



# PVC Pipes Readiness for the Hydrogen Economy

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# From natural gas to hydrogen

Netherlands:

- 125 000 km gas distribution grid
- 2/3 consists of PVC pipes
  - both PVC-Hi and PVC-U



Scenario

Permeation

# No showstoppers in the literature

- What else do we need?
  - Permeation of hydrogen through pipes
  - Permeation of hydrogen through couplers
  - Maximum angle of deflection of the couplers
- Safety issues?
- Loss of energy?
- Environmental issues?

Scenario

Permeation

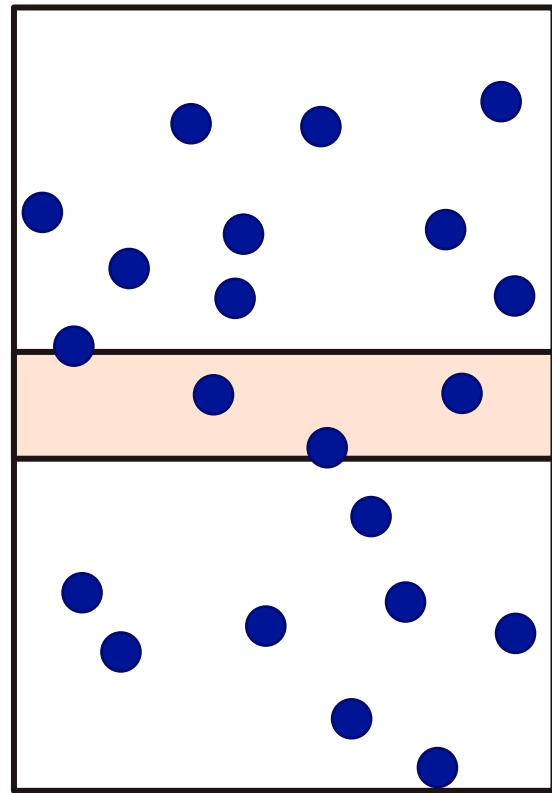
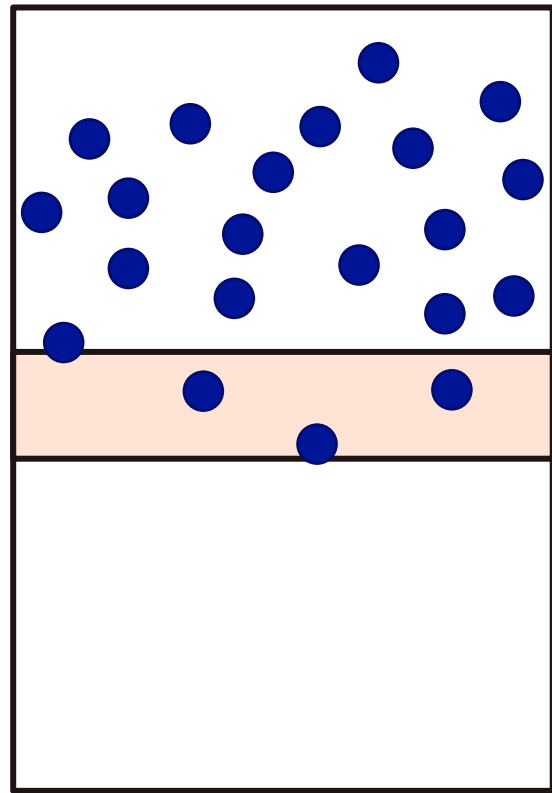
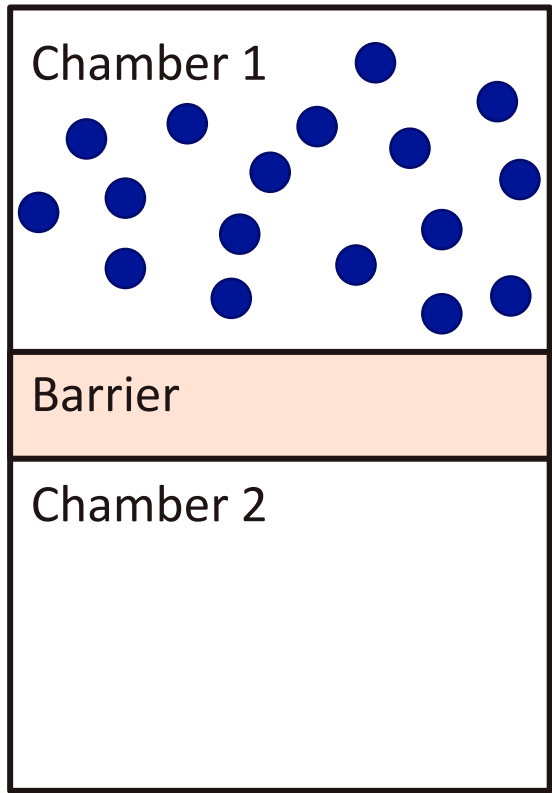
Deflection

