2023 Visual Resource Stewardship Conference

Exploring Multisensory Landscapes

A generic quantification of the landscape impacts of wind, solar and hydroelectric energy

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Research motivation

Social Unrest

Protest against wind turbine placement Tinos island, Greece:

Sum of challenged works in 2018:

1240 MW

Research aims

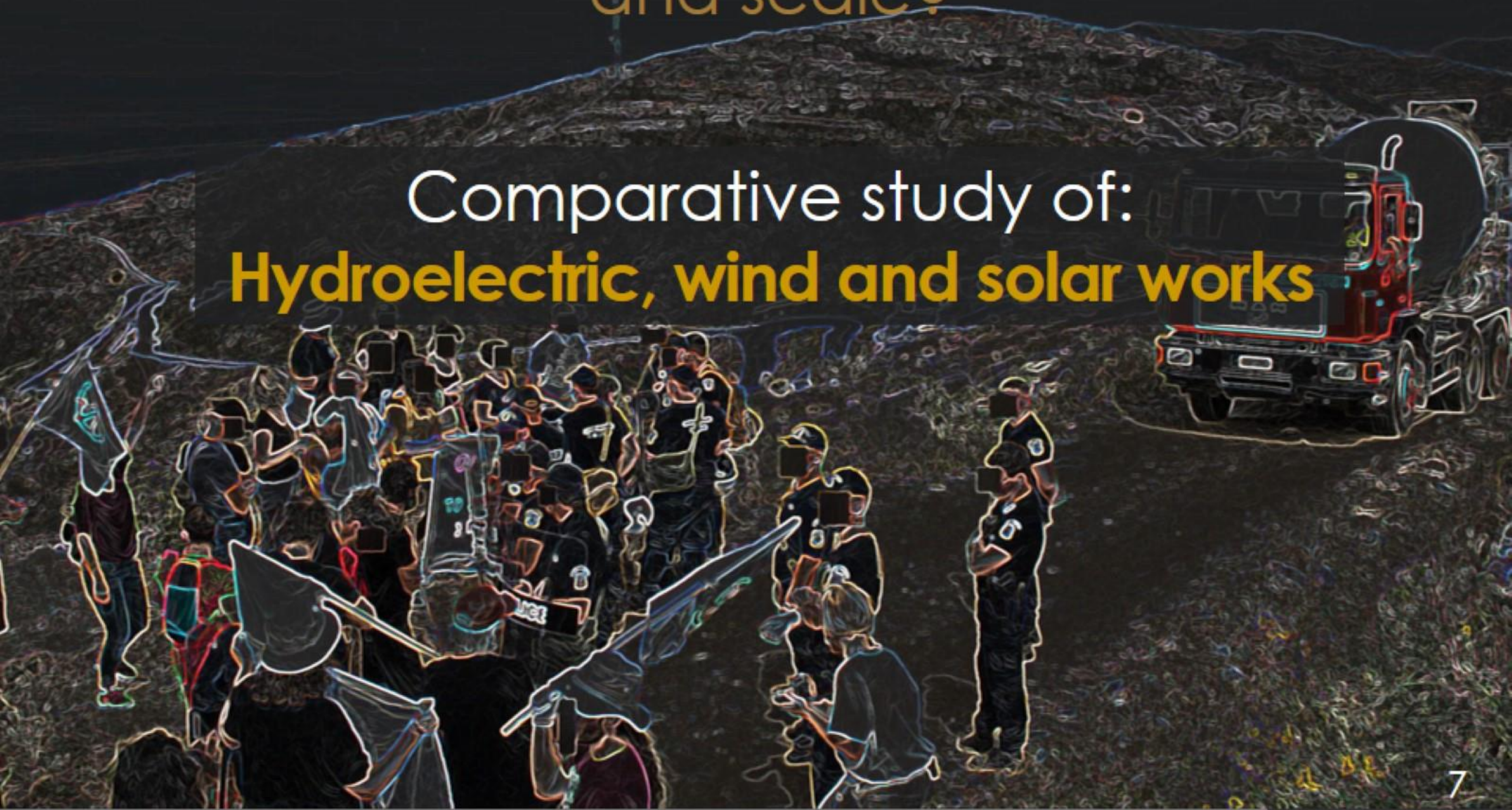
1. Examine the rationality of criticism of renewable energy regarding landscape impacts

2. Build the ground for improved mitigation of those impacts

Methods and results

Primary research question

Are the landscape impacts of different types of RE works different in character and scale?



Comparative study of:

Hydroelectric, wind and solar works

Primary research question

Are the landscape impacts of different types of RE works different in character and scale?

