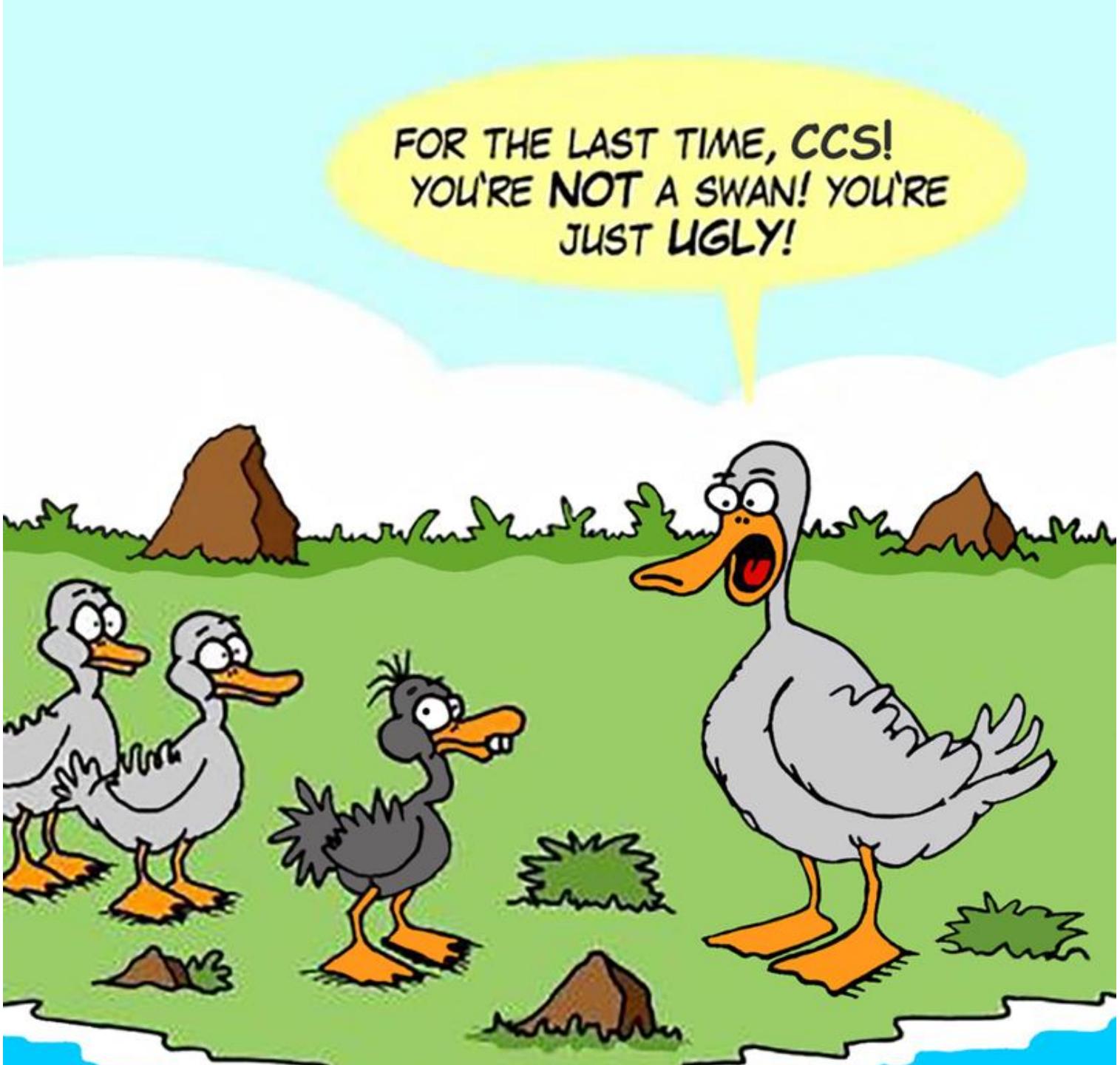
FOR THE LAST TIME, CCS! YOU'RE NOT A SWAN! YOU'RE JUST UGLY!

