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MOTIVATIONS FOR AND IMPLICATIONS OF CAPACITY-CONSTRAINED ONSHORE RENEWABLE POWER GENERATION DEVELOPMENT

Chair of Energy Systems & Energy Economics

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Motivations for and Implications of Capacity-constrained Onshore Renewable Power Generation Development *)

Agenda

- Background and motivation
- Research questions
- Multi-method approach
- Selected results (note: research still ongoing)
- Discussion and conclusions
- Limitations and future research needs

**) The research presented here draws on a variety of findings from different collaborations. In particular, I would like to thank Desta Fitiwi, Margeret Hall, Jason Harold, Marie Hyland, Muireann Lynch and Viktor Slednev.*

Background and Motivation

- Greenhouse gas emissions need to be reduced globally to combat climate change → defossilisation of the energy system
  - EU plans based on energy efficiency and renewables → significant investments required
- Citizens generally express acceptance of these investments on an abstract level, however, policy makers and planners are frequently met with resistance from local communities
- Exact reasons yet subject to research (“NIMBY” explanation widely acknowledged as far too simplistic)
- But: research does show that people’s acceptance increases when setback distance is increased
- Impact of increased setback distance on available areas, system costs…?

Source: Slednev et al. (2017), Harold et al. (2018)

Background and Motivation (cont’d)

	Germany	Austria	Ireland	US
Min. setback distance	~400-1000m recommended, indiv. exceptions possible >1000m general min. discussed	>800-2000m	>500m >4*turbine height	>2,500 feet (Alabama), varying >1.5-2.5*turbine height depending on scale (Connecticut)


Handelsblatt

WINDENERGIE

Die Abstandsregelung für Windräder ist vom Tisch – zumindest vorerst

Im jüngsten Entwurf des Kohleausstiegsgesetzes ist Altmaiers 1000-Meter-Regel nicht mehr enthalten. Die Branche begrüßt den Sinneswandel.


Independent.ie

Government rolls out strict new wind turbine rules but keeps minimum 500m set back distance near homes

Stock Image: PA

Research Questions

- RQ1: Does increasing the setback distance help increase public acceptance of renewable energy developments and, if so, how much?
- RQ2: Since distance does is a ‘proxy’, what are the fundamental determinants of public acceptance of renewable energy developments and how do they affect people’s preferences for proximity/distance?
- RQ3: What other effects does increasing setback distances have on the energy system?
  - Total system costs?
  - Lost load?
  - Renewable curtailment?
  - …
- RQ4: Would people‘s preferences remain unchanged if they knew about these consequences?

Multi-method approach

- Conduct surveys on nationally representative samples of the populations in Germany, Ireland, US and analyse stated preferences in a cross-country econometric analysis (N>4500)
  - Understand how setback distance relates to acceptance
  - Understand what actually drives people’s preferences for spatial proximity for different renewable energy technologies
- Employ an energy system optimisation model, accounting for network effects (linearised AC-OPF), which are largely neglected in previous studies
  (Ireland only so far, Germany and US in progress)
  - Construct different renewable development scenarios (lower vs. higher spatial constraints representing higher vs. lower setback distance)
  - Determine techno-economic effects (e.g., costs, emissions, grid congestions)

Selected survey question items: dependent variables

- Asking respondents for assessment of minimum distance between new power generation technology and their place of residence so that they would accept the construction

- Response categories
  - 0-1 km/miles
  - 1-5 km/miles
  - > 5 km/miles
  - Reject regardless of distance

- Considered technologies
  - Wind power
  - Solar power
  - Biomass power plant
  - Coal-fired power plant
  - Gas-fired power plant

Source: Bertsch et al. (2016, 2017), Harold et al. (2018)

Selected survey question items: independent variables

- External (socio-demographic)
  - Age, tenure type, education
- Internal (attitudes and beliefs)
  - Trade-offs between (energy) policy objectives
    - Pairwise trade-offs (9-point scale as AHP) between policy objectives: *economic affordability, environmental sustainability, supply reliability* and *social impact*
  - Technology-specific perceived impact assessments (subjective)
    - Perceived impact of technology on landscape, sound, health, local environment, local economy, local employment, air quality, water quality, odour, technical safety