This answers both:

1) The question of rationality –
If more impactful types of RE face more opposition this would enforce the view that opposition is rational

2) Helps to define and differentiate directions for mitigation of impact for each type of RE

METHODOLOGY

- Use of literature review:
  200+ sc. Publications and national/global datasets

- Aim for the calculation of:
  global averages of impacts
  (from realized projects and for energy generation on large scales)

REVIEWED PARAMETERS

A. LAND USE

Land use , as the area directly affected by the infrastructure

SPATIAL INDEX (m^2)

B. PUBLIC PERCEPTION

Perception particularly in the context of landscape (positive/negative)

PERCEPTUAL INDEX (%)

C. VISIBILITY

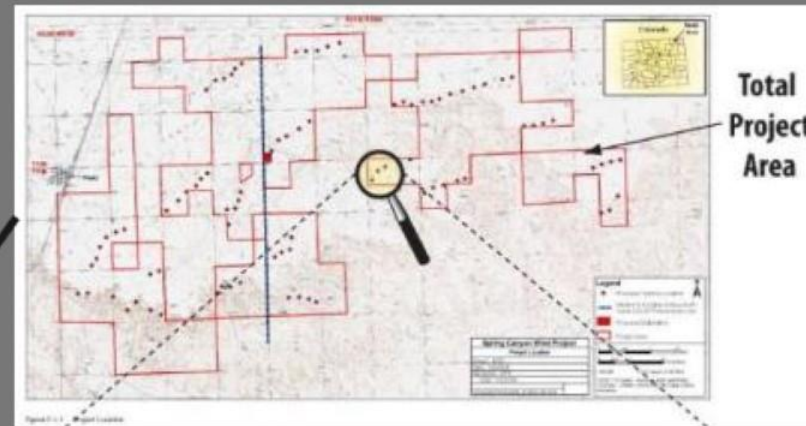
The area from which the infrastructure is visible as quantified with GIS (m^2)

SPATIAL-PERCEPTUAL INDEX

A. LAND USE

A. LAND USE

Total land use



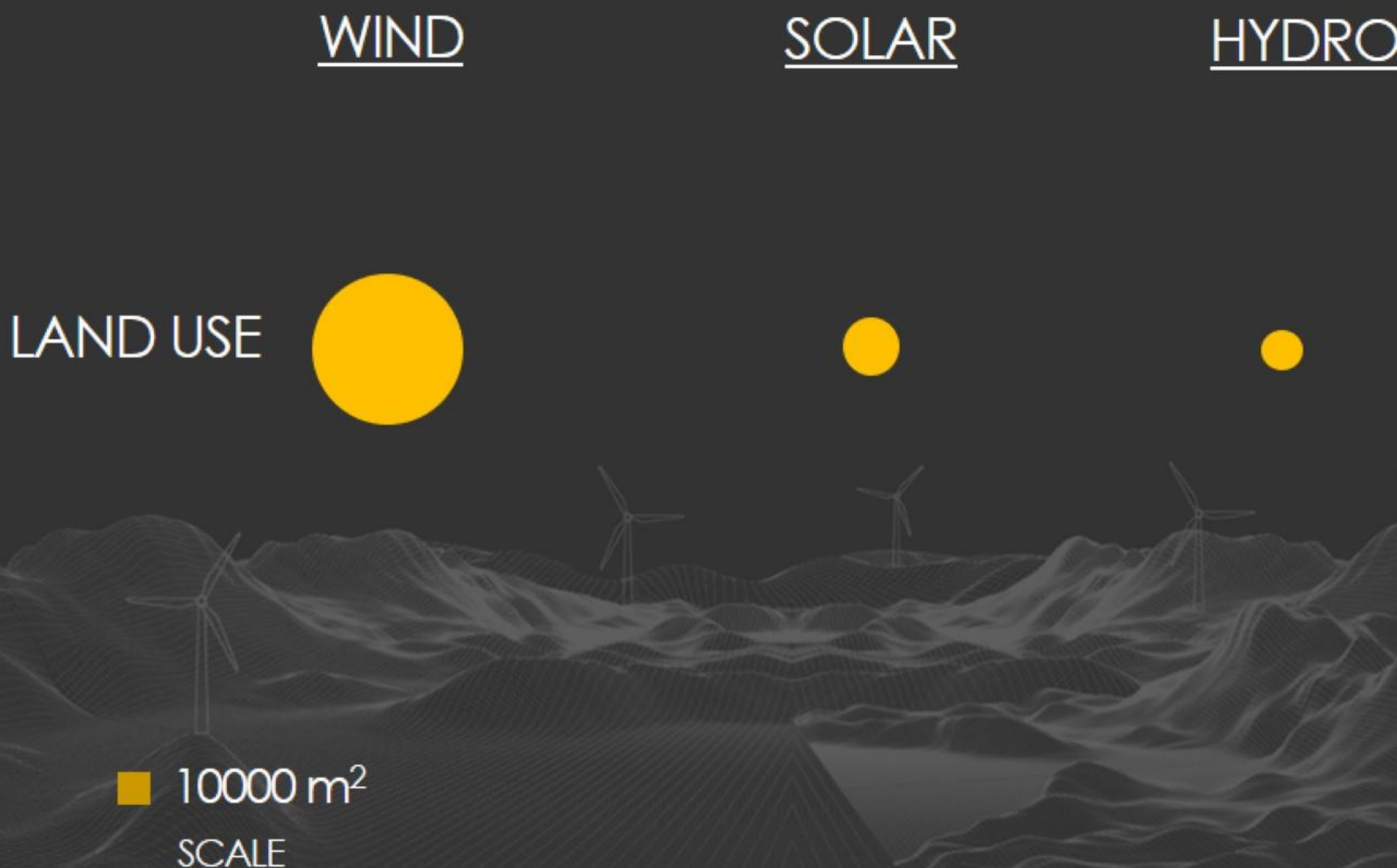
Types of RE infrastructure	Average land use per energy generated (m^2/GWh)
Wind	**176 000**
Solar	**28 000**
Hydro	**?**