CONCLUSION

Next Steps



# Process of permeation



Scenario

Permeation

Deflection

Conclusion

Next Steps

# Dependencies

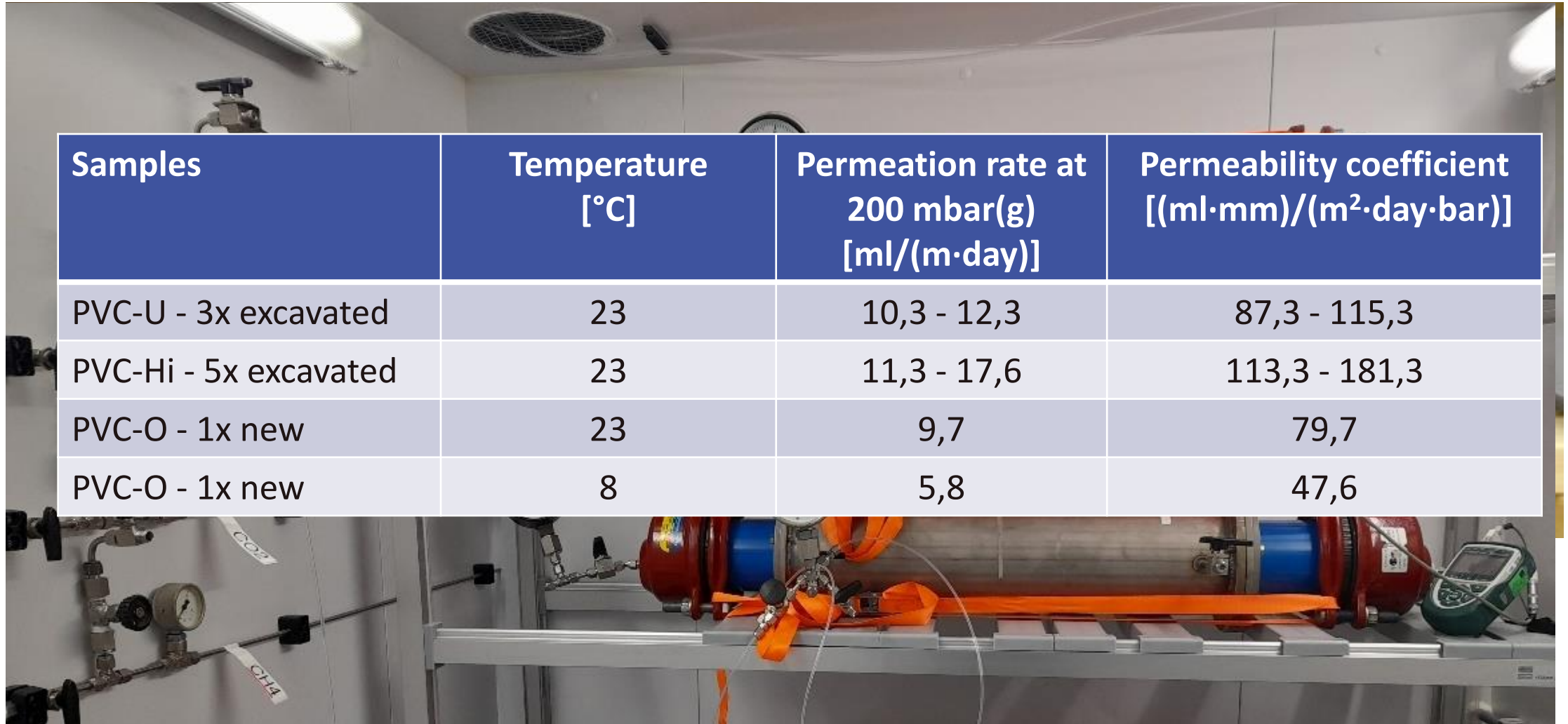
- Permeation rate -  $Q$
- Permeability coefficient -  $P_c$ 
  - Gas
  - Material
  - Temperature
- Area of the barrier layer -  $A$
- Partial pressure difference -  $p$
- Thickness of the barrier layer -  $e$