Source: Bertsch et al. (2016, 2017), Hyland & Bertsch (2018)

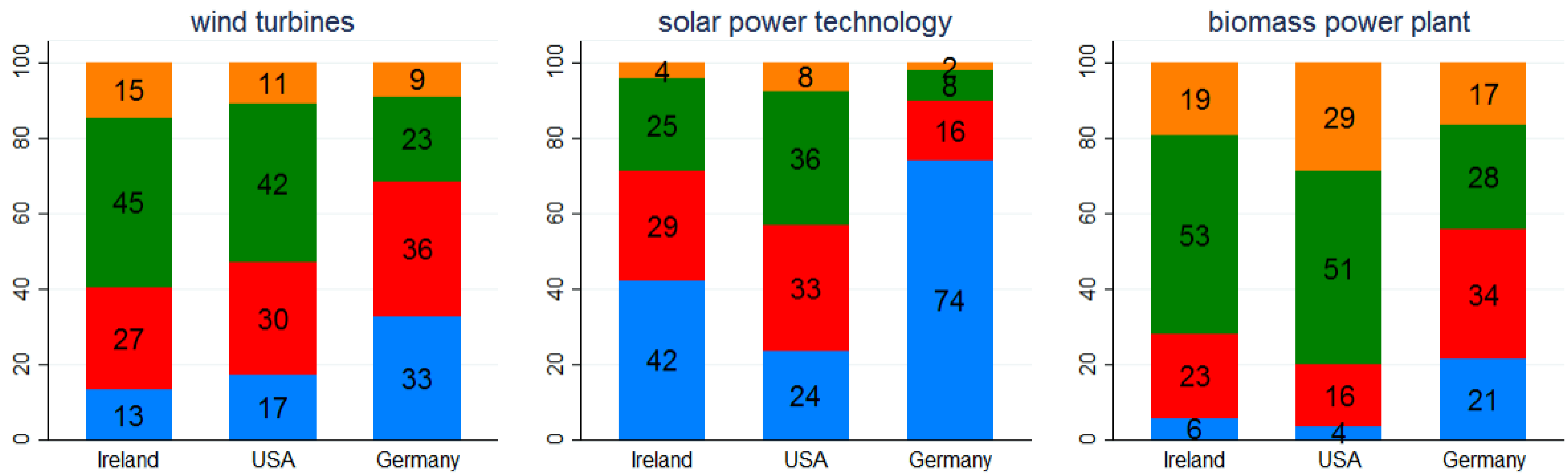
Scenarios considered using the optimisation model

Cases	*Variations*			Storage cost
	Storage deployment	*Wind onshore*	*Solar PV*	
Unconstrained *Lower setback distance*	Unlimited capacity	$\leq$ 400 MW per transmission node	$\leq$ 50 MW per transmission node	High Low
Constrained *Higher setback distance*	Limited capacity	$\leq$ Peak demand at each transmission node	$\leq$ min {50 MW; Peak demand at each transmission node}	High Low

- RES-E 2030 target of 55% is assumed for all scenarios (2020 target was 40%)
- RES-E 2030 target of 70% considered as sensitivity (Irish Government's 2019 Climate Action Plan)

Source: Fitiwi et al. (2019)

Results: descriptive statistics on setback distance (RQ1)



