

# Public Acceptance of CCS

## - Dutch Citizen Perspectives -

S. Anders, N. Lokuge<sup>1</sup>, A.H. Mohammed<sup>1</sup>,  
J. Meyerhoff<sup>2</sup>, U. Liebe<sup>3</sup> M. van der Baan<sup>1</sup>

<sup>1</sup> U Alberta, Canada <sup>2</sup> HWR Berlin, Germany <sup>3</sup> U Warwick, UK



UNIVERSITY OF ALBERTA  
DEPARTMENT OF RESOURCE ECONOMICS  
AND ENVIRONMENTAL SOCIOLOGY

# Objective

“CCS is central to any CC mitigation scenario. It’s success does not only rely on political commitment, but also on the response from the public.”

- ❖ **Can the public accept or even support CCS to remove CO<sub>2</sub> emissions?**
- ❖ **What factors matter to public acceptance of CCS?**
- ❖ **How do individuals evaluate benefit-cost & risk trade-offs associated with a scale-up of CCS?**

# Study Approach

Nationally representative online surveys & economic experiments with  $N \approx 1000$  adults in Canada, Germany, Netherlands, Norway, UK

## **Stage #1 =**

- + **Survey questionnaire**
- + Ranking of CC policy approaches
- + Scenario experiment on acceptance of CCS deployment strategy & perceived fairness of CO<sub>2</sub> imports

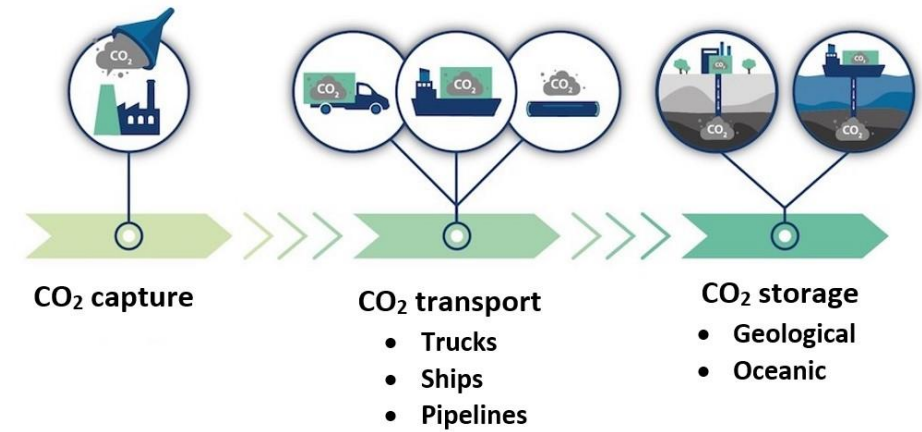
## **Stage #2 =** (re-invite after 10 days, 54-68%)

**Choice Experiment** on CCS preferences & benefit-cost/risk trade-offs in project implementation (risk  $\approx$  potential seismicity)

# Survey questions we ask

- Do individuals believe in the human causes of Climate Change?
- What do public preferences for available low carbon technologies look like?
- How do CO<sub>2</sub> emissions rank among today's societal challenges?
- Does the public know what CCS is? It's benefits, costs & risks?
- Is there support for storing CO<sub>2</sub> underground?
- How do CCS risks rank among other environmental risks?
- Does / how does induced seismicity factor into individuals' views of CCS?
- What CCS monitoring regimes does the public prefer?
- How much trust is there in CCS stakeholder bodies?
- Who do people want to be responsible / liable for CO<sub>2</sub> storage operations?