$$Q = P_c \cdot \frac{A \cdot p}{e}$$

Property

Application

# Measuring permeation



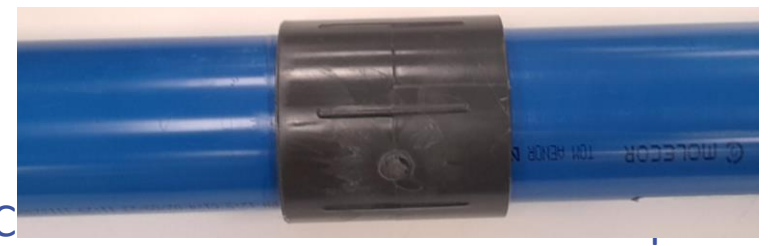
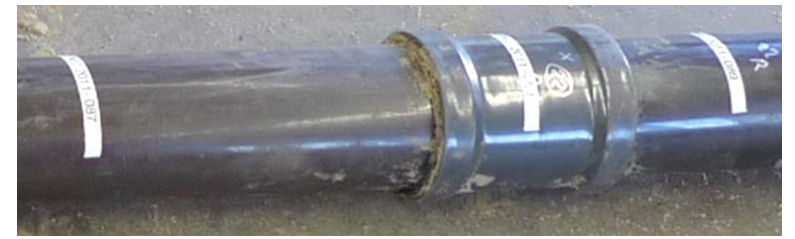
| Samples               | Temperature [°C] | Permeation rate at 200 mbar(g) [ml/(m·day)] | Permeability coefficient [(ml·mm)/(m <sup>2</sup> ·day·bar)] |
|-----------------------|------------------|---|--|
| PVC-U - 3x excavated  | 23               | 10,3 - 12,3                                 | 87,3 - 115,3   |
| PVC-Hi - 5x excavated | 23               | 11,3 - 17,6                                 | 113,3 - 181,3  |
| PVC-O - 1x new        | 23               | 9,7   | 79,7   |
| PVC-O - 1x new        | 8                | 5,8   | 47,6   |

