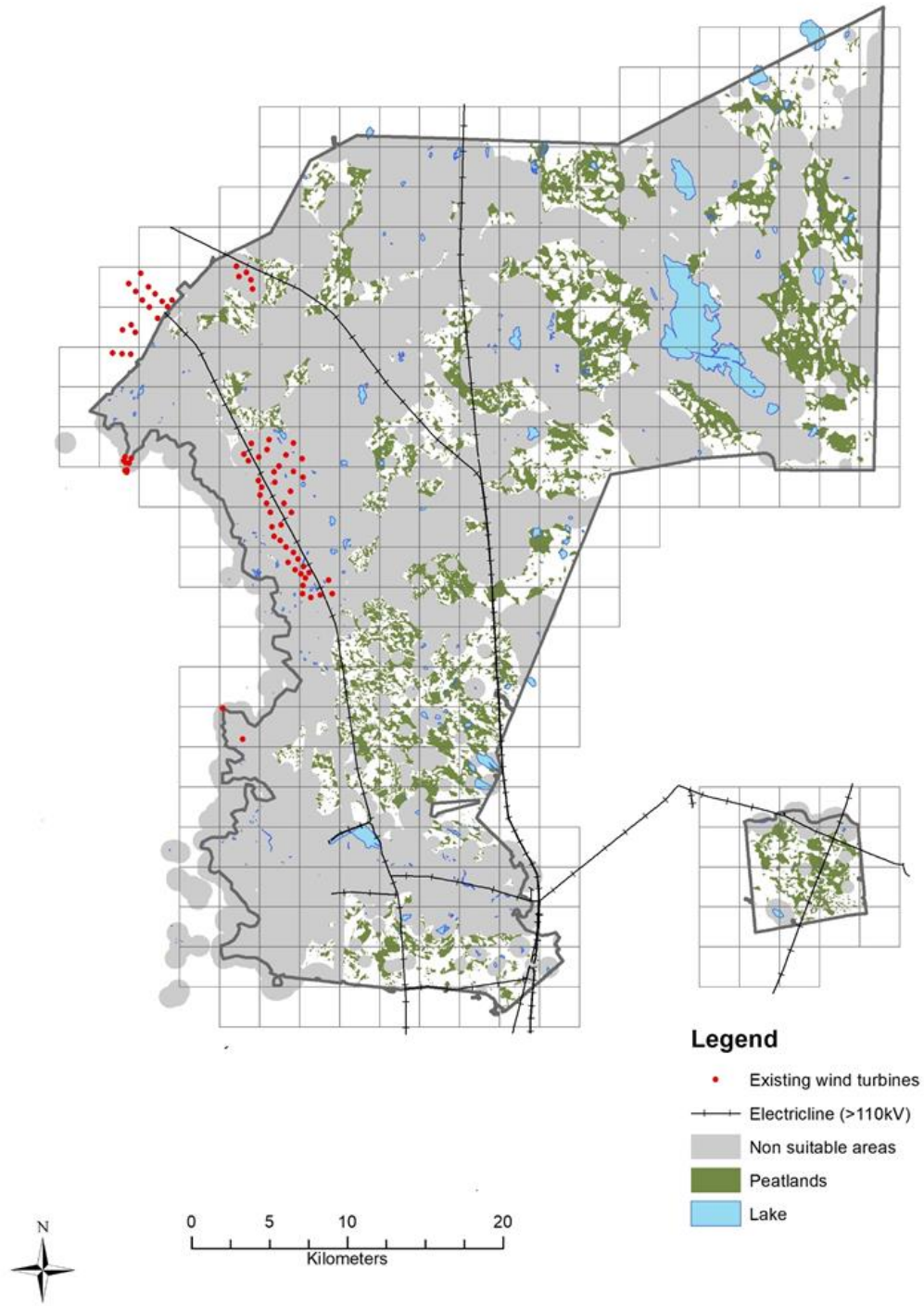
Tuulivoiman potentiaaliset alueet
Case Ii

Table 2. Land use restrictions and safety distances to roads, building, etc.