# What we told participants



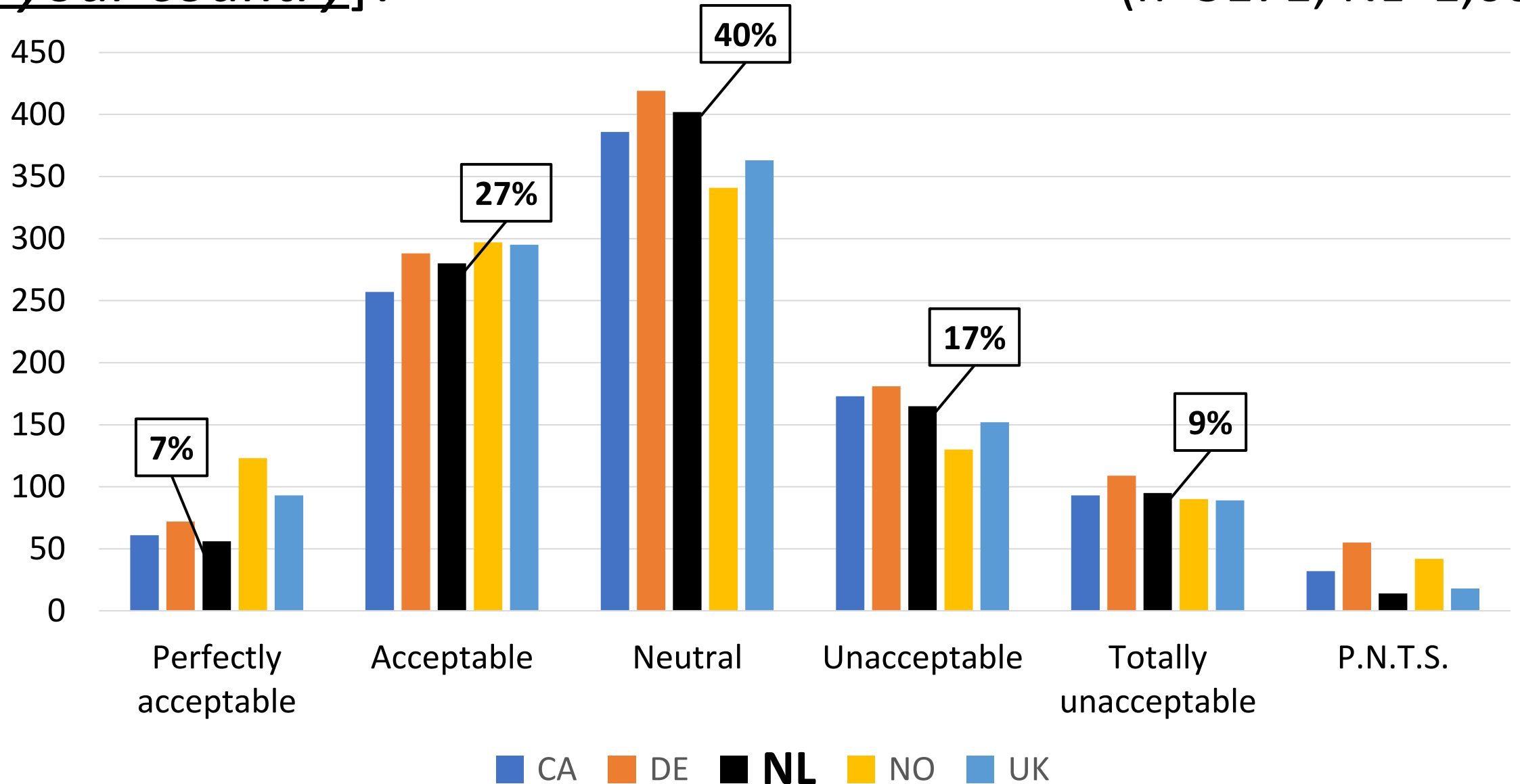
- The purpose of this survey is to find out what citizens in [your country] think about mitigating greenhouse gas emissions and using available technologies to achieve this objective.

## Definition of CCS

Carbon Capture & Storage (CCS) refers to a set of technologies aimed at capturing, transporting, and permanent storage of carbon dioxide (CO<sub>2</sub>) from different emission sources in deep underground reservoirs.

