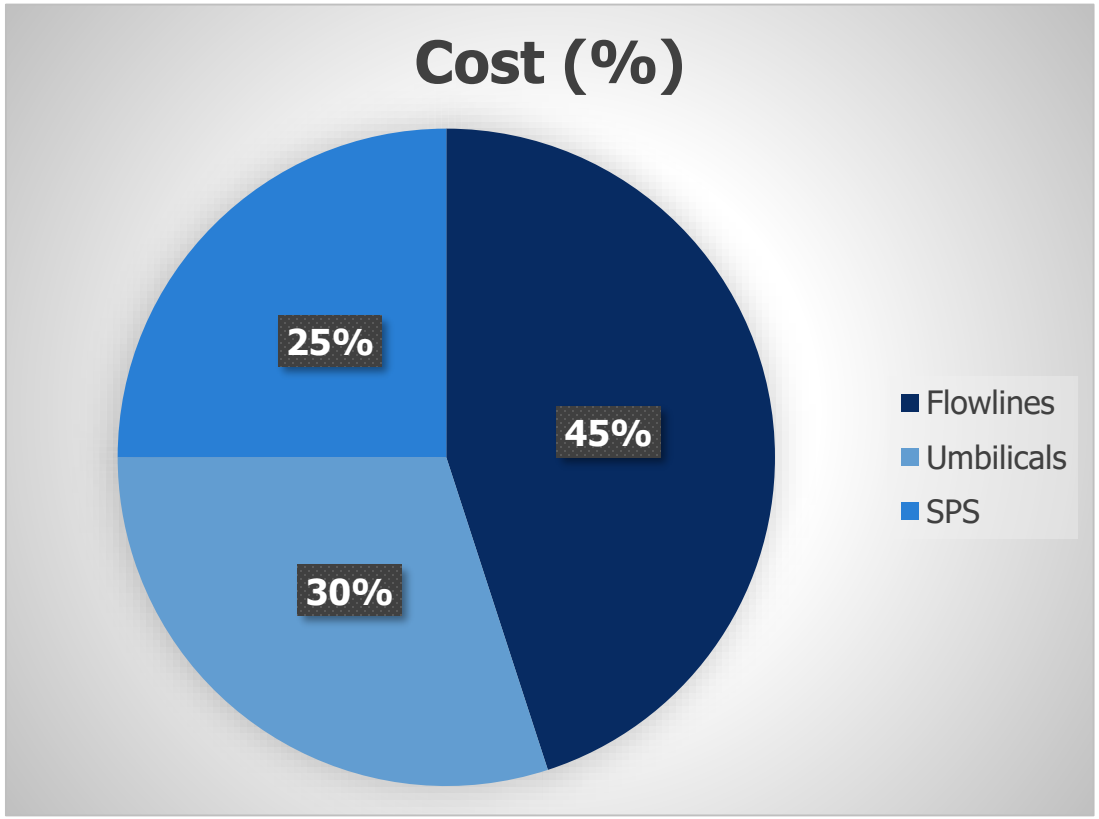
The Oil & Gas Technology Centre
Your Innovation Partner

Crondallenergy
Floating Production & Subsea Specialists

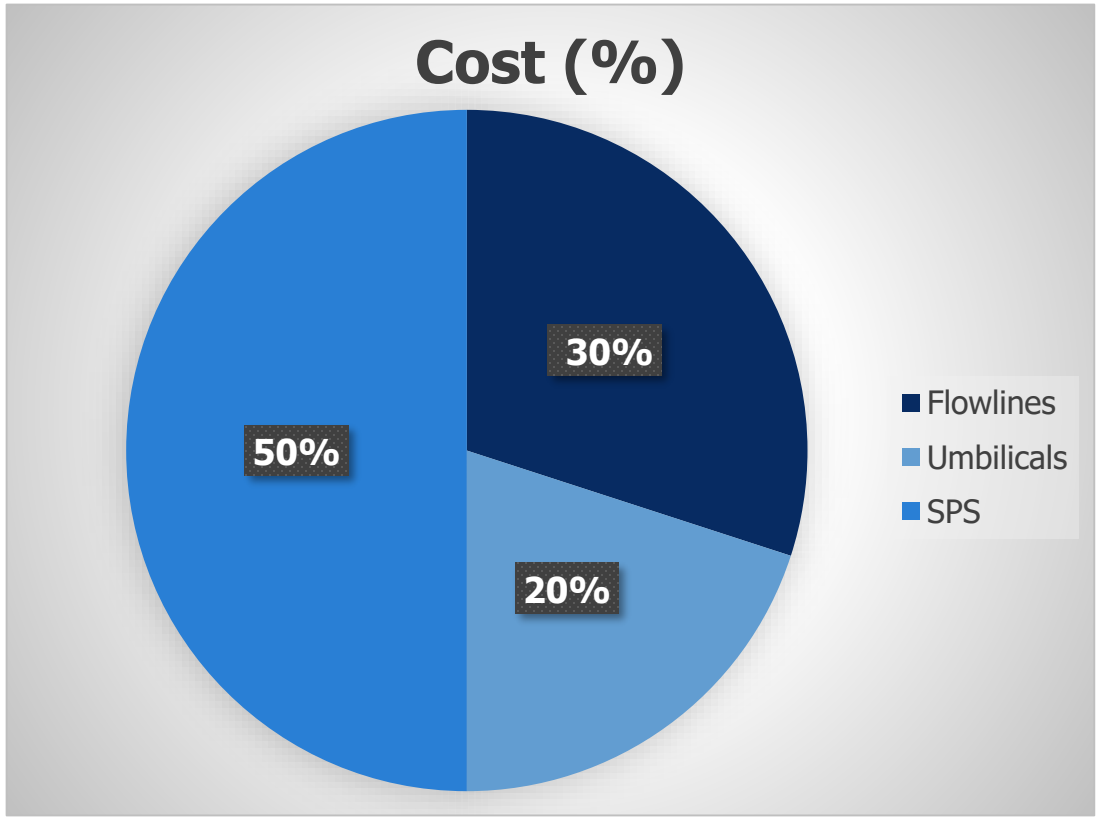
Subsea Flowlines - Advanced Flow Management & Reuse