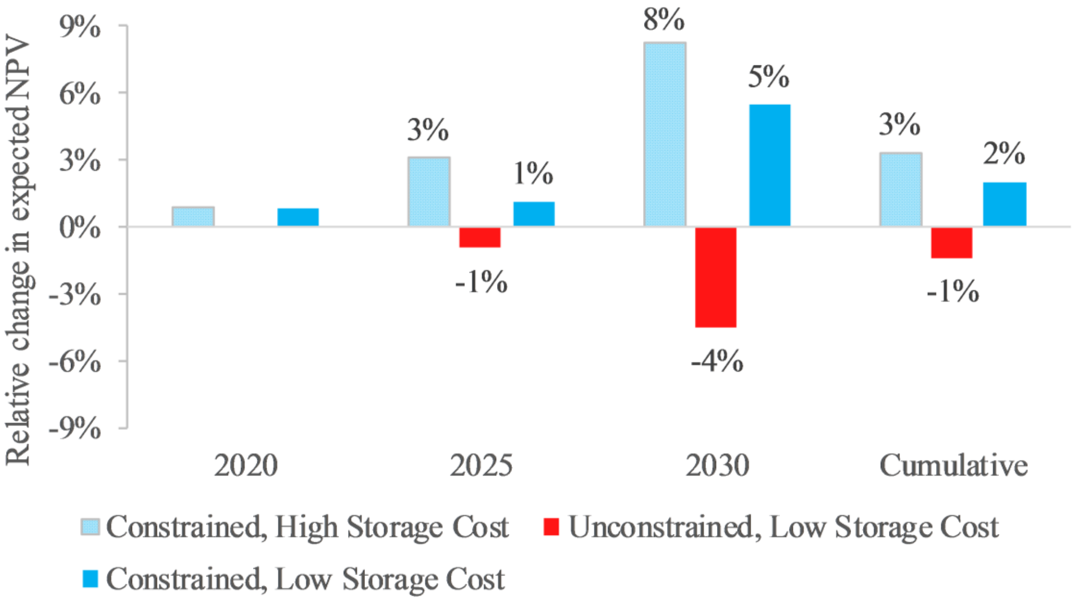
→ Acceptance does increase with distance based on stated preferences

Source: Harold et al. (2018)

Results: econometric analysis of survey data (RQ2)

- Socio-demographic factors
  - German and Irish citizens are willing to accept energy infrastructure at smaller distances to their homes than their US counterparts
  - Exception of wind power: no statistically significant difference between Ireland and US
- Attitudinal factors shape people's preferences more consistently than any socio-demographic aspects
  - In particular, the economic-environmental trade-off is significant across technologies, people who rank economic concerns higher
    - less likely to accept RES technologies at close distances and more likely to reject regardless of distance
  - Technology-specific considerations: Perceived impact on landscape, health and local economy are significant factors for all technologies

Results: techno-economic effects of increasing setback distance (RQ3)
Total costs / NPV



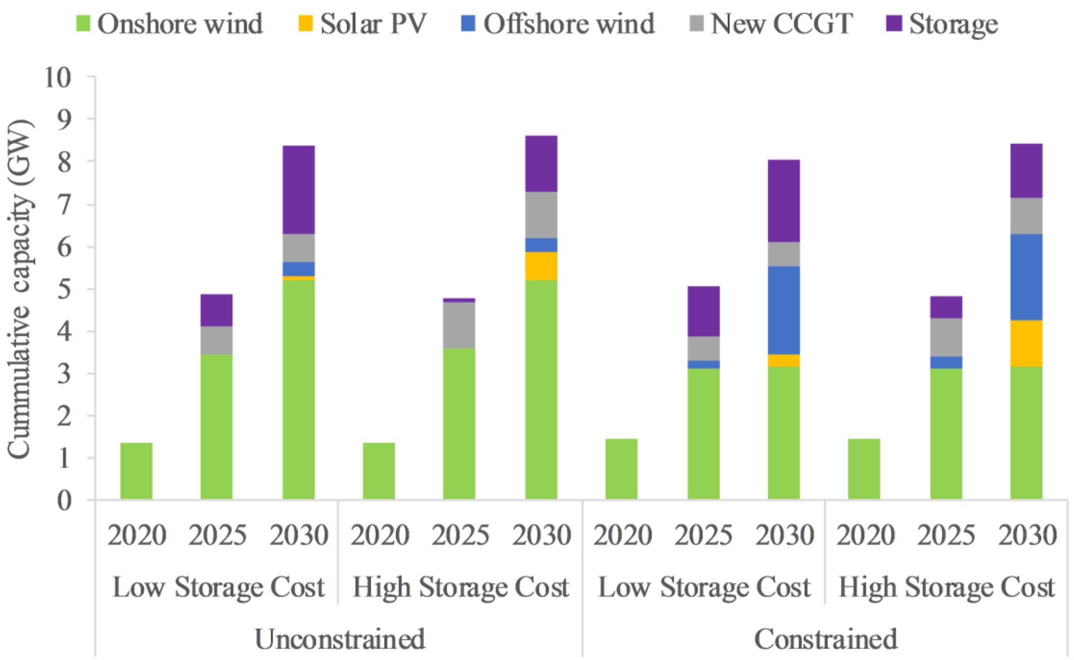
NPV of system costs: relative change compared to unconstrained case with high storage costs