# To what extent do you accept the underground storage of CO<sub>2</sub> [*in your country*]?

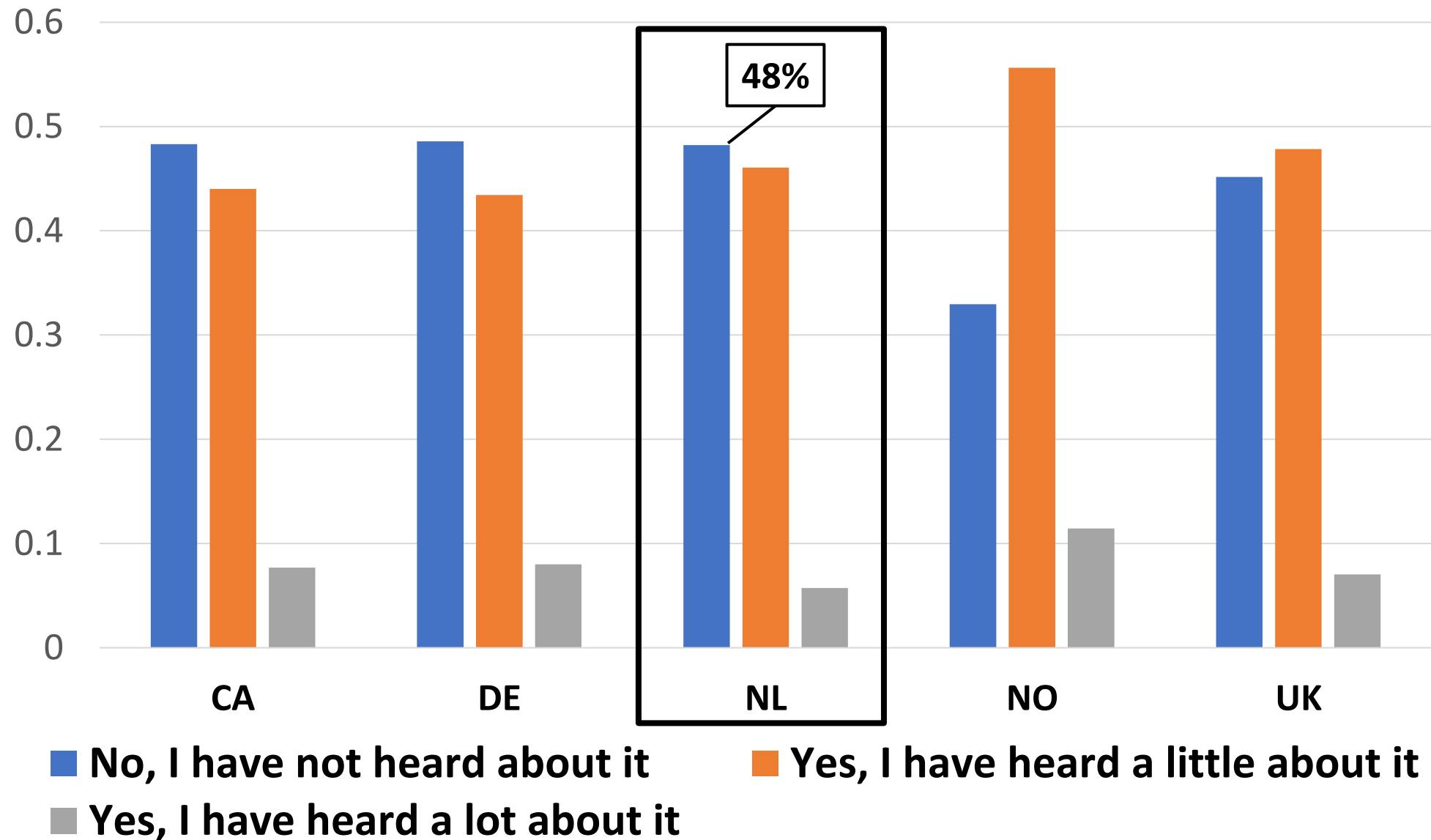
(n=5171; NL=1,000)



Who are these people?

How do they evaluate aspects of CCS?

# Have you ever heard of Carbon Capture and Storage (CCS)? (%)





# Dutch Views: We are especially interested in your level of familiarity with CCS (%)

CCS technologies can capture more than 90% of CO<sub>2</sub> emissions from individual emitting facilities.