Are flowline costs significant ?

Long step-out 45%



Short step-out 30%



Is there an opportunity to lower flowline cost through technology & by applying The Circular Economy ?

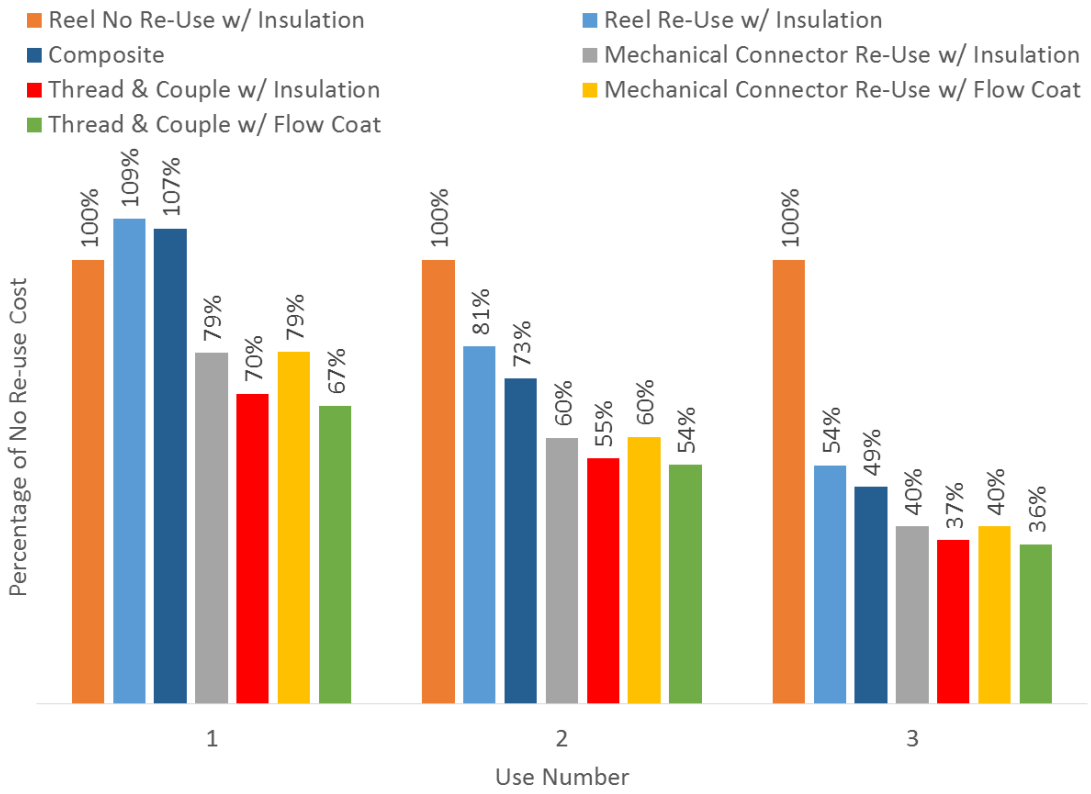
© Crondall Energy Subsea Ltd 2017
All rights reserved