# Permeation of joints

End c

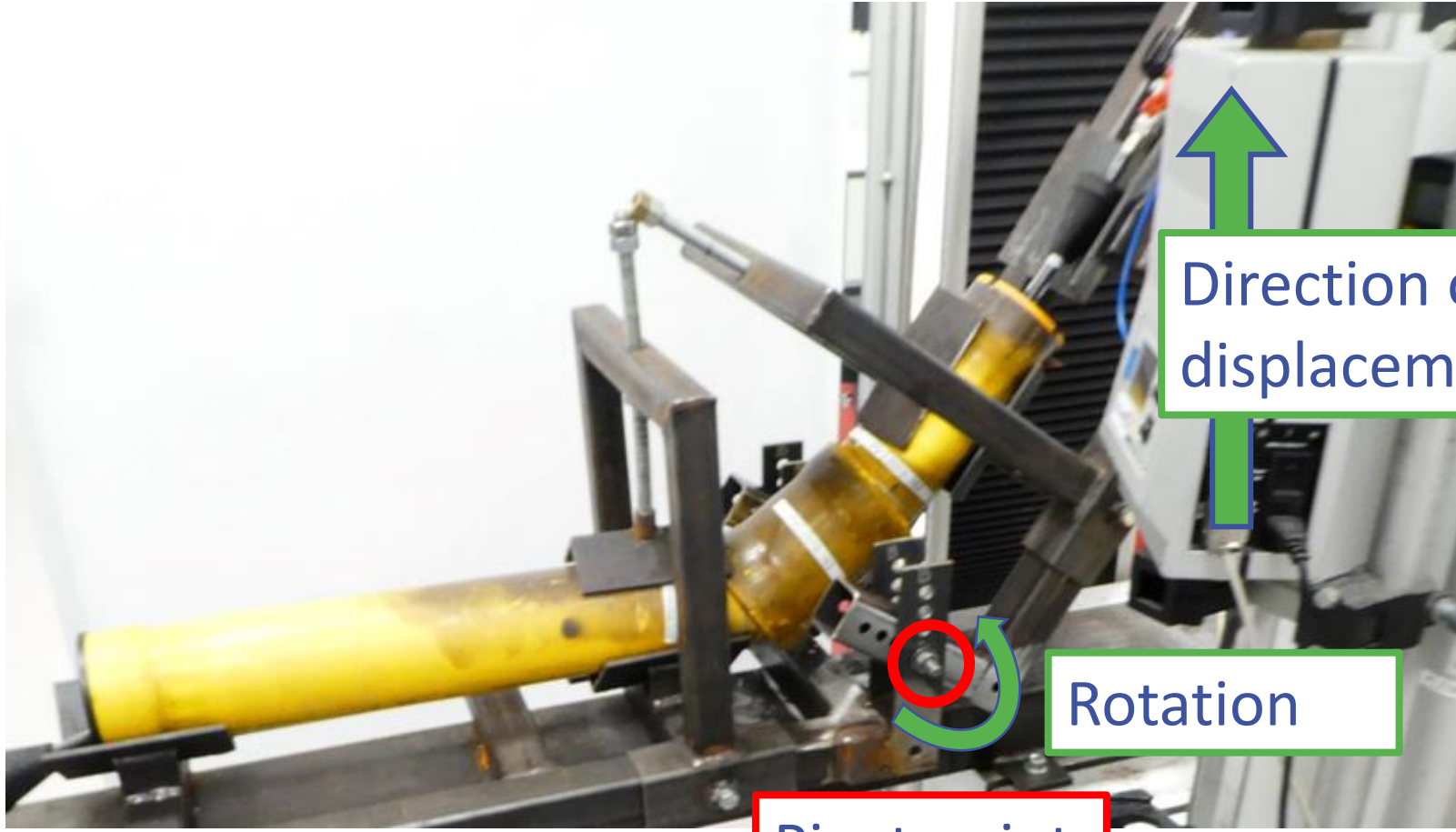
Steel jacket pipe

| Samples               | Temperature [°C] | Permeation rate at 200 mbar(g) [ml/day] |
|-----------------------|------------------|---|
| PVC-U - 2x excavated  | 23               | 6,5 – 7,5                               |
| PVC-Hi - 2x excavated | 23               | 7,3 – 7,4                               |
| PVC-O - 1x new        | 23               | 4,9                                     |
| PVC-O - 1x new        | 8                | 2,9                                     |



Permeation rate is similar for pipes of the same length.  
Cannot derive a permeability coefficient.