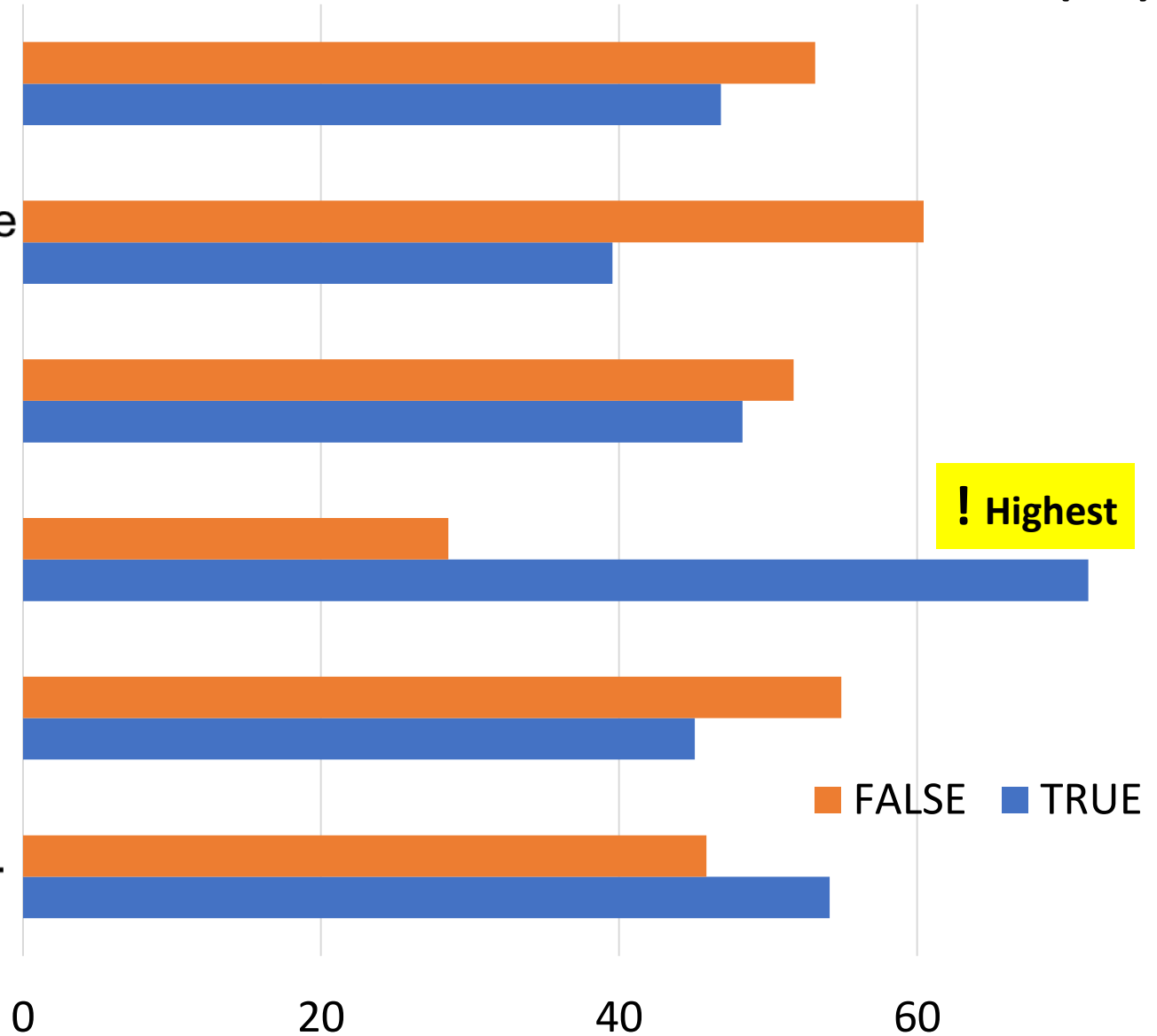
CCS is viewed as the only practical way to achieve effective decarbonization of the industrial sector.

CCS storage of CO<sub>2</sub> occurs deep under the surface, well below groundwater aquifers.

A significant leak of CO<sub>2</sub> to the atmosphere from a depth of more than 1 km is almost impossible.

CCS will always cause earthquakes, which will always be felt by humans at the surface.

CCS is likely to cause groundwater contamination.



New technologies for reducing CO<sub>2</sub> emissions such as CCS, which seeks to permanently store CO<sub>2</sub> emissions deep underground, may have a number of associated benefits and risks.

Some of these are currently still uncertain.

**To what extent do you agree with the following statements regarding CCS?**

## 8 Statements regarding Benefit & Risk Factors.

CCS...

Q1 Helps decrease CO<sub>2</sub> emissions & mitigate climate change (B)

Q2 Is a cheaper option than forcing a reduction in the consumption of fossil fuels (B)

Q3 Leads to an increase in economic growth in my country (B)

Q4 Environment benefits from decrease in CO<sub>2</sub> (B)