Flowline Technology

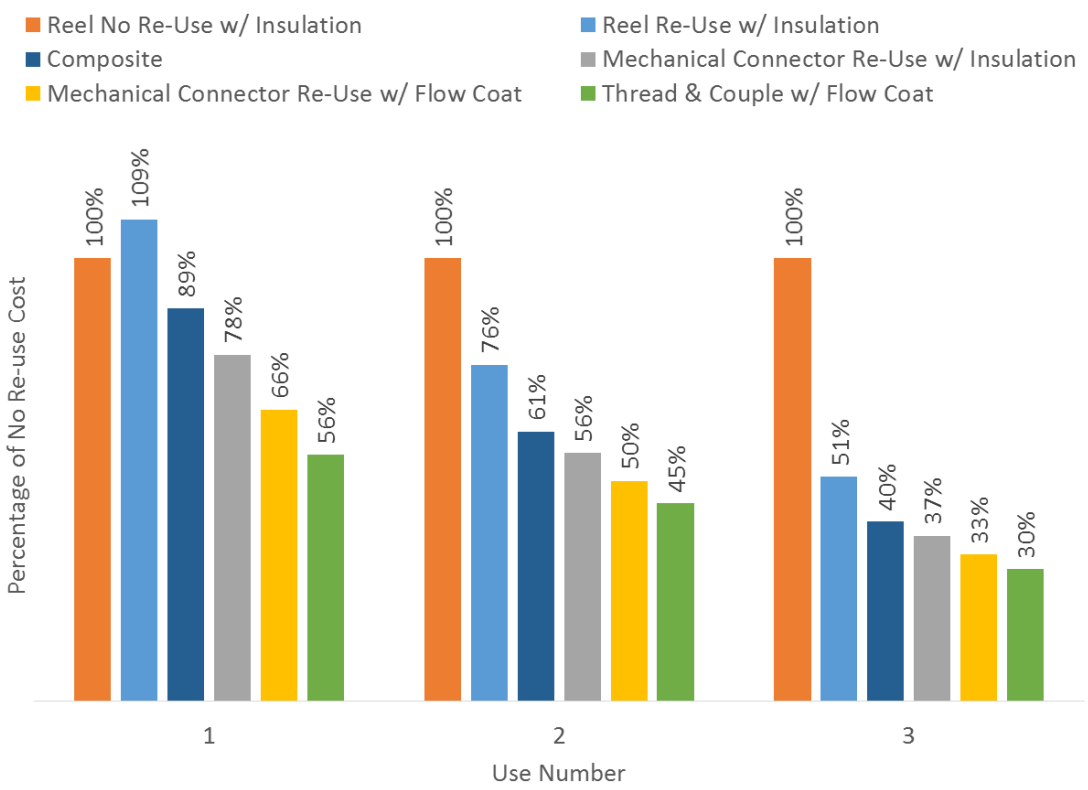
© Crondall Energy Subsea Ltd 2017
All rights reserved

Cost Assessment 6-inch x 10 km

Carbon Steel



CRA Mechanically Clad



- **20km sees a further small reduction on re-use**

© Crondall Energy Subsea Ltd 2015
All rights reserved

Flow Assurance

Conventional Flow Management:

- Keep fluids hot (high levels of insulation)
- Chemically treat with inhibitors (umbilicals and service flowlines)

The Aim:

- Eliminate insulation
- Minimise chemical injection

Possible Solutions:

- Cold flow – modify fluid behaviour to avoid deposition and blockage in conventional pipeline systems
- Advanced surface preparation – modify pipeline inside surface to prevent deposit adhesion and blockage

© Crondall Energy Subsea Ltd 2015
All rights reserved

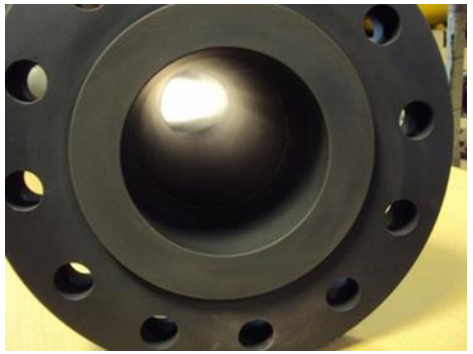
Internal Surface Coatings

To realise flow assurance benefits:

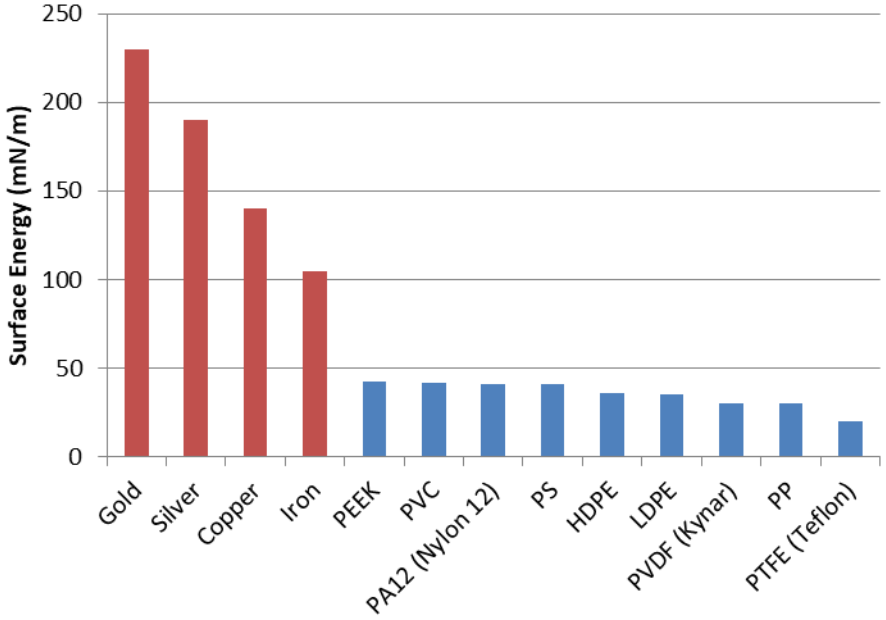
1. Low surface energy
2. Low surface roughness

Advanced polymer coatings are under development

- Presents an opportunity to learn from other industries



Example coatings (not exhaustive)			
Name	Type	TRL	Comment
Whitford Plastics	PTFE	3	Low surface energy and surface roughness; likely to have good flow assurance properties.
Victrex	PEEK	3	Low surface energy and surface roughness; likely to have good flow assurance properties.
Tuboscope	Epoxy	4	Corrosion coating; limited flow assurance benefit. Field proven for down-hole service
Bredero	Epoxy	5	Flow coating; limited flow assurance benefit. Field proven for gas pipeline service.



- Short length non-welded joints are enablers for this technology
- Composite pipe offers similar internal surface & benefits

© Crondall Energy Subsea Ltd 2015
All rights reserved

Internal Coatings - Conclusions

Coatings exist which have the potential to eliminate insulation and flow assurance chemicals.

Coatings also protect the pipe against corrosion

Coatings could simplify upset operations

However:

- Currently no field proven systems. Significant application-specific research and testing is needed.
- Behaviour of coatings under pressure is a major uncertainty.
- May imply increased risk of blockage as a trade off for reduced CAPEX
- Reliance solely on internal coatings requires intervention strategies.
- Not suitable for conventional welded construction

© Crondall Energy Subsea Ltd 2015
All rights reserved

Mechanically Connected Pipelines

Not a new idea

Joint Industry Projects:

- Trevor Jee Joint Industry Programs (1995, 2000)
- 2H Threaded Riser and Flowline JIP (2000)
- DNV Mechanically Connected Pipelines 2016/17

Example connectors (not exhaustive)			
Name	Type	TRL	Comment
GMC	Stab + pressure	4	Weld on connector, extensively tested. Post test re-design unqualified. Field proven on riser and tendon use. Some pipeline field history: BP Harding 2005.
Zap-lok	Friction Stab	5	Extensively tested; Field proven. Current w.d. limit 100m. Further development needed for deeper water.
VAM TTR	Threaded + coupled	4	Extensive use downhole – avoids welding if use more connections; suited to coating application.
Marine Direct	Stab + ferrule make-up	2	Weld on connector, preloaded BX seal hubs. In detail design; qualification planned
Strength and fatigue better than welded pipe.			

© Crondall Energy Subsea Ltd 2017
All rights reserved

Mechanically Connected Pipelines - Conclusions

Advantages:

- Internal coatings
- Recovery and re-use
- Higher strength steel
- Reduced CAPEX

However:

- Reliability concerns
- Long term integrity management
- Connector/pipe interaction
- Limited Track record for flowlines

© Crondall Energy Subsea Ltd 2015
All rights reserved

Composite pipe

An interesting alternative to steel pipe.

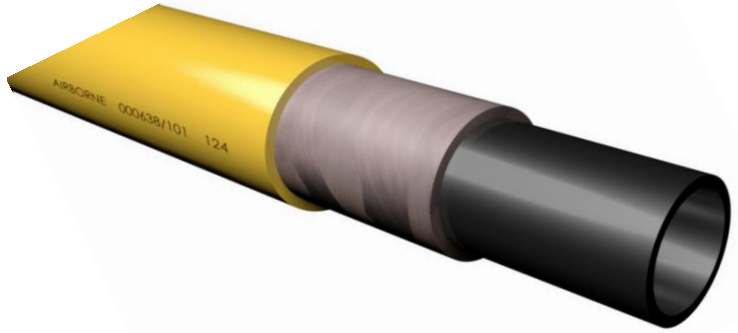
Qualified products from Airborne & Magma

Advantages:

- Flow assurance
- Corrosion
- Suitable for Reuse
- Install by CSV
- Lower cost tie-ins

However:

- Limited to 6 or 8-inch diameter
- Hydrodynamic stability
- Limited supply chain
- Limited track record



© Crondall Energy Subsea Ltd 2015
All rights reserved

Re-usable pipelines

Most existing flowlines will be decommissioned in-situ

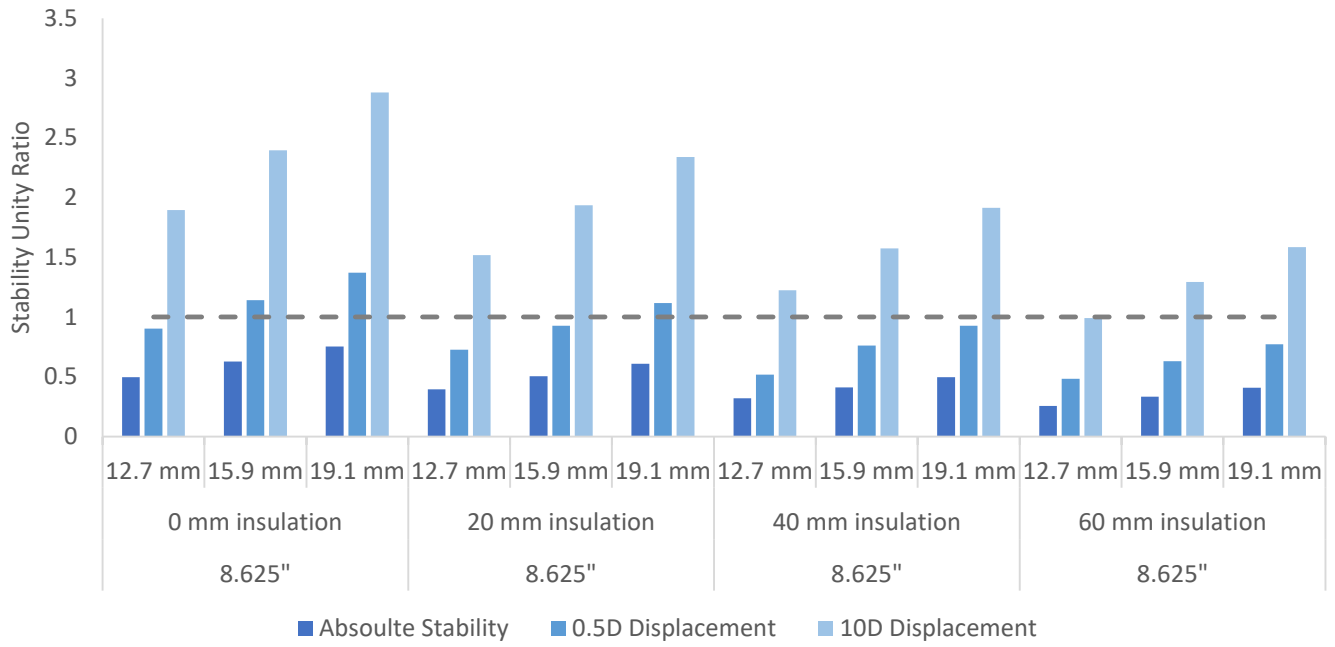
Drivers for Re-use for future developments:

- **Commercial arrangements**
- **Pipe not returned to shore between deployments**
  - Implies cost effective offshore inspection/certification can be developed to assure next user of retrieved condition
- **On bottom pipeline design is adopted**
  - Reduces cost of first use
  - Reduces cost of retrieval
  - Requires agreement with fishermen

© Crondall Energy Subsea Ltd 2015
All rights reserved

On bottom design - Stability

- **NNS Steel pipes are stable within displacement limits**
- **CNS Steel pipes are stable within displacement limits**
- **SNS Steel pipes are not stable**
- **Effect of insulation**
- **Composite pipe is not stable**