Safety distances for land uses	Distance for analysis	Reference
Residential building (NLS)	1000, 1500, 2000	used in this study
Leisure houses (NLS)	700, 1000, 1300	used in this study
Others facilities industrial, sport etc. (NLS)	300, 428	Seifert (2003)
Roads over 100km/h*	300, 335	Liikennevirasto (2012)
Roads other*	265, 315	Liikennevirasto (2012)
Railroads*	265, 315	Liikennevirasto (2012)
Nature protection areas	1000	Rinne et al. (2018)
Emergency landing strip	12000	Liikennevirasto (2012)
Weather radar	5000	OPERA II (2006)

* Railroad distance to wind turbines total height + 30m, roads total height + 30m,

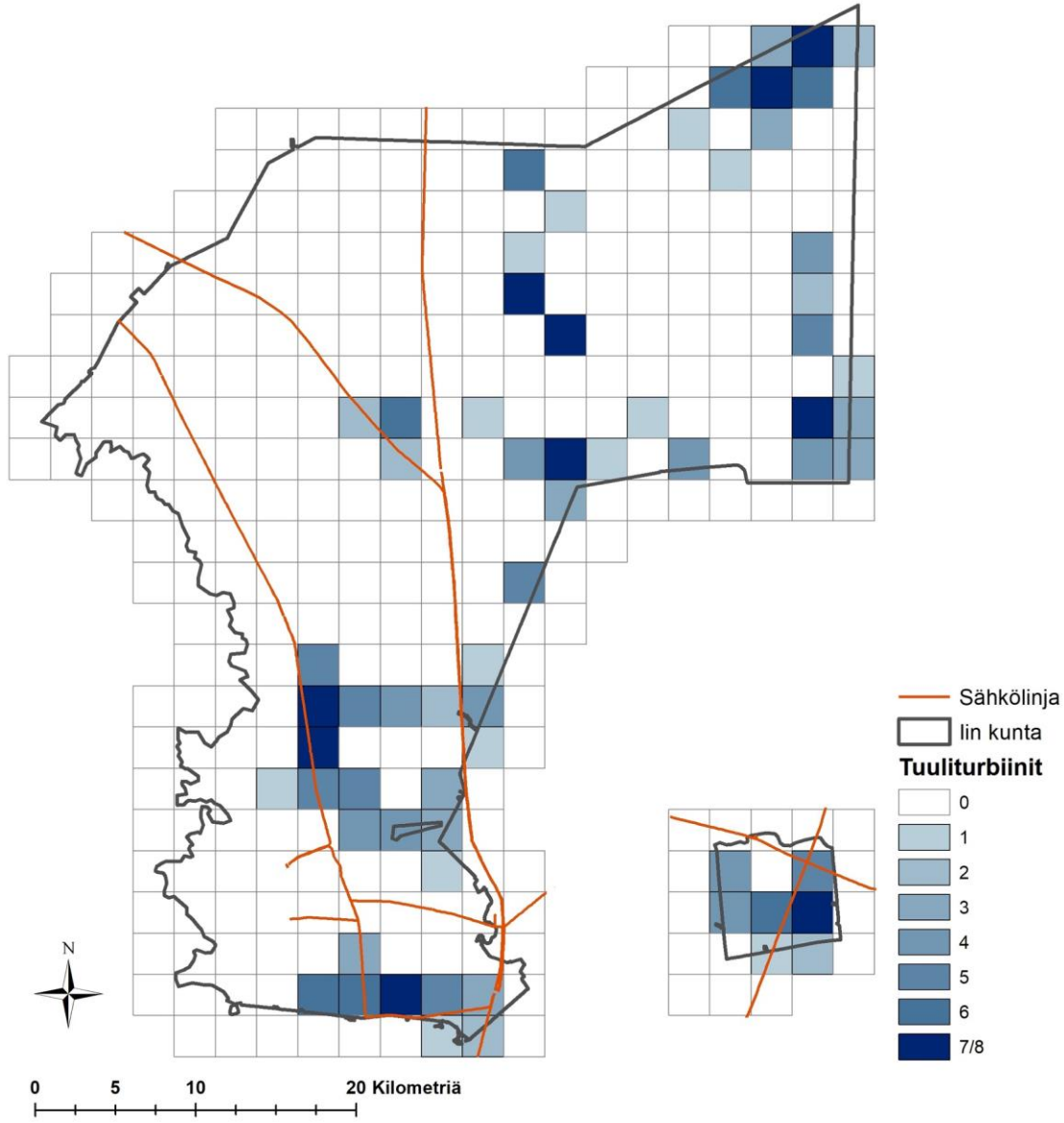
main roads >100km/h total height +50m (Liikennevirasto, 2012)