(NREL, 2009)
(NREL, 2013)

Range of estimations in literature:
From **2000 m^2/GWh** to **768 234 m^2/GWh**

10 000 (Fritsche et al., 2017)
16 900 (Trainor et al., 2016)

RESULTS (per GWh/year)



B. PUBLIC PERCEPTION

B. PUBLIC PERCEPTION OF LANDSCAPE IMPACTS

For each type of RE, the first 60 relevant studies were collected from Google Scholar and analyzed

WILEY	SPRINGER	ELSEVIER	**sum**
20	20	20	**60**

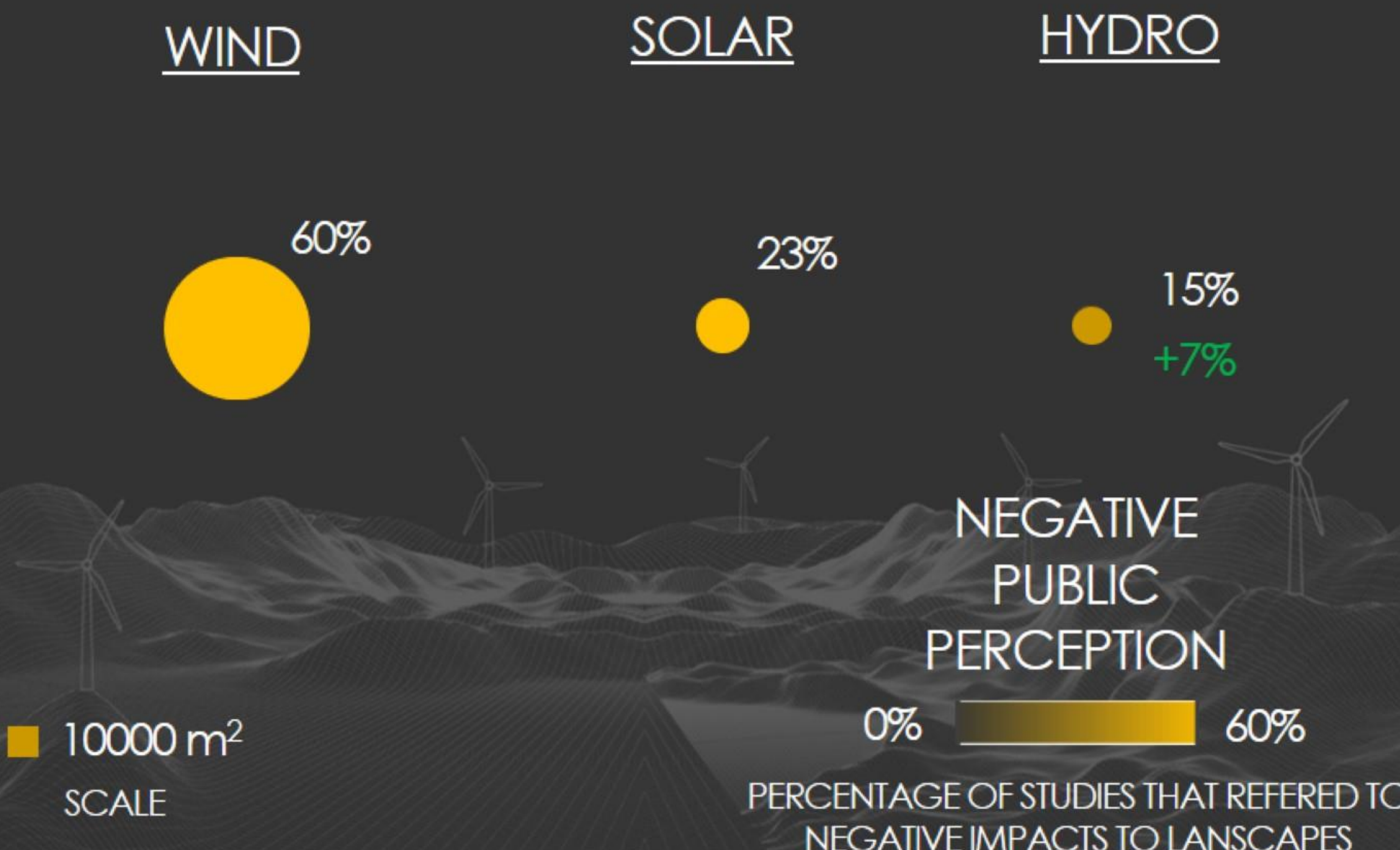
and were characterized for including
POSITIVE/NEGATIVE remarks on RE
Using an algorithmic procedure of search of particular keywords