© Crondall Energy Subsea Ltd 2015
All rights reserved

On bottom design – Lateral Buckling

Welded Pipe

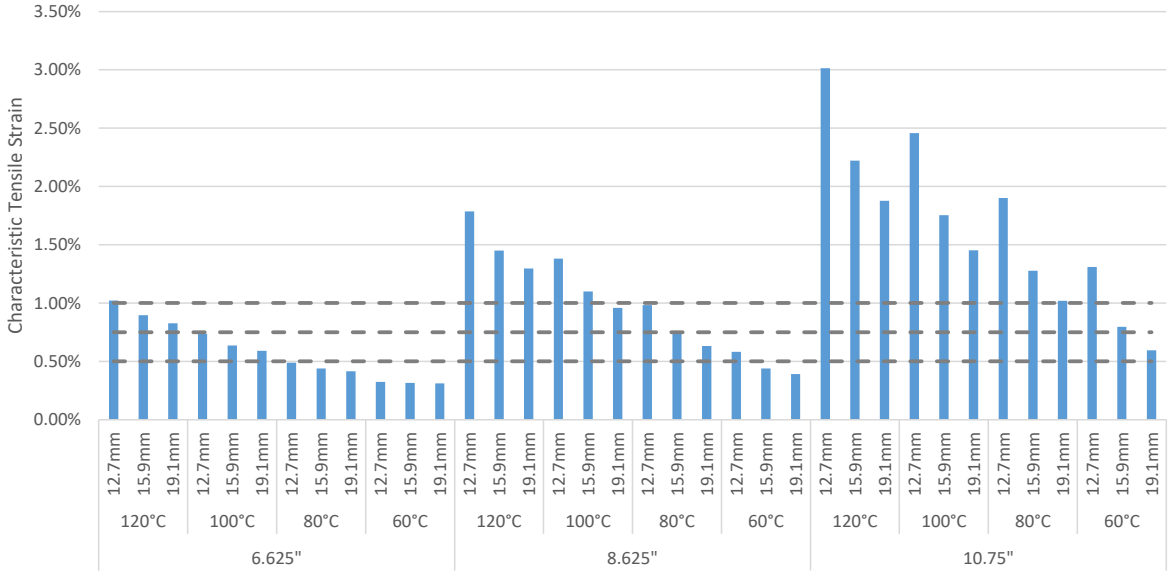
- Probability of failure due to local buckling is acceptable in most cases
- Fracture limit state dependant on D/t ratio and temperature

Mechanically Connected Pipe

- Capacities of connectors exceed pipe
- Strain concentrations

- **Local Buckling**

- **Fatigue and Fracture**



© Crondall Energy Subsea Ltd 2015
All rights reserved

Cost Assessment

Crondall energy

- **Identify cost impact of advanced internal coatings, alternative flowline technologies & reuse**

- **Parameters**
  - OD = 10-inch/8-inch/6-inch
  - Length = 10km & 20km
  - Carbon Steel or CRA Clad pipe or Composite pipe
  - Mechanical connectors or Thread & Coupled
  - External Insulation with internal Corrosion Coat or internal Advanced Flow Coat
  - 1, 2 or 3 uses
  - Re-use cases: Smart operational monitoring & offshore inspection
  - Pipe not returned to shore between uses

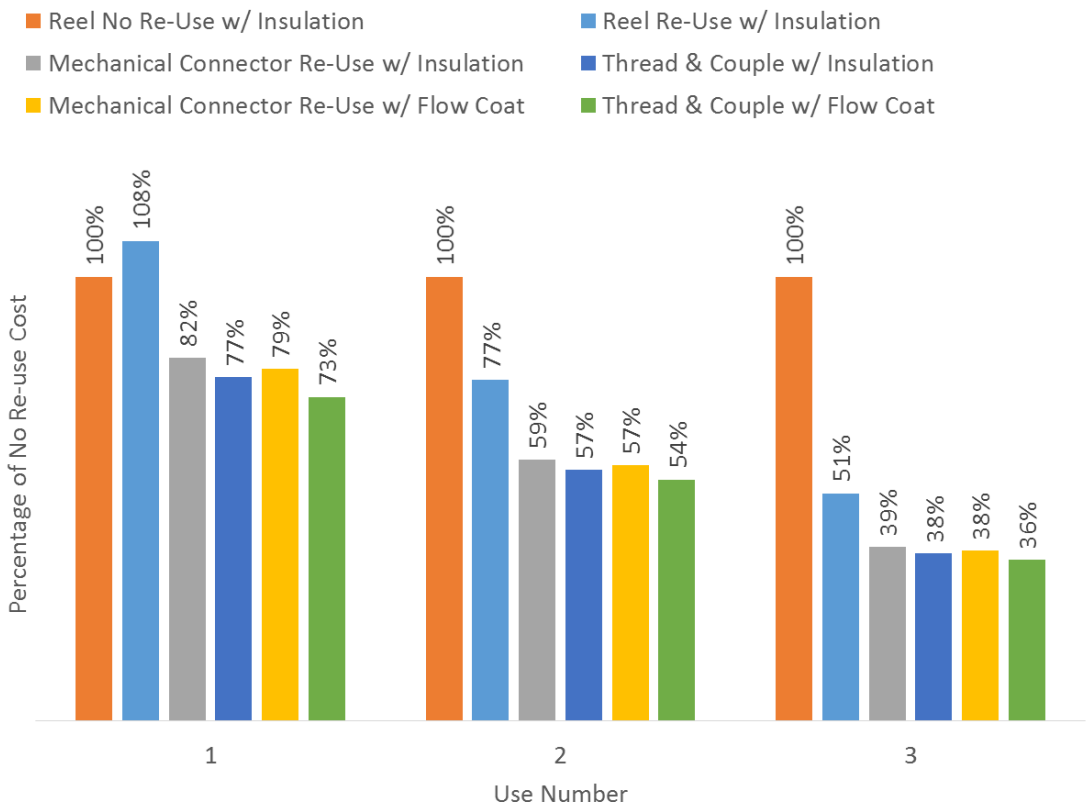
- **Typical Operating Conditions**
  - Temperature = 80°C
  - Pressure = 345 Bar (5ksi)
  - Water Depth = 100m