Rotterdam Opslag en Afvang Demonstratieproject (ROAD)

Lessons Learnt

CATO Meets the projects 15th November 2017

Andy Read, ROAD Technical Director

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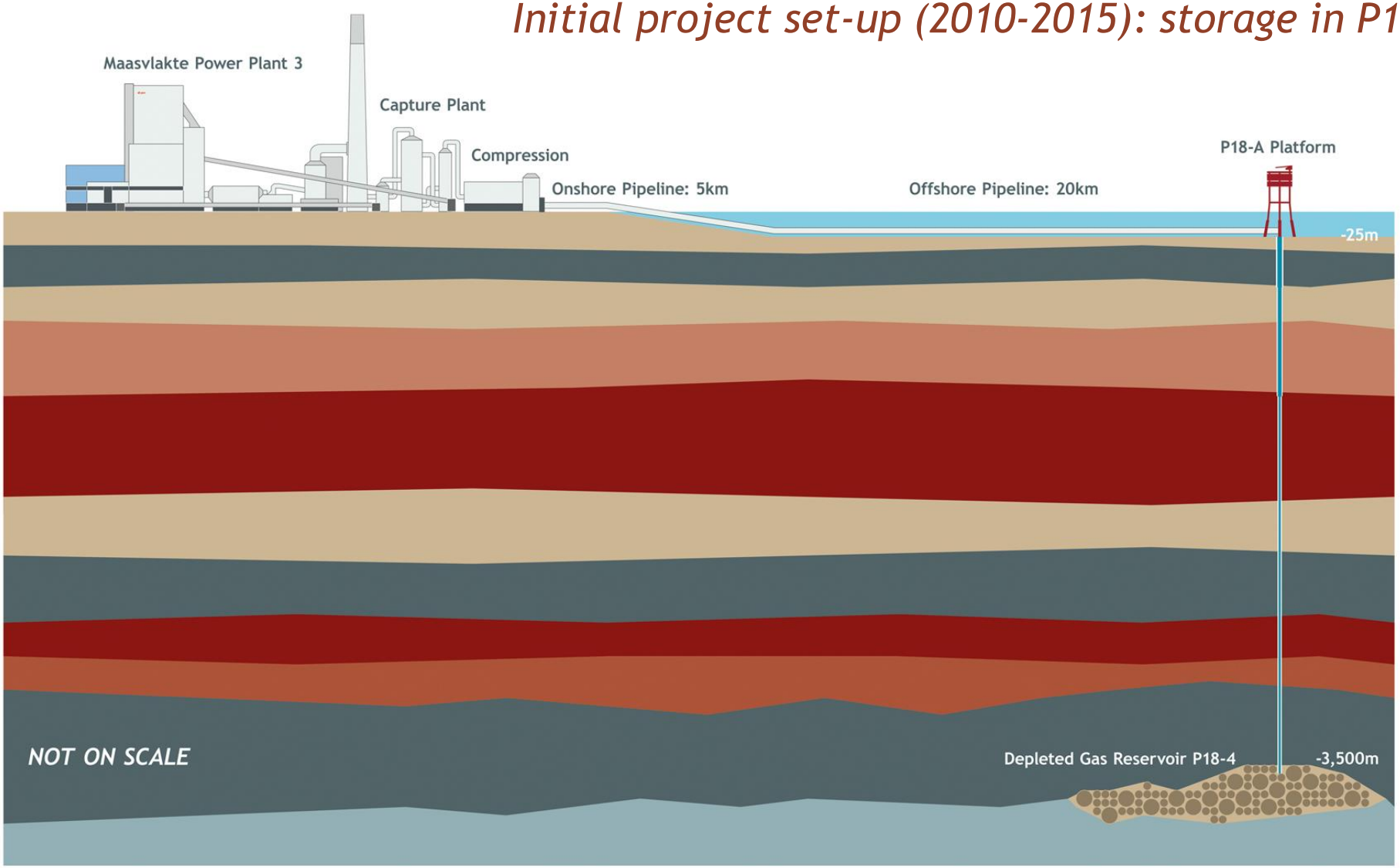
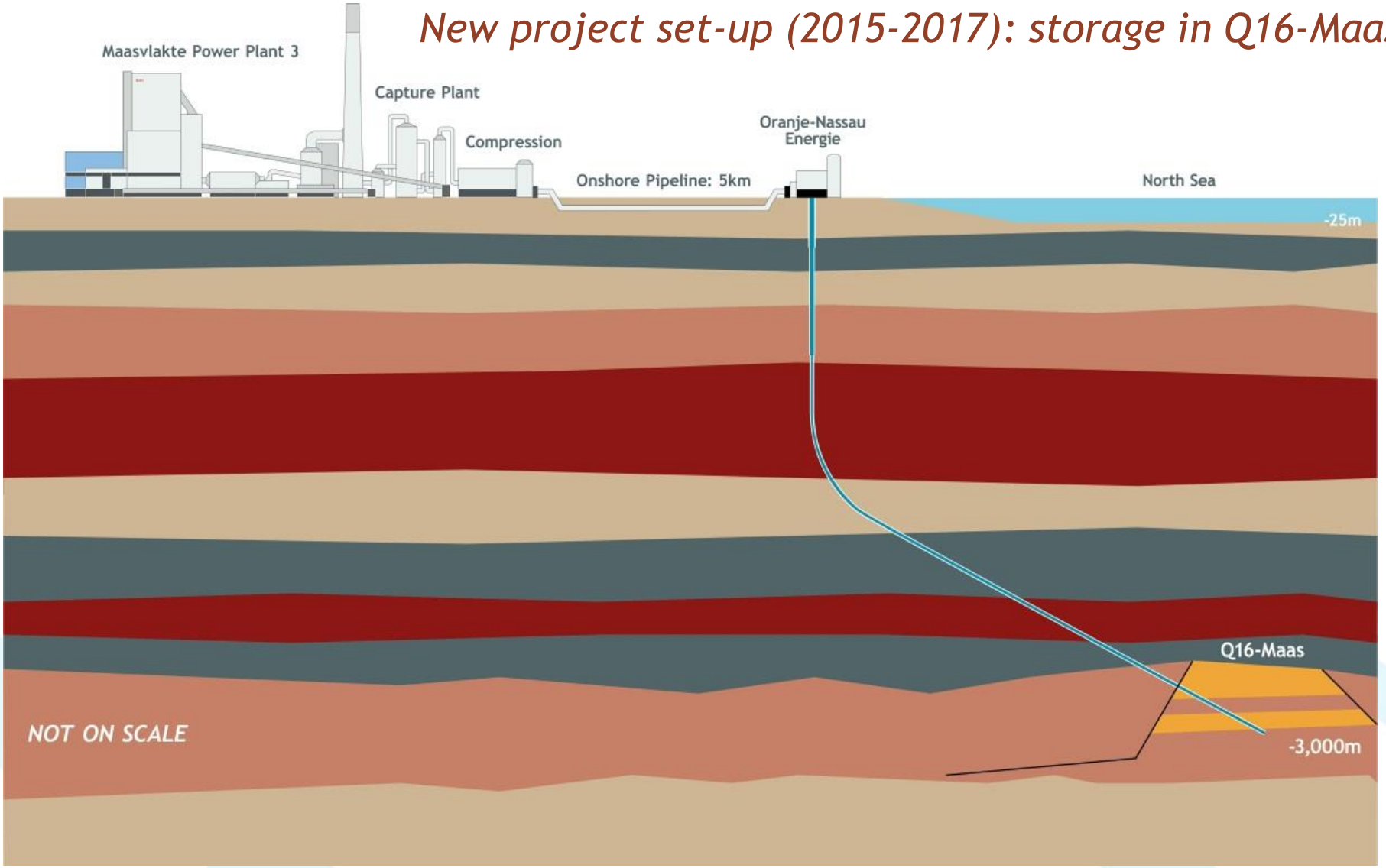
European Energy Programme for Recovery