B. PUBLIC PERCEPTION OF LANDSCAPE IMPACTS

THE 180 PUBLICATIONS INCLUDED:

- The opinions of **scientists** that have written the studies
- Studies based on giving questionaries to the **public (local inhabitants, tourists, etc.)** for RE works
- Interviews with **experts** and **stakeholders**
- Analysis of **media** coverage

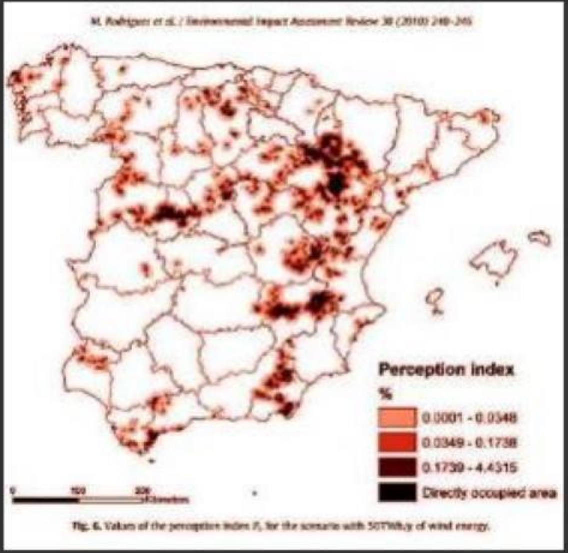
RESULTS (per GWh/year)



C. VISIBILITY

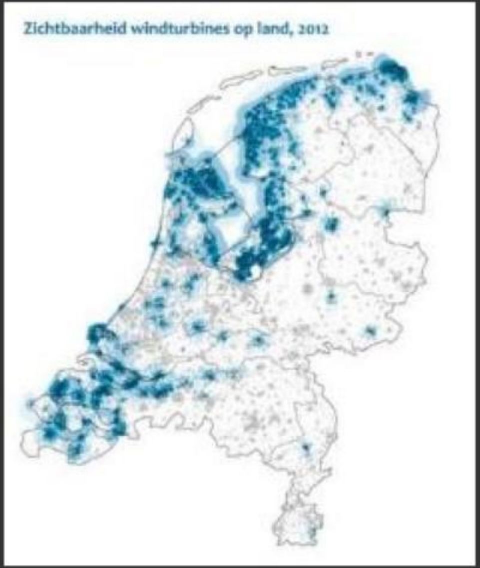
C. VISIBILITY ANALYSES (ON LARGE SCALES)

Spain



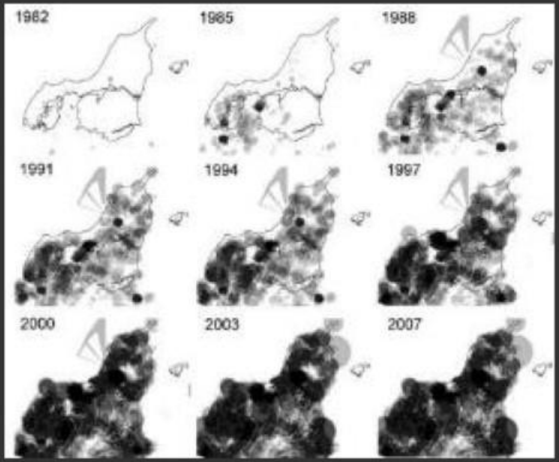
(M.Rodrigues et al.,2010)

Netherlands



(CBS, 2014)

Denmark (Jutland):



(Möller, 2010)