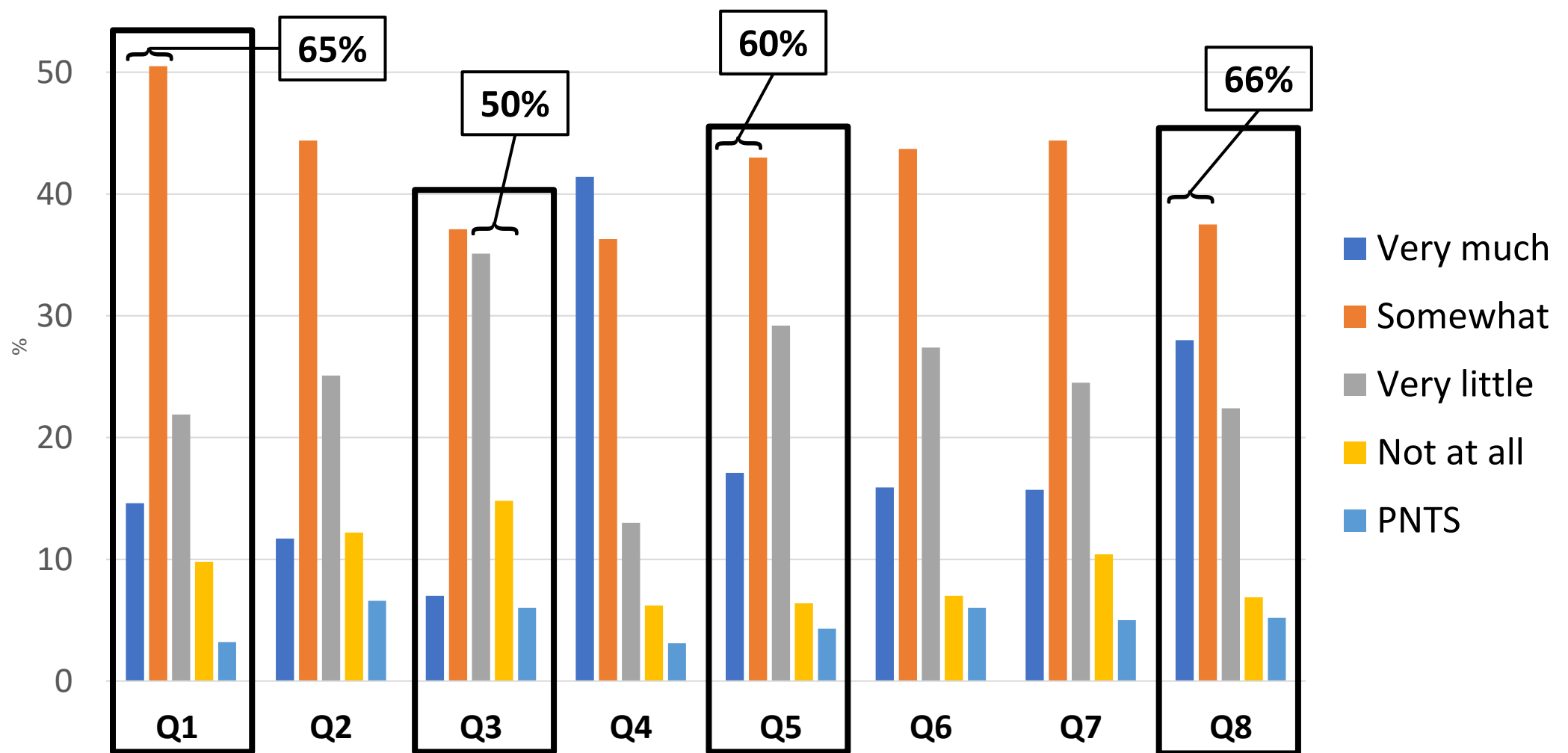
Q5 Likely causes earthquakes (R)

Q6 CO<sub>2</sub> leakage out of underground CCS reservoirs contributes to future climate change (R)

Q7 Lowers the drive to cut carbon emissions (R)

Q8 Is driven more by profit than by the public interest (R)

# Dutch Views



**Q1 Helps decrease CO<sub>2</sub> emissions & mitigate CC.**

Q2 Is a cheaper option than forcing a reduction in the consumption of fossil fuels.

**Q3 Leads to an increase in economic growth in my country.**

Q4 Environment benefits from decrease in CO<sub>2</sub>.

**Q5 Likely causes earthquakes.**

Q6 CO<sub>2</sub> leakage out of underground CCS reservoirs contributes to future climate change.

Q7 Lowers the drive to cut carbon emissions.

**Q8 Is driven more by profit than by the public interest.**

Government & industry groups in [your country] are already considering CCS as a viable technology to mitigate climate change.

When it comes to the development and implementation of CCS, please evaluate the following stakeholders in terms of:

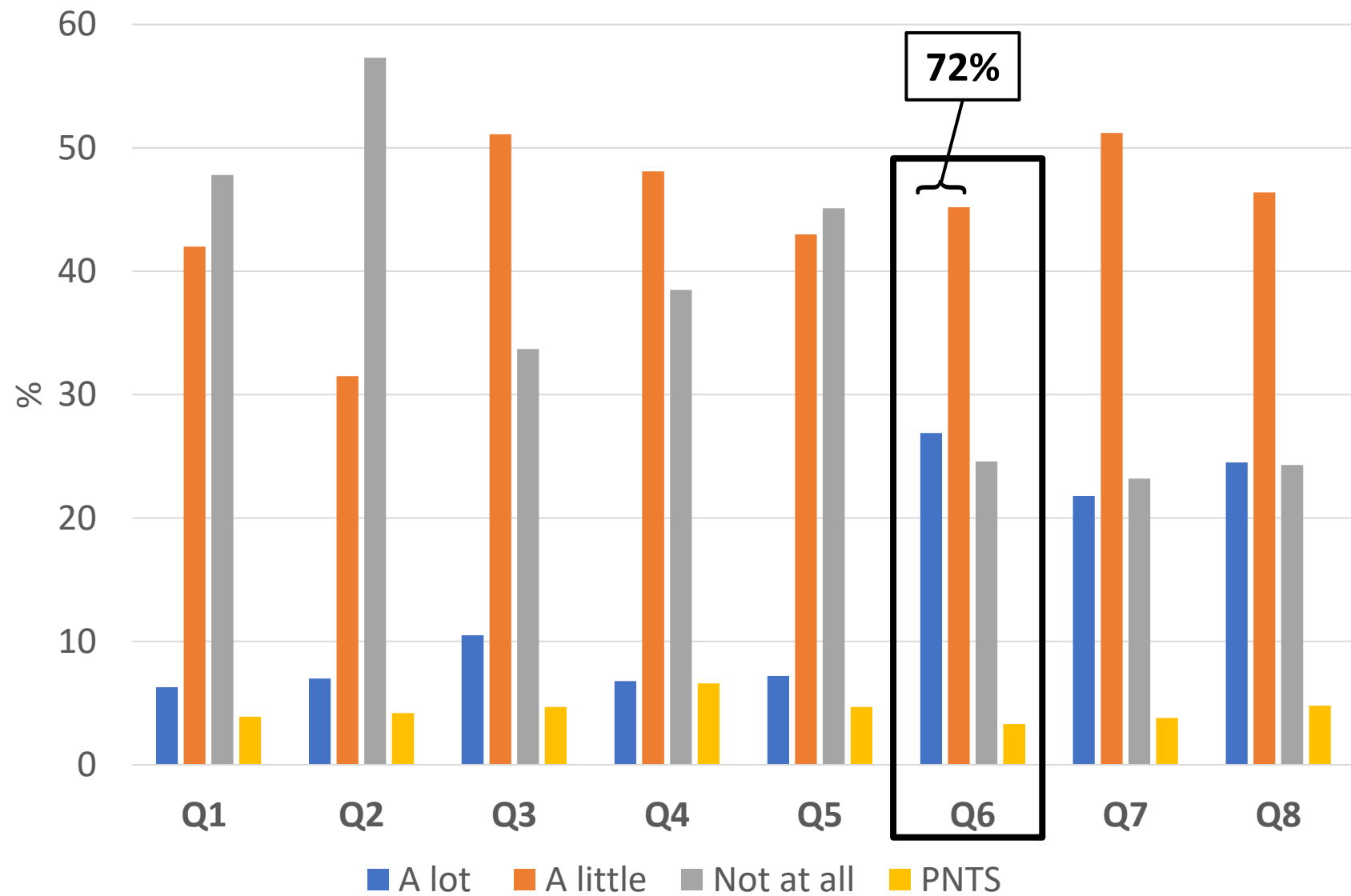
**I think this organization tells you the whole truth about issues concerning Carbon Capture and Storage technology.**

## 8 CCS Stakeholder Groups... [in your country]

1. Domestic energy companies
2. Multinational energy companies
3. The national governmental energy regulator
4. Your state-level government
5. Politicians specializing in energy issues
6. Environmental organizations
7. Specialized independent oversight bodies
8. Publicly funded research organizations & universities

# Dutch Views

1. Domestic energy companies
2. Multinational energy companies
3. The nat. gov. energy regulator
4. Your state-level government
5. Polit. specializing in energy issues
- 6. Environmental organizations**
7. Spec. independent oversight bodies
8. Publicly funded research orgs & Unis