# Measuring angle of deflection



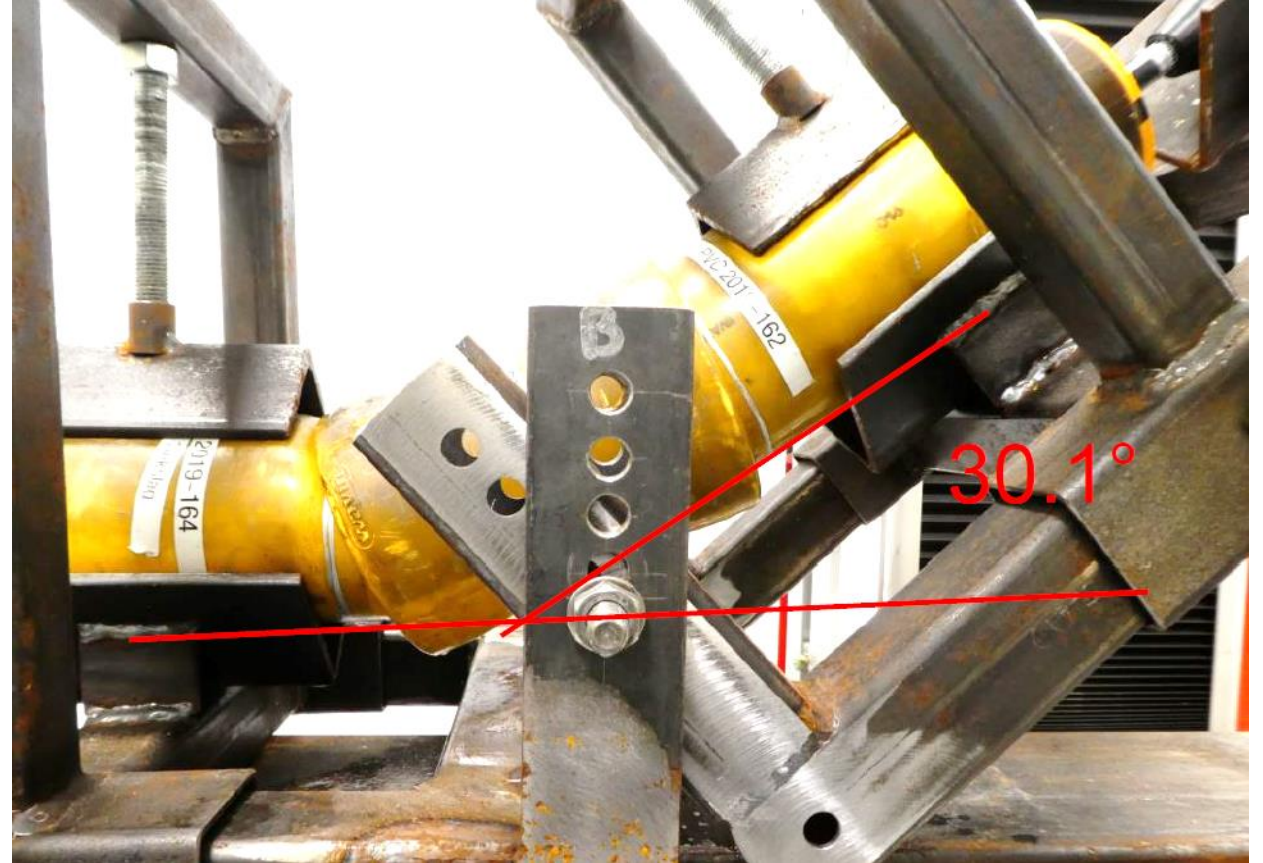
Direction of displacement

Rotation

Pivot point

# Angle of deflection

- Excavated joints (socket fitting):
  - 4x additional aging at 60°C, 1000 hours, in hydrogen
  - 4x not aged
- Angle of deflection at leakage always  $\geq 5^\circ$
- Requirement  $4^\circ$



# Conclusion

- Permeation rate is determined
  - Estimate loss of hydrogen for practical applications
- Permeation rate of the joints is similar to the permeation rate of a pipe with the same length
- Maximum angle of deflection until leakage is determined
  - Both aged and not aged meet requirements

# Pilot projects:

- Lochem <https://www.alliander.com/nl/energietransitie/pilots-met-waterstof/lochem/>
- Hoogeveen <https://groenemorgenhoogeveen.nl/waterstof-hoogeveen>
- Stad aan 't Haringvliet <https://h2goeree-overflakkee.com/project/stad-aardgasvrij-hydrogen-city/>
- Wagenborgen <https://www.groningerhuis.nl/projecten/waterstofwijk-wagenborgen/>
- The green village <https://www.thegreenvillage.org/project/waterstofstraat/>
- HyDelta <https://hydeltanl/>



## Project with PVC4Pipes: Goals

- Give proof of evidence of the **long term suitability** of PVC pipelines (including joints) to distribute hydrogen in actual pilot settings in place in the Netherlands, by investigating the PVC material quality
  - before putting pipes in operation (2024)
  - after 2 years operation (2026)
- **Minimum duration** of the project is 2 years. There is a possibility to extend the time for some of the pilots which are planned to run up to 10 years.
- Give insights in the quality of PVC pipes and fittings after some years under **practical conditions** as applicable in a gas distribution gas grid transporting **100% hydrogen**.
- Project proposal has been presented to a Committee of experts of NBNL dedicated to Hydrogen. **All DSOs members of NBNL** operating the 5 pilots using PVC pipes, have **confirmed their interest** to participate in such project.

# Project with PVC4Pipes: Milestone Plan

1. Perform initial tests on to establish **initial quality**
  - a. 6 PVC pipes taken from the 5 pilots tested by means of **tensile impact tests**.
  - b. 5 PVC joints taken from the 5 pilots tested by means of a **visual and mechanical tests** on the rubber sealing material in the joint
2. Let the pilots run for at least 2 years. Investigations **in case of failure**.
3. Perform tests to identify any **effect of the hydrogen**
  - a. 6 PVC pipes taken from the 5 pilots tested by means of **tensile impact tests**
  - b. 5 PVC joints taken from the 5 pilots tested by means of a **visual and mechanical tests** on the rubber sealing material in the joint
  - c. 5 PVC joints taken from the 5 pilots on which to perform a **leak tightness tests**
4. **Final reporting** on the project and outcomes

# Acknowledgements



PVC **4** PIPES

Thank you!

[pvc4pipes.com](http://pvc4pipes.com)



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### PVC-O pipe