Visibility of wind energy infrastructure from 17% of the land area

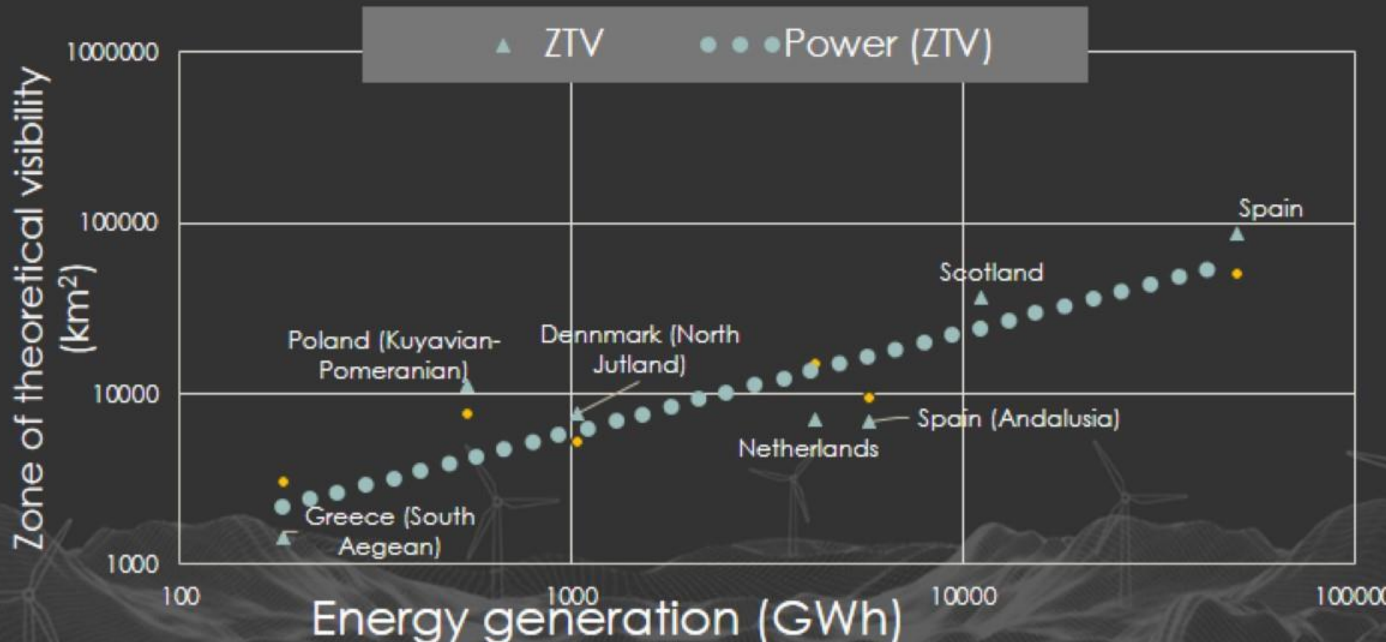
Visibility from 21% of the land area

Visibility from 96% of region

C. VISIBILITY

RESULTS - AVERAGES