**I think this organization tells you the whole truth about issues concerning CCS technology.**

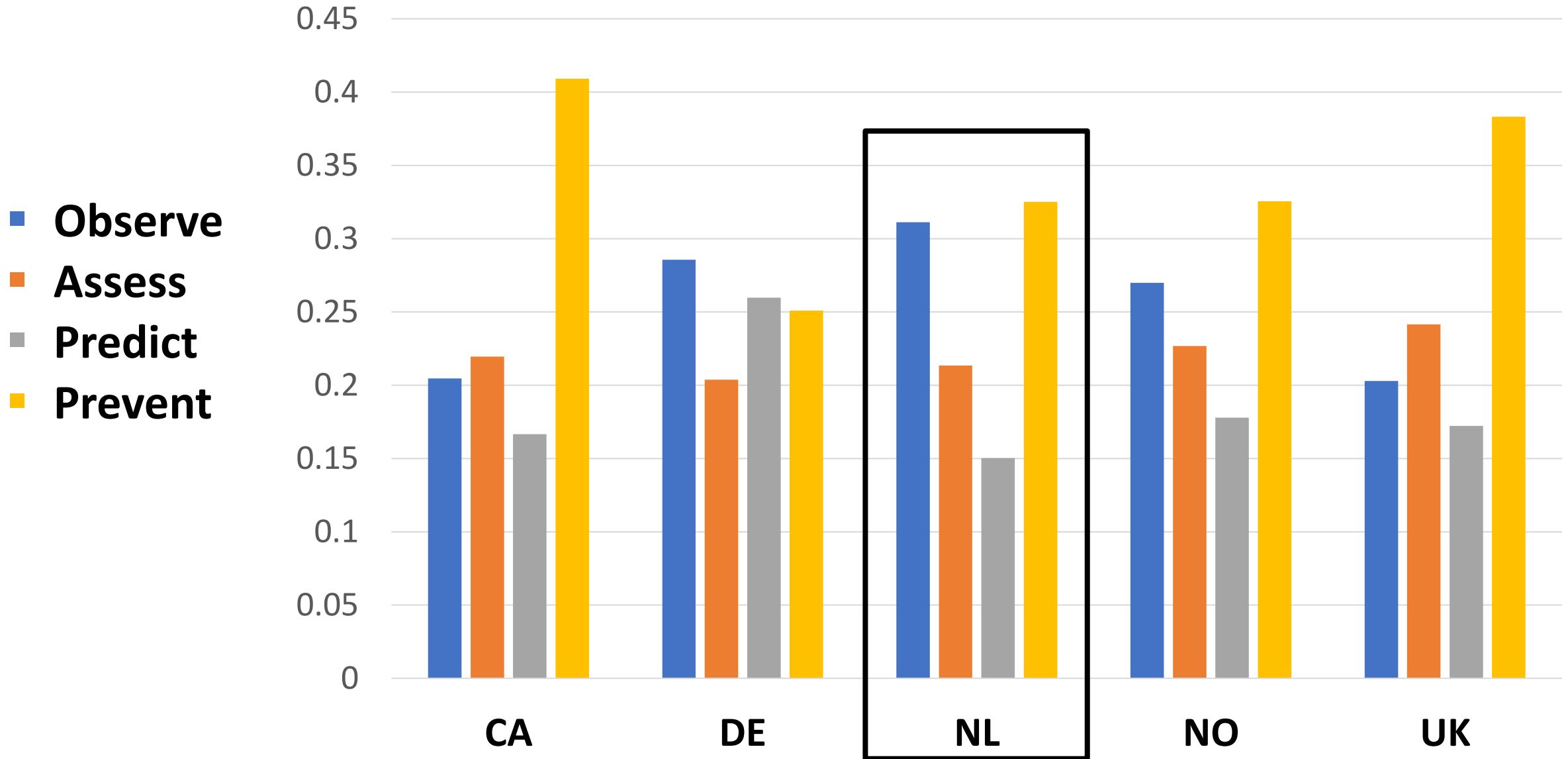
# In your opinion, what should be a minimum acceptable level of monitoring of CO<sub>2</sub> storage facilities to assure their safe operation?



- Mandatory monitoring (observe) of CCS earthquake risks throughout the operation of the facility.
- Mandatory monitoring that can understand (assess) the likelihood & severity of CCS earthquake risks throughout the operation of the facility
- Mandatory monitoring that can forecast (predict) the likelihood & severity of CCS earthquake risks throughout the operation of the facility.
- Mandatory monitoring that can mitigate (prevent) the likelihood & severity of CCS earthquake risks throughout the operation of the facility.



In your opinion, what should be a minimum acceptable level of monitoring of CO<sub>2</sub> storage facilities to assure their safe operation? (%)

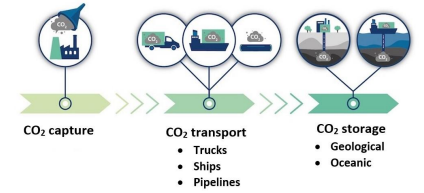


# Economic Experiment

*“If people had a say,  
what would CCS implementation look like?”*

**Choice Experiment** = individuals make repeated choices among alternative scenarios involving variations in benefit–risk/cost trade-offs that mimic real-world situations.

# What we told participants



This second part now **focuses on your preferences for the design of possible CCS projects** in [your country].

Your responses to the following **scenarios will assist companies in the energy sector & policy makers** in [your country] devising CCS implementation **plans & regulations** to assure **the safe & effective mitigation** of greenhouse gas emissions.