Main effects:

- Unconstrained case only marginally cheaper than constrained case (3% cumulative NPV)
- Decreased storage costs reduce cumulative NPV of system costs by 1%

Source: Fitiwi et al. (2019)

Results: techno-economic effects of increasing setback distance (RQ3) Generation investments



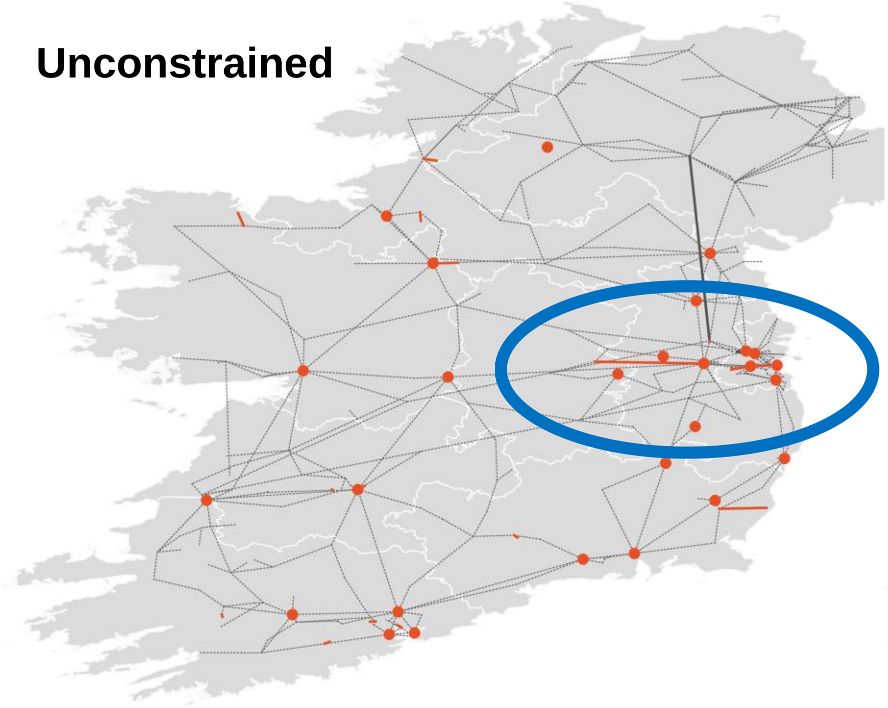
Main effects:

- Ceteris paribus, increasing setback distance / constraining RES potential onshore leads to decreased wind onshore developments and increased solar PV and wind offshore developments
- Decreased storage costs reduce CCGT capacity required to cover demand