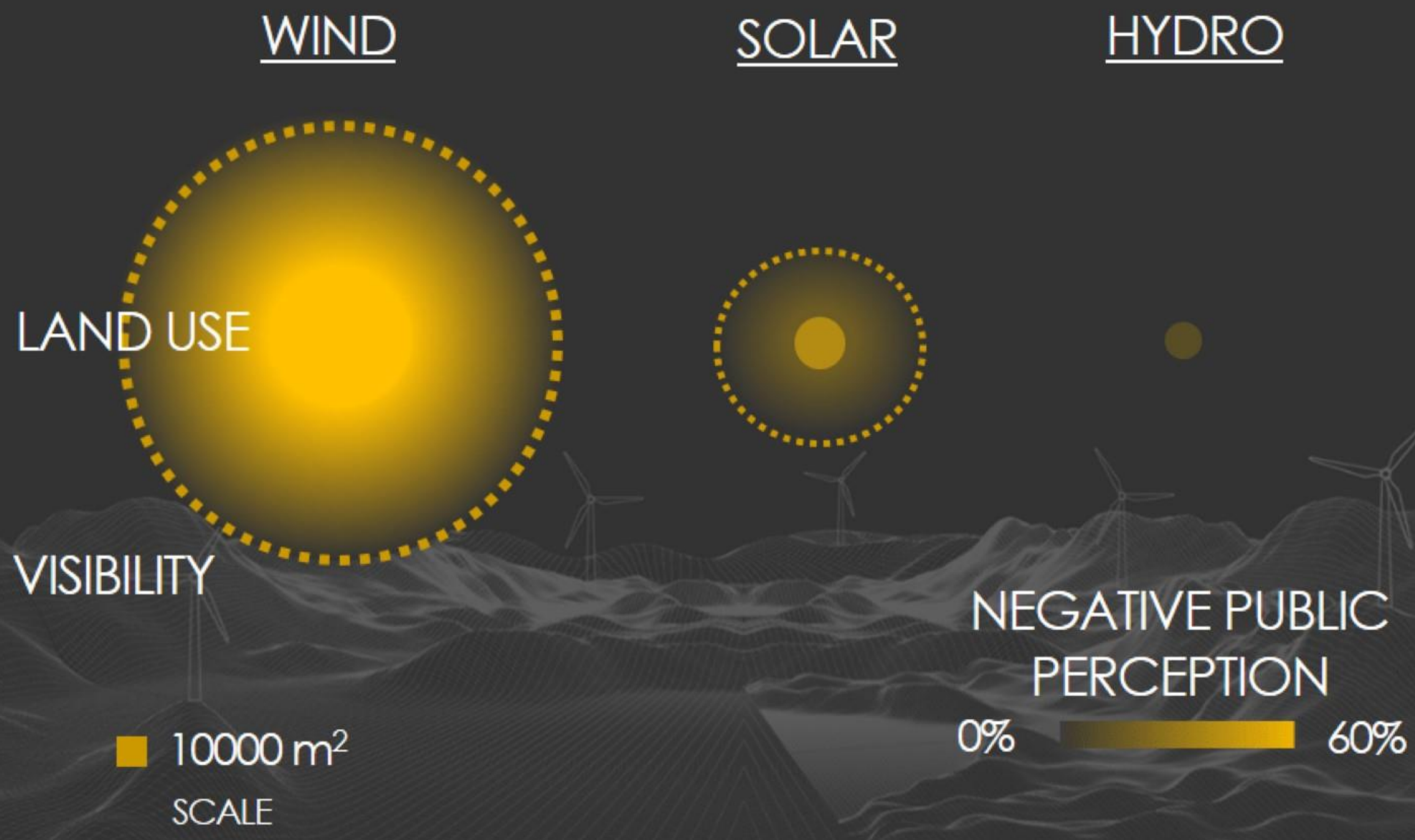
Wind energy



Type of RE	Average visibility(m^2/GWh)
Wind	**2 014 800**
Solar	**451 500**
Hydro	**Not available**

TOTAL RESULTS: QUANTIFICATION OF LANDSCAPE IMPACTS

AVERAGES(per GWh/year)



CONCLUSIONS(1)