© Crondall Energy Subsea Ltd 2015
All rights reserved

Cost Assessment 10-inch x 10km

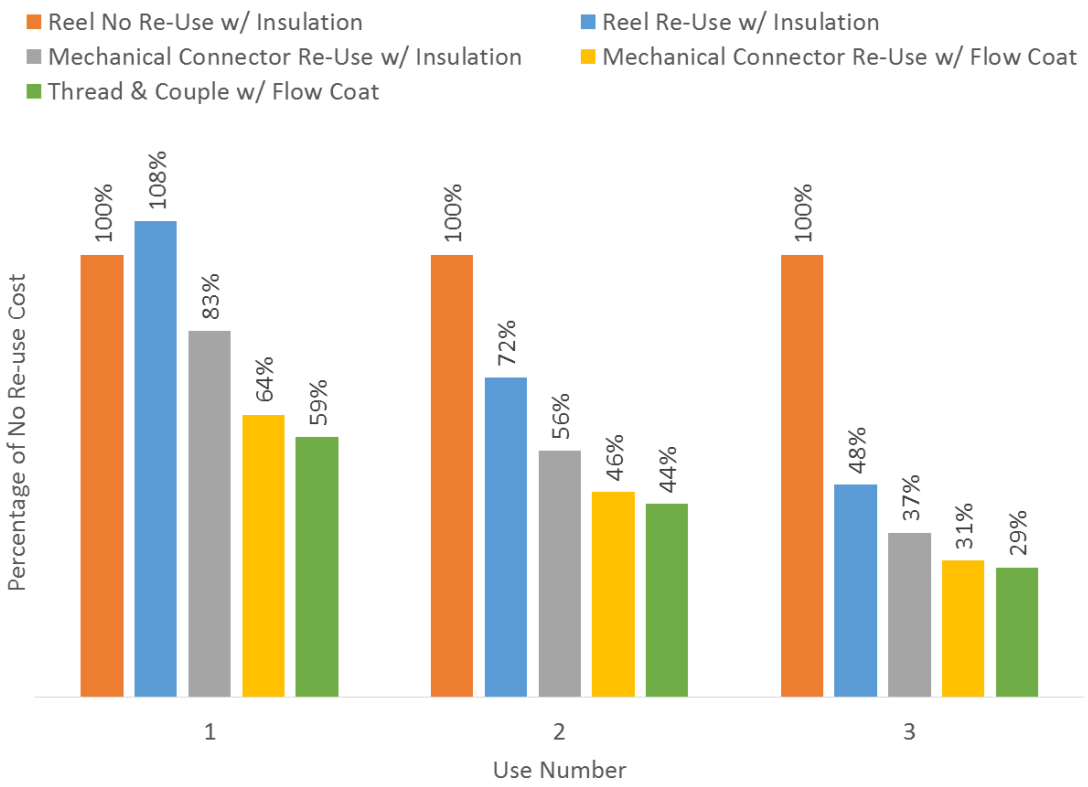
Carbon Steel

***No Composite Option**



CRA Mechanically Clad