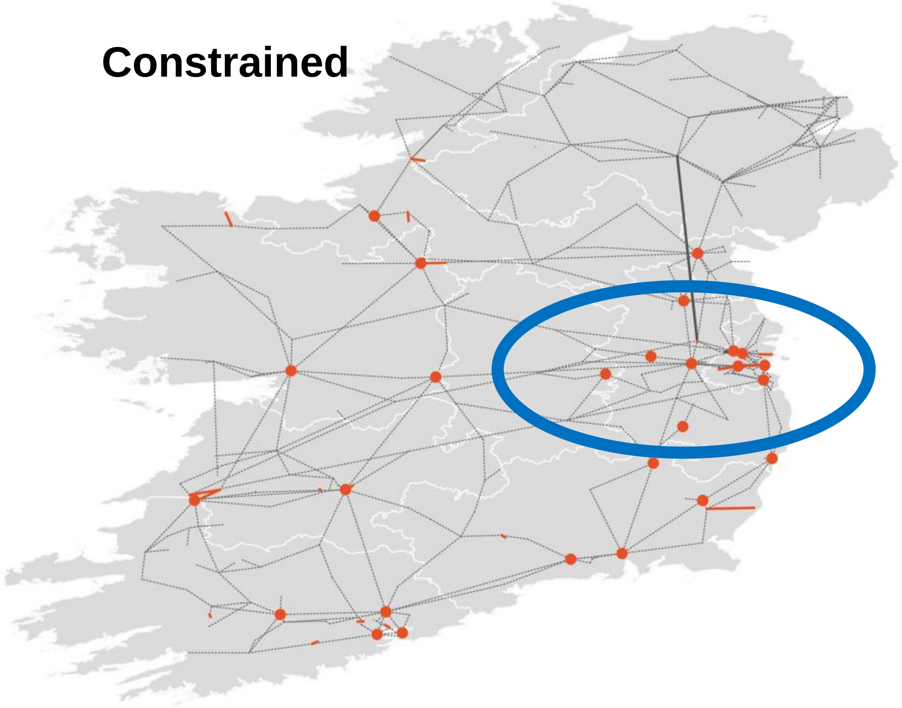
Source: Fitiwi et al. (2019)

Results: techno-economic effects of increasing setback distance (RQ3)
Transmission grid congestions