WIND and SOLAR works

- Extensive **spatial and visual** impact of landscapes

More perceivable in wind turbines due to their size and movement

- Critique on **industrialization** of landscapes

Infrastructure with fixed form – no capability for architectural interventions

↓

IMPACT MITIGATION

Through **spatial planning** to minimize **visual impacts**

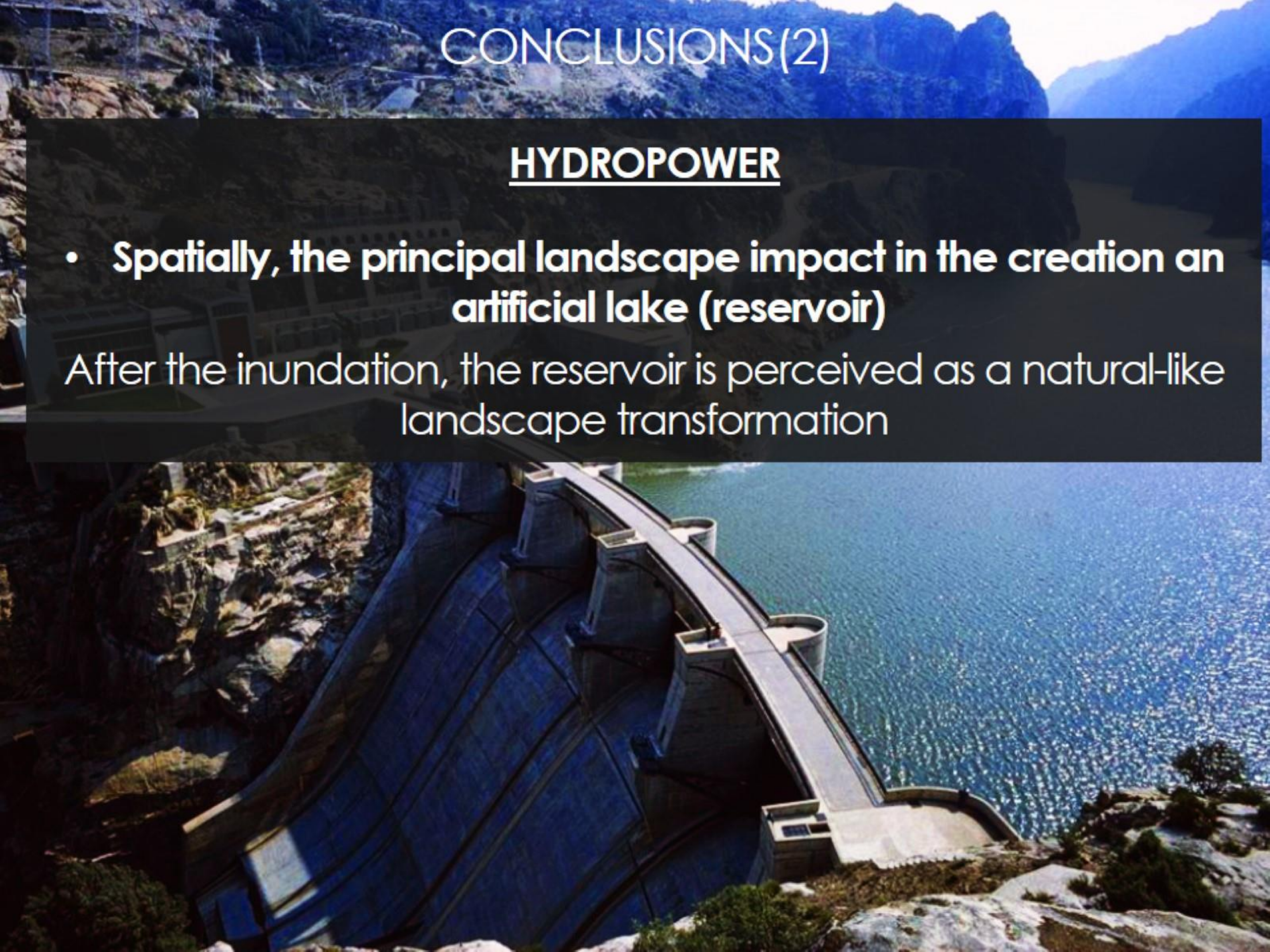
More on the follow up presentation on Reverse Visibility Analysis

CONCLUSIONS(2)

HYDROPOWER

- **Spatially, the principal landscape impact in the creation an artificial lake (reservoir)**

After the inundation, the reservoir is perceived as a natural-like landscape transformation



CONCLUSIONS(2)

Platanovrisi dam, Greece
Lack of architectural or landscape study

CONCLUSIONS(2)