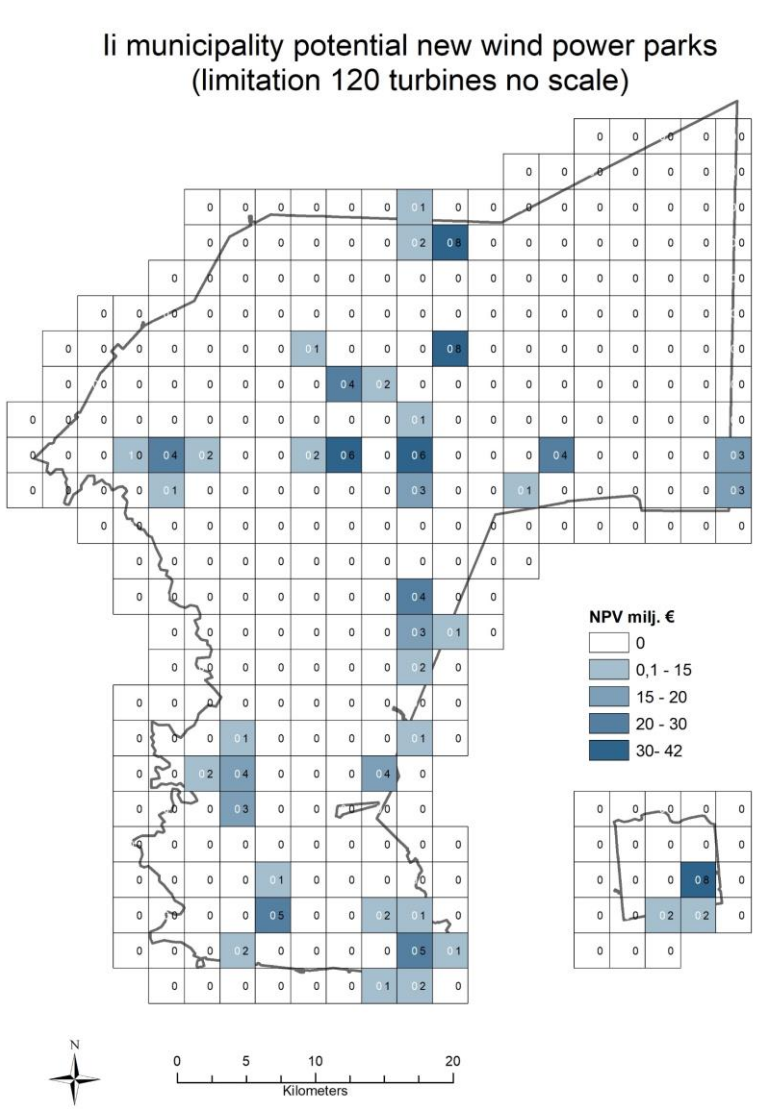
Tuulipotentiaali - Ii

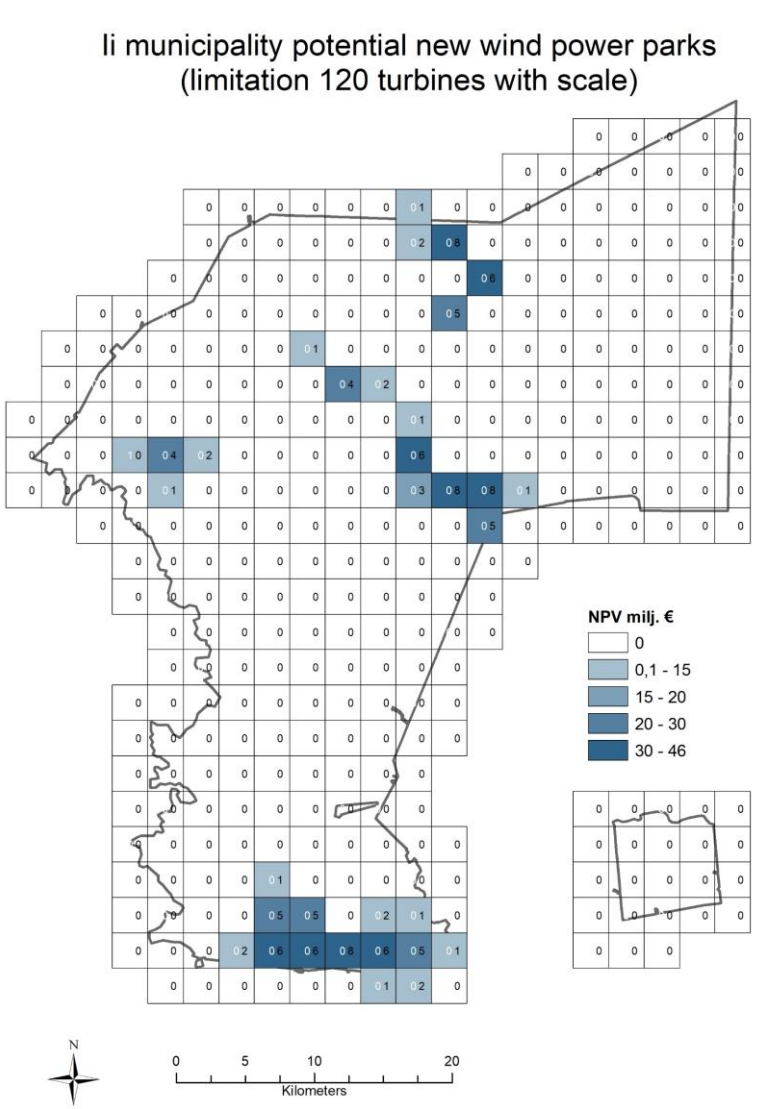
Basic case – all suitable grid points, with

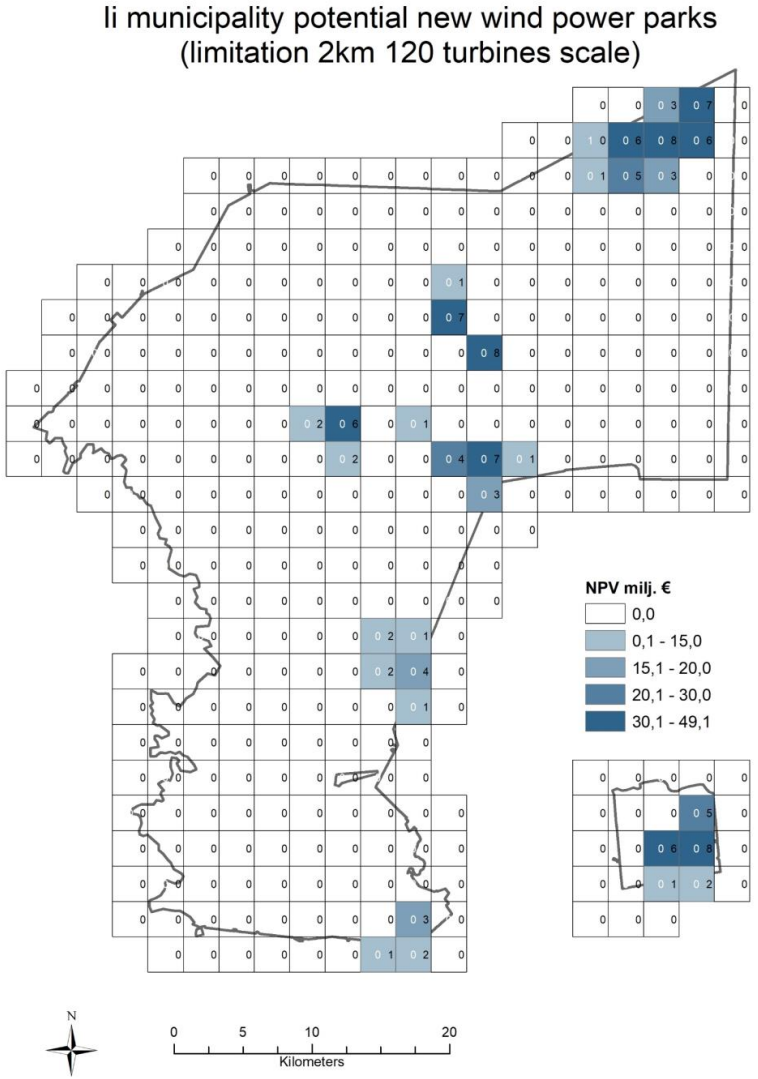
- minimum distance to residential buildings 2 km
- If a suitable area includes more than 50% peatland in a grid, then the grid is not suitable for wind power
- A minimum of 5 turbines on adjacent grids is required
- Scale effect on costs not included (same cost per MW whether 5 or 10 or 25 turbines)