Unconstrained

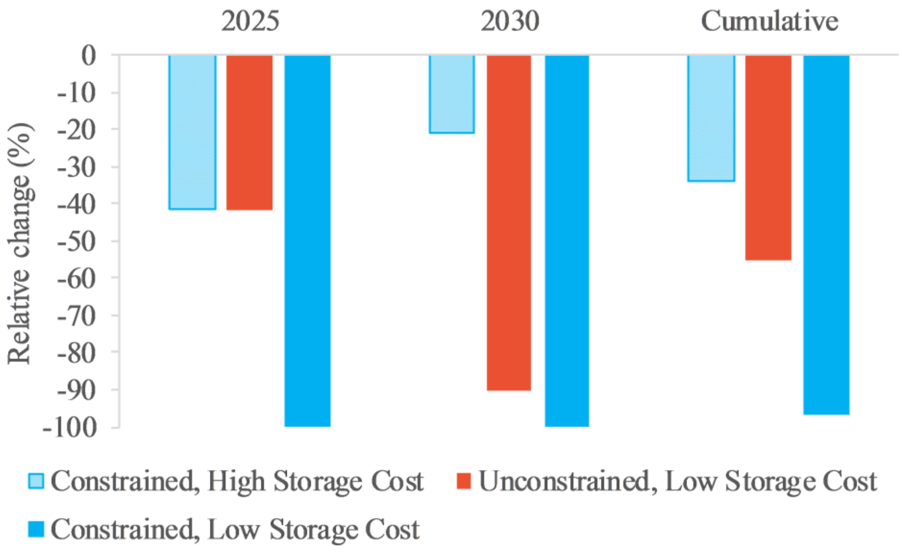


Constrained

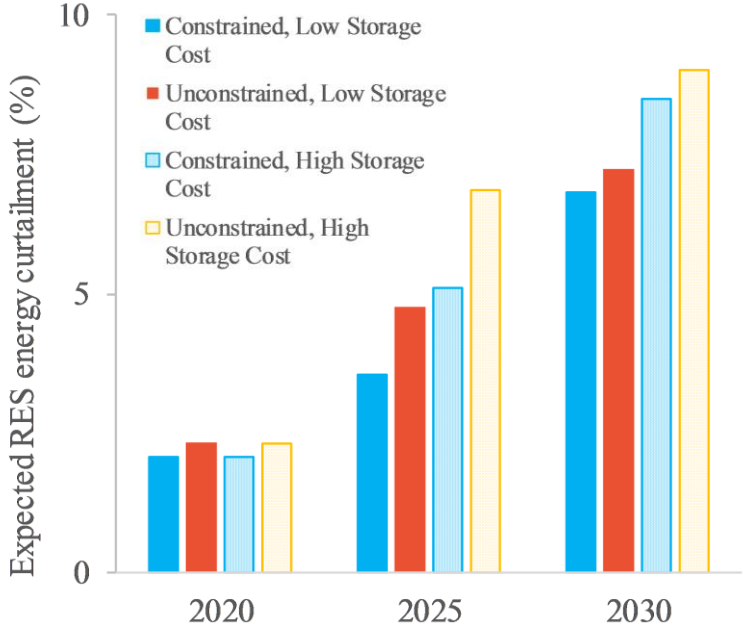


Source: Fitiwi et al. (2019)

Results: techno-economic effects of increasing setback distance (RQ3)
Lost load and RES curtailment



Lost load: relative change compared to unconstrained case with high storage costs



RES curtailment

Results: techno-economic effects of increasing setback distance (RQ3)
Comparison of effects for higher RES-E targets

	SNSP level	*75%*	*75%*	*90%*
	RES-E Target	*55%*	*70%*	*70%*
Changes in investment (%)	*New CCGT*	-21	+56	-31
	Onshore wind	-40	-39	-39
	Solar PV	+62	-8	+14
	Offshore wind	+515	+58	+66
	Storage	-42	-2	-5
Changes in key system variables (%)	*Expected emissions*	0	0	0
	Expected RES curtailment	-14	-5	-13
	Expected self-sufficiency	+15	+6	+4
	Expected NPV	+3	+5	+5
	Case	RES-E 55	RES-E 70	RES-E 70 & SNSP 90

→ Cost difference (NPV) between constrained and unconstrained case increases

Discussion and conclusion: socio-economic effects

- Respondents are indeed more accepting of renewable energy developments as setback distances increase
- People's preferences for spatial proximity between various energy technologies and their homes are driven by
  - trade-offs between national energy policy preferences
  - their technology-specific perceptions
  - to a lesser extent their socio-demographic characteristics

Discussion and conclusion: techno-economic effects

- The unconstrained portfolio is only marginally cheaper than the constrained one
- Substantial differences in the final generation portfolios
- Network reinforcement requirements greater under the unconstrained approach
- Lower storage costs only slightly mitigate the costs of capacity constraints but significantly alter the spatial distribution of generation investments
- Differential in costs between the unconstrained and constrained cases increases non-linearly with renewable generation targets
  → Achieving very high renewable targets may be challenging, if not impossible, if setback distances are increased too much

Discussion and conclusion: policy implications

- Policy makers may choose to trade achieving RES-E targets off against arriving at the least-cost scenario
  - If a constrained roll-out of renewables helps overcome public opposition to high RES levels, the increase in total costs may be acceptable, from a policy-maker’s point of view
  - Assessment and monitoring of expected cost (increase) very important given that increased energy prices for consumers may themselves prove a barrier to social acceptance

Limitations and future research needs

- Analysis based on stated preferences → extent of alignment with actions unknown
- Independent variables not considered here: e.g., place attachment, trust, institutional structure and ownership type (affecting perceived procedural and distributional justice)
- “Exact” link between distance and costs (and other techno-economic effects) not yet operationalised
  - Distance to what? (e.g., 1000m to each individual house, group of at least 5 houses as discussed in Germany recently, impact of urban sprawl such as in Ireland…)
  - Limitations of quantitative modelling in general

Next steps

- Energy systems models for Germany and US for cross-country analysis
- RQ4: Iterative and “bidirectional” acceptance assessment
  - Interactive methods and tools needed for “mass online preference elicitation”

Research largely builds on three papers, 2 of which under review (R&R)

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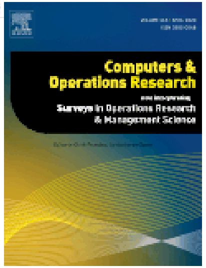
Harold, J., Bertsch, V., Lawrence, T. & Hall, M. (2018) Drivers of people's preferences for spatial proximity to energy infrastructure technologies: a cross-country analysis. ESRI Working Paper 583.



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