## Instructions:

Companies & the regulator in [your country] **responsible for overseeing CCS** are evaluating several sites for CCS **facilities within a 100 km radius of your residence.**

This process involves testing the site-specific underground conditions at each location relevant to the safe operation & long-term storage of CO<sub>2</sub>. **All sites are suitable for CO<sub>2</sub> storage in principle.**

However, the current state of research leaves scientists with **varying levels of uncertainty** regarding the residual **short-term and long-term risks of induced seismicity** potential for CO<sub>2</sub> leakage at each CCS site.

Although the scenarios shown are **hypothetical**, your responses and the results of this **study will guide policy makers** in [your country] as they implement CCS.

# Attributes of CCS & Levels in Experiment

Attribute	Levels
CCS Contribution to Emissions Reduction	<ul style="list-style-type: none"><li>• The plant's annual capacity is equivalent to the emissions of <b>5%</b> of all households in your state.</li><li>• The plant's annual capacity is equivalent to the emissions of <b>10%</b> of all households in your state.</li><li>• The plant's annual capacity is equivalent to the emissions of <b>20%</b> of all households in your state.</li></ul>
Earthquake Risk Monitoring	<ol style="list-style-type: none"><li>1. <b>No</b> monitoring.</li><li>2. Statutory monitoring <b>during</b> the operational phase.</li><li>3. Statutory monitoring <b>during and after</b> the operational phase.</li></ol>
Transparency of seismicity monitoring system	<ol style="list-style-type: none"><li>1. Data will <b>not</b> be shared.</li><li>2. Data sharing <b>only</b> with the national regulator.</li><li>3. <b>Full public</b> data access via the internet.</li></ol>

# Attributes of CCS & Levels in Experiment

Attribute	Levels
<b>Anticipated Seismicity Risk &amp; Severity (Mercalli)</b>	<ol style="list-style-type: none"><li>1. Shaking is only detectable by sensors. Virtually certain to occur.</li><li>2. <b>Weak</b> shaking is not recognized as an earthquake by many people. Likely to occur.</li><li>3. <b>Mild</b> shaking is noticeable. Dishes, windows, doors, and walls are disturbed. Unlikely to occur.</li><li>4. <b>Moderate</b> shaking. Some dishes or windows are broken, and unstable objects are overturned. Very unlikely to occur.</li><li>5. <b>Strong</b> shaking causing heavy furniture moved but negligible damage to buildings. Extremely unlikely to occur.</li><li>6. <b>Violent</b> shaking that causes moderate damage to buildings and infrastructure. Exceptionally unlikely to occur.</li></ol>
<b>HH Electricity Cost Burden (HH/year)</b>	<ul style="list-style-type: none"><li>• +€250</li><li>• +€200</li><li>• +€150</li><li>• +€100 or \$, Kroner</li><li>• +€50</li><li>• +€25</li><li>• ±€0</li></ul>

# Example of Choice Set in Stage 2 of Study

	Choice 1	Choice 2
<b>CCS Contribution to Emissions Reduction</b>	The plant's annual capacity is equivalent to the emissions of 20% of all households in your state.	The plant's annual capacity is equivalent to the emissions of 5% of all households in your state.
<b>Earthquake Risk Monitoring</b>	Statutory monitoring during the operational phase.	Statutory monitoring during and after the operational phase.
<b>Transparency of seismicity monitoring system</b>	Data will not be shared.	Full public data access via the internet.
<b>Anticipated Seismicity Risk &amp; Severity (10-year horizon)</b>	Mild shaking is noticeable. Dishes, windows, doors, and walls are disturbed. Unlikely to occur.	Weak shaking is not recognized as an earthquake by many people. Likely to occur.
<b>HH cost burden (household/year)</b>	+\$100	+\$250
<b>Your Choice?</b>	<input type="radio"/>	<input type="radio"/>

**Method:** Respondents made **8** choices randomly assigned from a design 48 pairs.

-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

GHG Reduction

Monitoring 2

Monitoring 3

Transparency 2

Transparency 3

Seismicity 2

Seismicity 3

Seismicity 4

Seismicity 5

Seismicity 6

HH Cost

# Dutch Preferences

! Don't care about CC benefits

! Monitoring Matters

! Transparency Matters

!

Strongest Seismicity Concerns

!

!

NL



-1.0 -0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0

GHG Reduction

Monitoring 2

Monitoring 3

Transparency 2

Transparency 3

Seismicity 2

Seismicity 3

Seismicity 4

Seismicity 5

Seismicity 6

HH Cost

In comparison

! Don't care about CC benefits

! Monitoring Matters

! Monitoring Matters

Strongest Seismicity Concerns

CA

DE

NL

NO

UK

!

!

!



Thank you!

# What statement about climate change do you agree with?