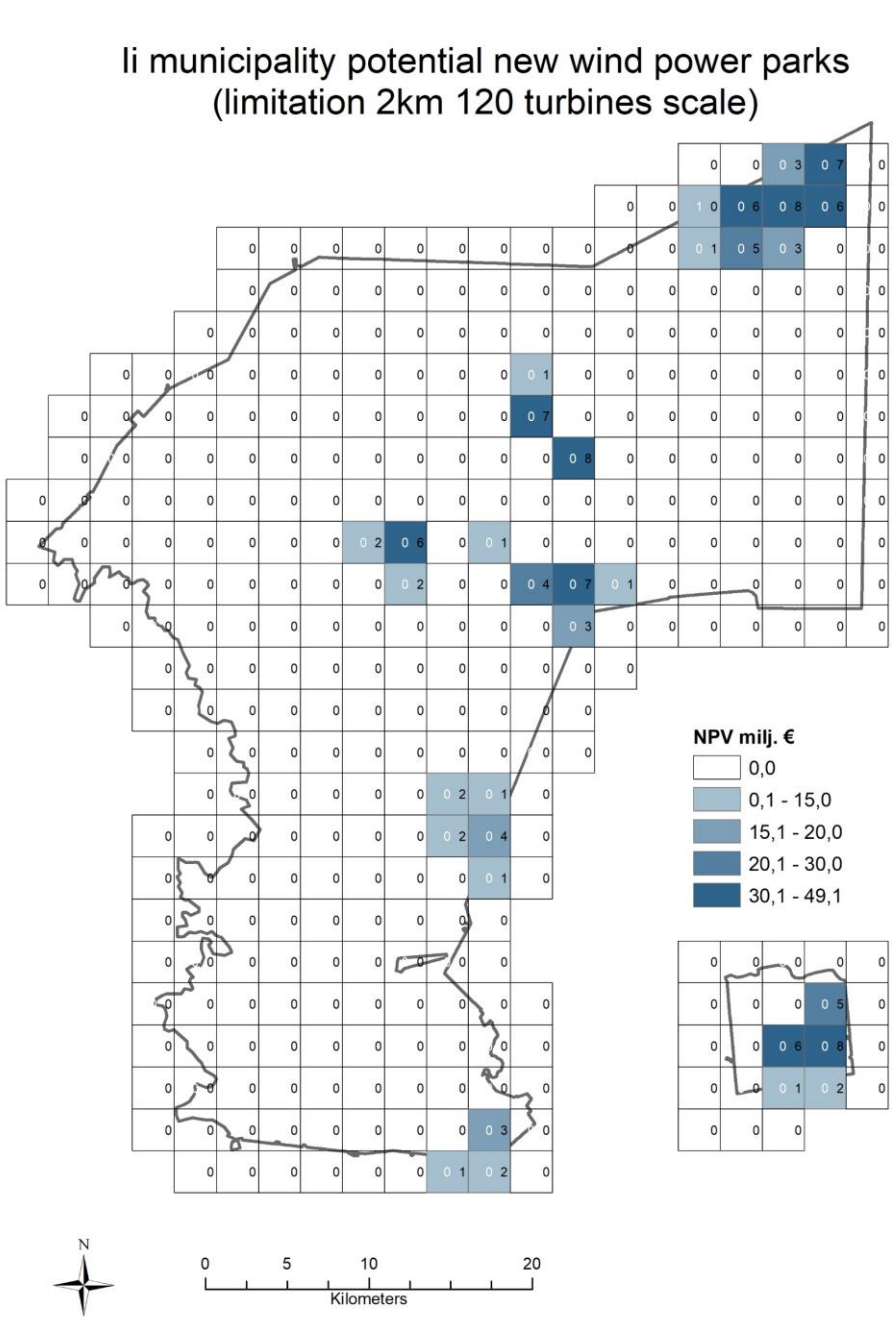
Tuulipotentiaali - 120 turbiinia, ja ottaen huomioon tuulipuistokoon vaikutuksen kustannuksiin, 1–> 2 km