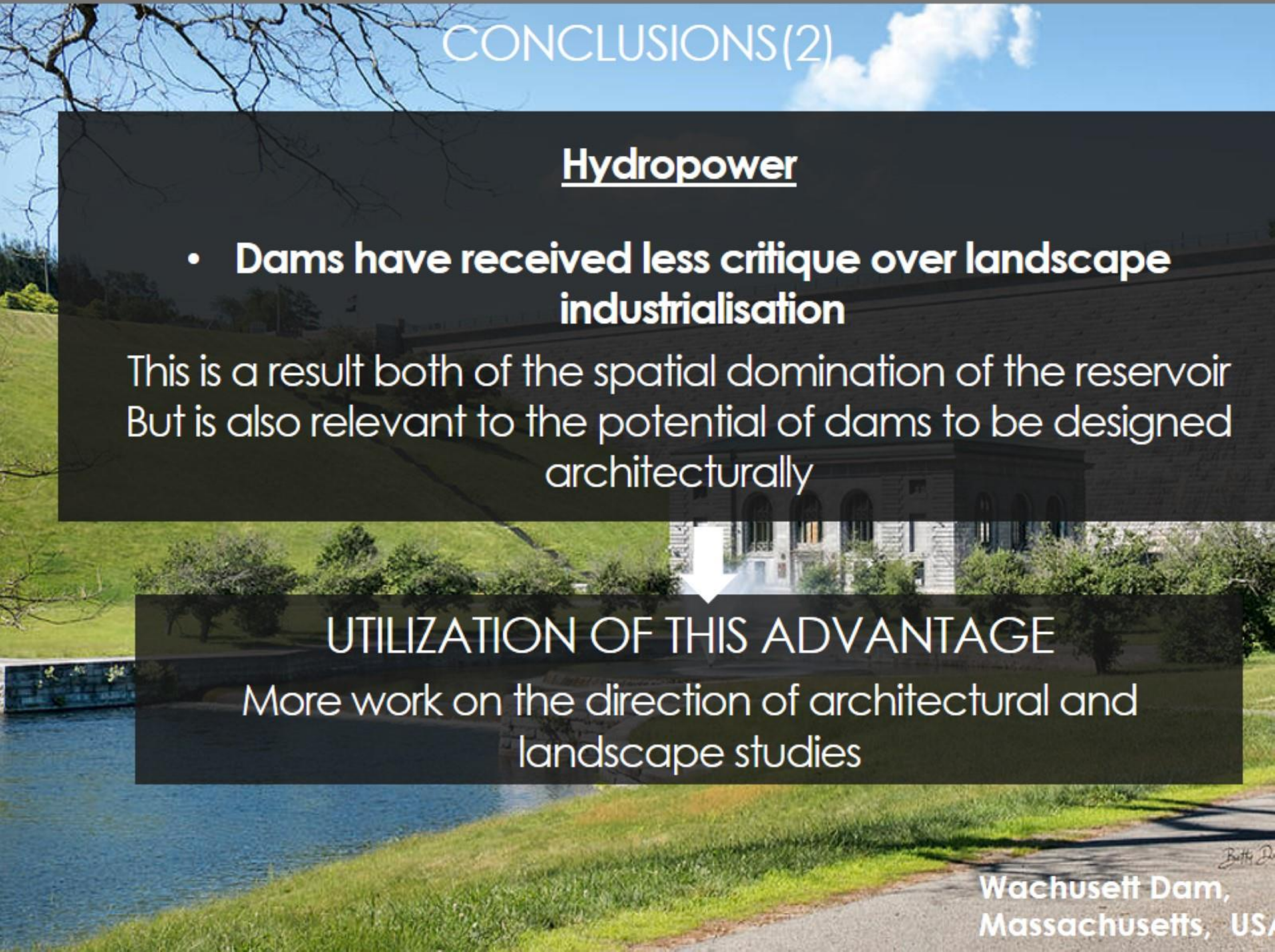
Hydropower

- **Dams have received less critique over landscape industrialisation**

This is a result both of the spatial domination of the reservoir
But is also relevant to the potential of dams to be designed architecturally

UTILIZATION OF THIS ADVANTAGE

More work on the direction of architectural and landscape studies



Wachusett Dam, Massachusetts, USA

Marathon Dam,
Attica, Greece

RELEVANT PUBLISHED WORK

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

A review of land use, visibility and public perception of renewable energy in the context of landscape impact

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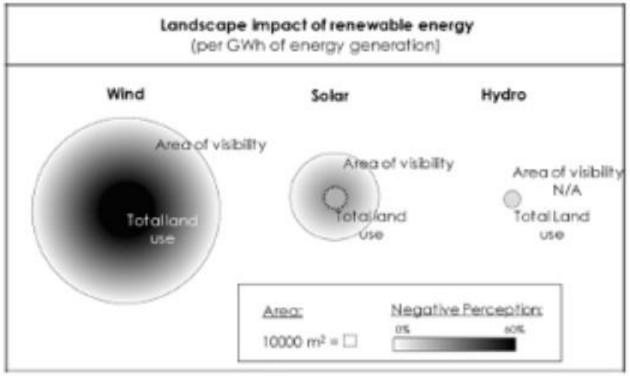
HIGHLIGHTS

- Wind energy ranks 1st, solar 2nd and hydro 3rd on land use and visibility.
- In the negative perception index wind energy scores 60%, solar 22% and hydro 15%.
- Depending on landscape type any technology can potentially be the least impactful.
- Opposition to renewable energy should not be uncritically attributed to NIMBY.
- Hydroelectric dams have untapped potential for high quality architectural design.

GRAPHICAL ABSTRACT



ARTICLE INFO

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Public perception
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Wind turbines
Solar panels

ABSTRACT

Landscape impacts associated with aesthetics have been a persistent cause of opposition against renewable energy projects. However, the current uncertainty over the spatial extents and the rationality of reported impacts impedes the development of optimal strategies for their mitigation. In this paper, a typology of landscape impacts is formed for hydroelectric, wind and solar energy through the review of three metrics that have been used extensively for impact-assessment: land use, visibility and public perception. Additionally, a generic landscape-impact ranking is formed, based on data from realized projects, demonstrating that hydroelectric energy has been the least impactful to landscapes per unit energy generation, followed by solar and wind energy, respectively. More importantly, the analysis highlights the strengths and weaknesses of each technology, in a landscape impact context, and demonstrates that, depending on landscape attributes, any technology can potentially be the least impactful. Finally, a holistic approach is proposed for future research and policy for the integration of renewable energy to landscapes, introducing the maximum utilization of the advantages of each technology as an additional strategy in an effort to expand beyond the mitigation of negative impacts.

Abbreviations: RE, Renewable energy; PV, Photovoltaic; GIS, Geographic information system; ZTV, Zone of theoretical visibility; CF, Capacity factor

THANK YOU!

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