Initial project set-up (2010-2015): storage in P18-4



New project set-up (2015-2017): storage in Q16-Maas



Highlights on Capture, Transport & Storage (1)

Capture

- Proven capture technology available on market:
  - Multiple suppliers offering robust designs
- Some technical unknowns due to limited experience:
  - Design of 2012 would have needed some modification
  - Wise to allow for some contingency and some ‘teething’ problems
  - ... but engineers can solve all the engineering problems
- **Conclusion: the technology is available and will work**

Highlights on Capture, Transport & Storage (2)

Transport

- Some remaining technical uncertainties:
  - How to predict and manage two-phase flow behaviour (including transients)
  - QRA modelling for (onshore) CO_2 transport pipeline needs further development (e.g. “domino effect”)

- But the pipeline is largely conventional technology.

- **Conclusion: the technology is available and will work**

Highlights on Capture, Transport & Storage (3)

Storage

- Some remaining technical uncertainties:
  - Transients and two-phase flow in the well
  - Tolerance of the well to repeated temperature changes
- But a safe design was developed.
- Major regulatory barrier: Storage Liabilities.
  - The costs of long term storage liabilities are largely controlled by regulators and/or Government, and are largely out of the control of the operator. These liabilities need to be carried by the Government.
  - Especially true for large-scale or long-term projects.

- **Conclusions:**
  - **The storage technology is available and will work,**
  - **But storage regulation is not (yet) fit for purpose.**

Why did ROAD fail?

- **Nobody was prepared to pay for it**

- Industrial partners do not have a business case:
  - Neither short-term nor long-term (CO_2 price doesn't work on its own)
  - Perception that "industry must contribute" was not shared by industry!

- Public funders did not have sufficient public and political support:
  - CCS perceived as extending life-time of coal plants
  - CCS "competes" with investments in renewables
  - CCS positioned as (optional) measure of 'last resort'

- **In summary: ROAD was a project without a customer**

road CCS

Why did other European Projects Fail?

White Rose (UK)

"Too expensive" and too much cross-chain risk

Don Valley (UK)

No UK Govt funds

ROAD

Not enough funds

Porto Tolle (Italy)

No Govt funds and no permit

Compostilla (Spain)

No Govt funds

Mongstad (Norway)

Environment?, cost?, doubts over source?

Peterhead (UK)

"Too expensive"

Bełchatów (Poland)

No Govt support

Jänschwalde (Germany)

Public opposition to onshore storage

Key lesson learnt

- Government **has to fund CCS**:
  - There is no other customer

- To succeed the projects must be designed and run to maximise long term Government support.

- Therefore do things which make it easy for the Government to support you, and hard for them to stop.

Personal recommendations for a new project

- Start small – if expensive, it's too tempting to cut the budget
- A "no regrets" first step:
  - No implied lock-in to follow-on projects – that scares people
  - But scalable – support the long term decarbonisation vision
- Select non-controversial capture and storage sites
  - e.g. waste incinerator (avoid fossil fuel if possible) and off-shore gas storage
- Create a local (public) value proposition and local supporters – e.g. supporting jobs, local industry, CO_2 use if possible (e.g. greenhouses)
- Avoid large profits for private parties (politically inexplicable)
  - Therefore Government / public bodies must carry long term risks (e.g. storage liabilities)
- Create / support an active pro-CCS political lobby
  - Publicly, proactively advocate the project and CCS in general

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