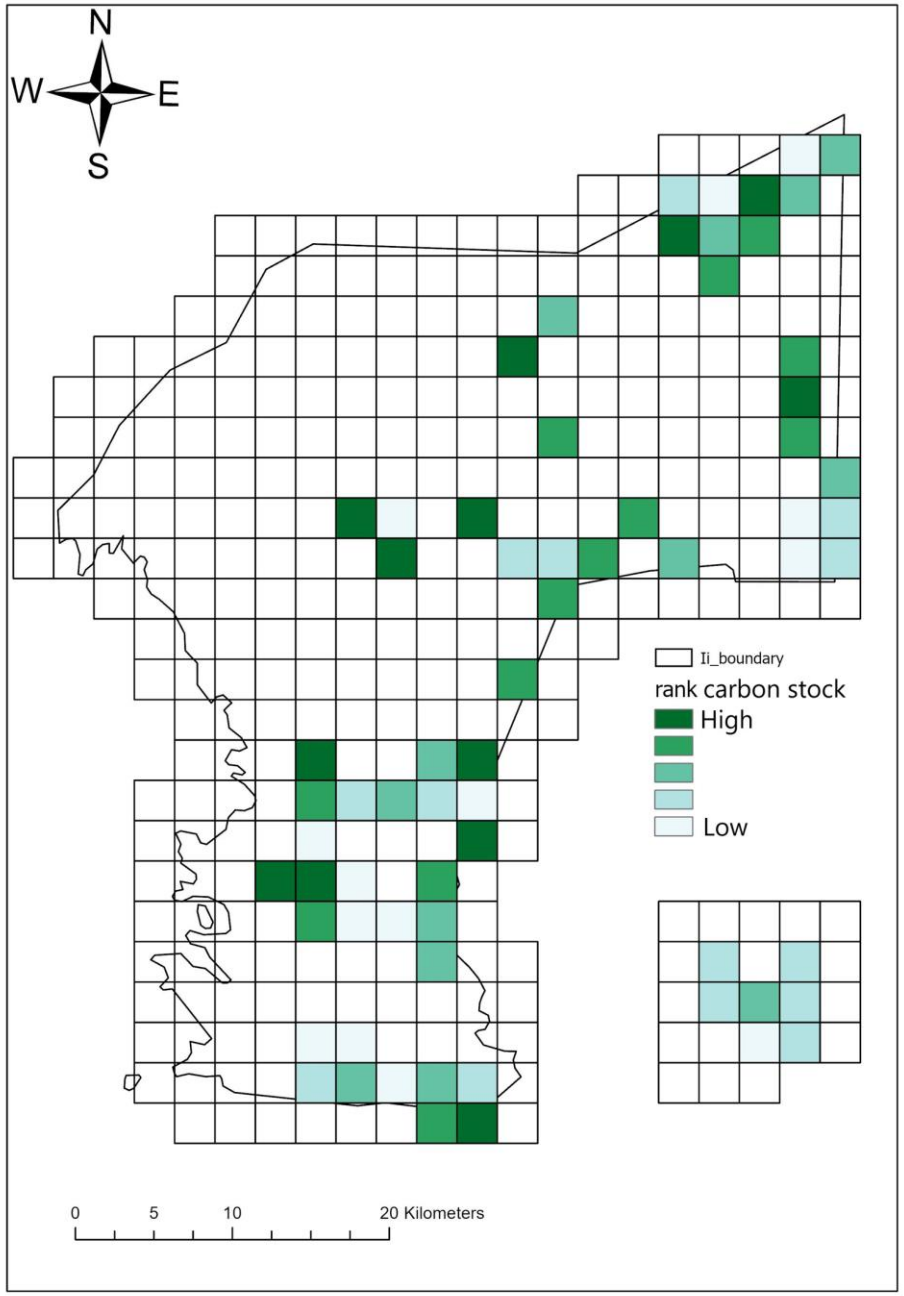




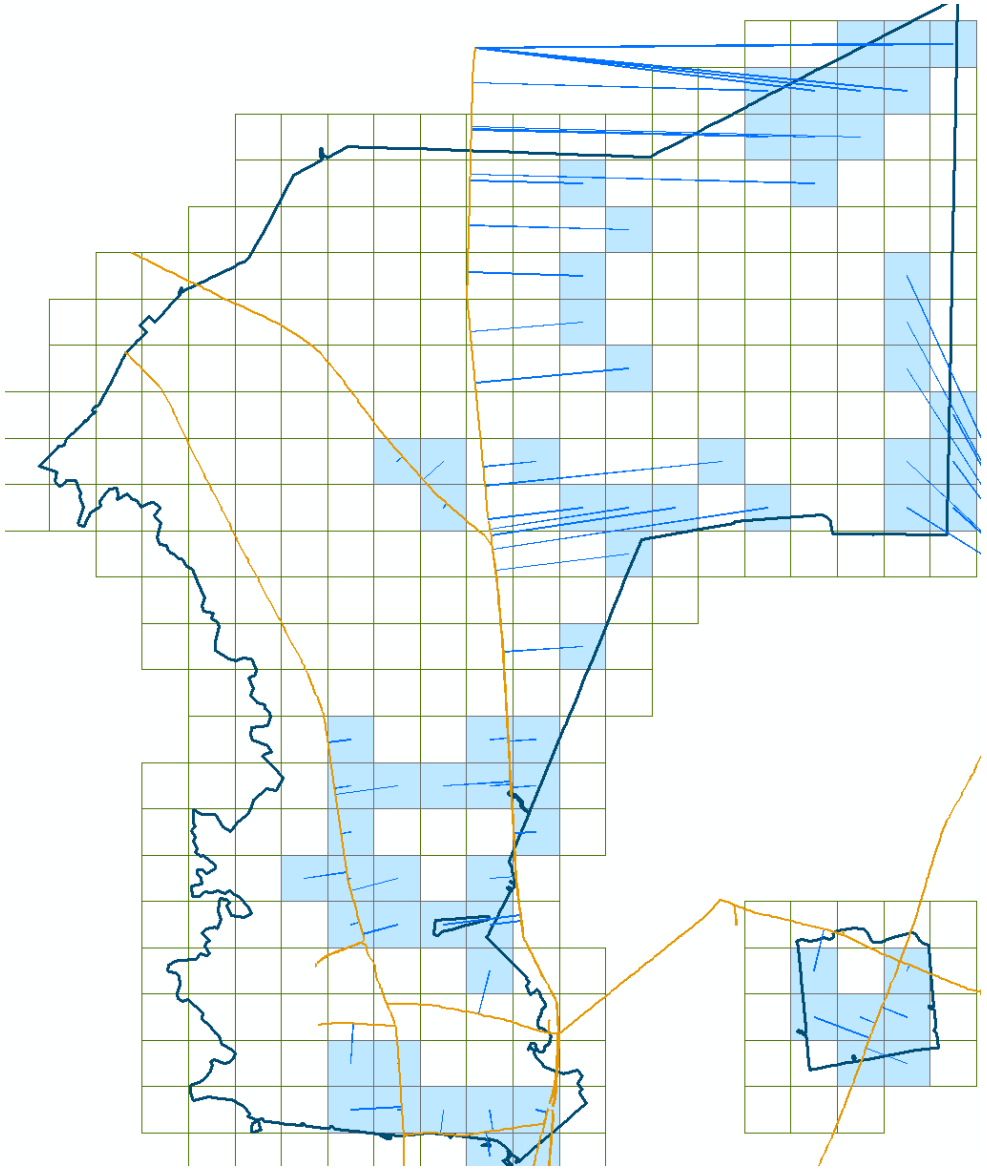


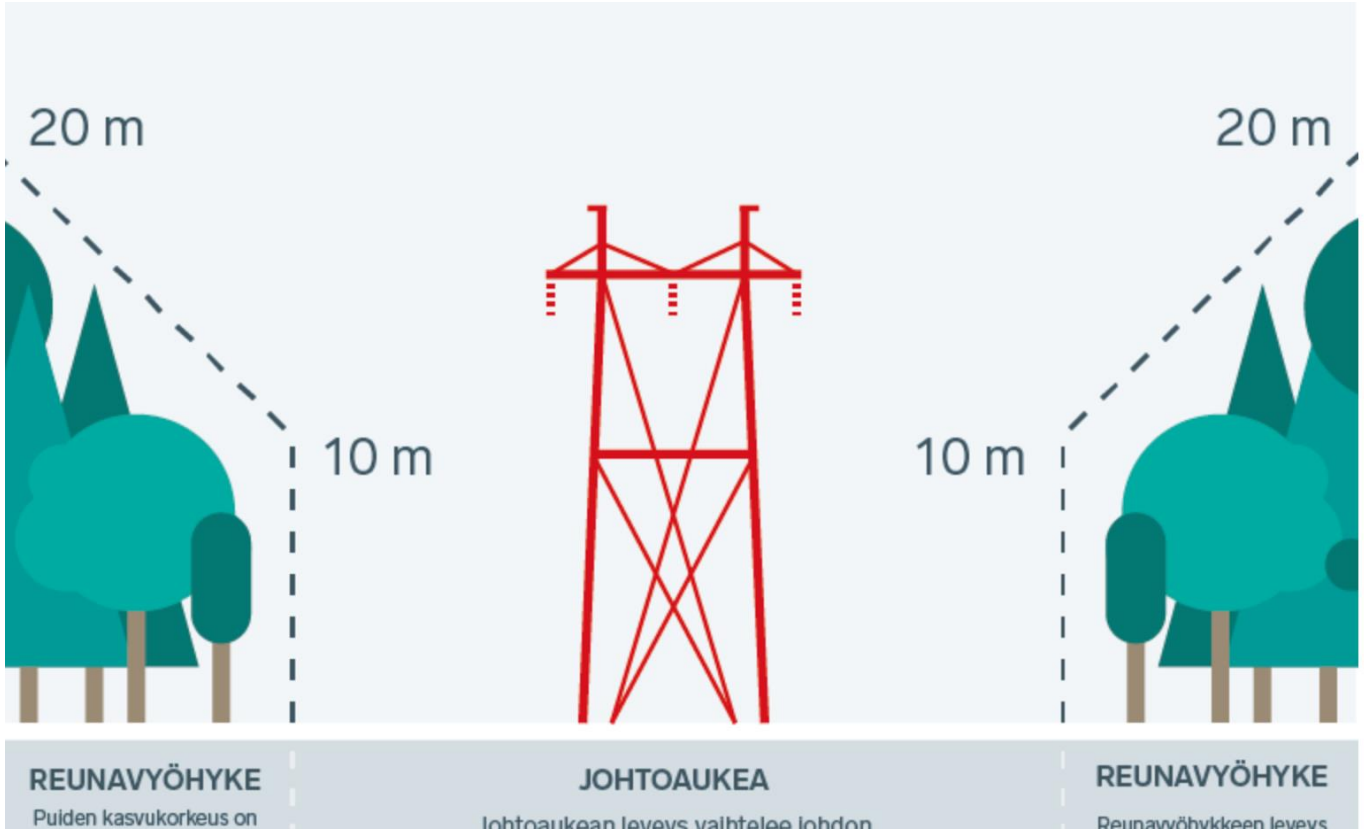
Tuulivoima-potentiaali – parhaat alueet kustannusten tai nielujen mukaan





Tuulipuistojen verkkoonliitännän vaikutus





Fingrid

110 kV linjat: 30m johtoaukealla metsäkato

Kiitos!

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