***No Composite Option**

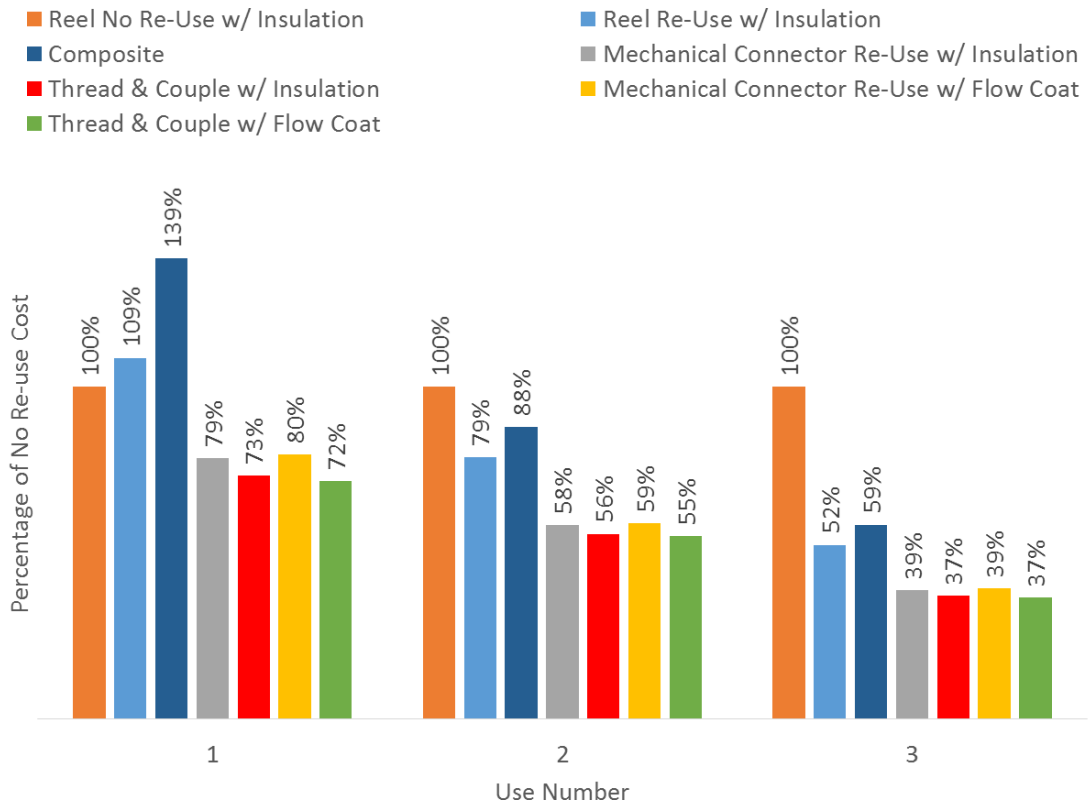


- **20km sees a further small reduction on re-use**

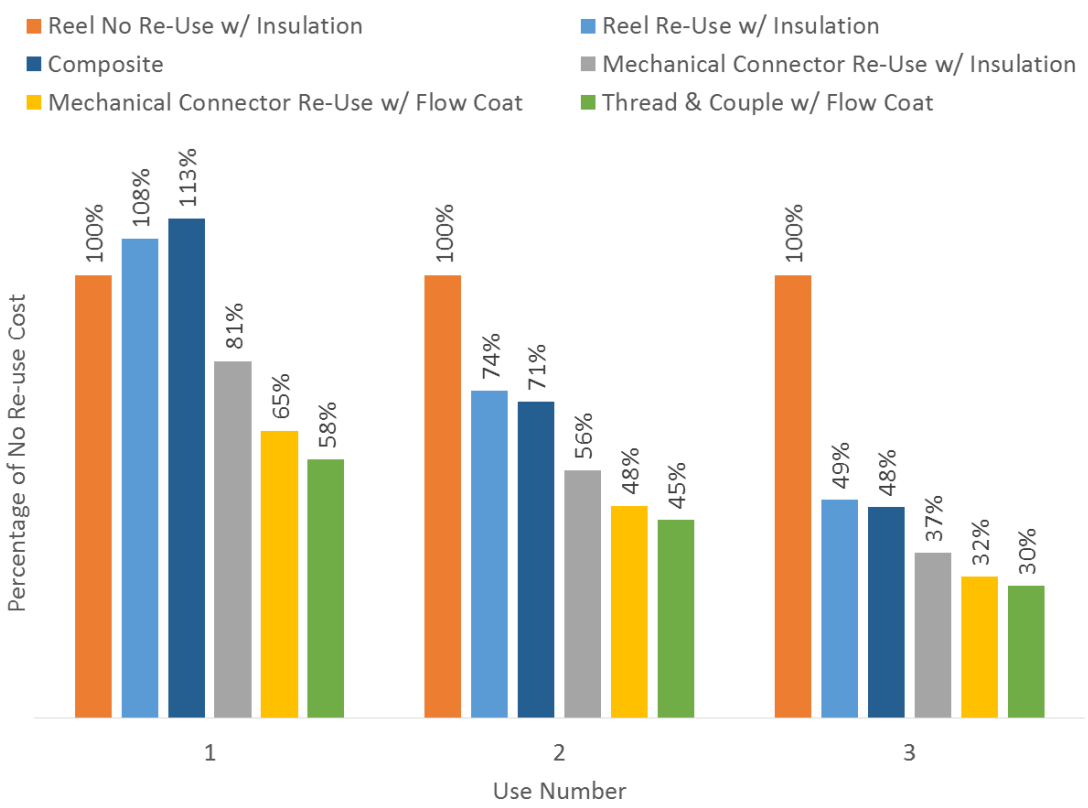
© Crondall Energy Subsea Ltd 2015
All rights reserved

Cost Assessment 8-inch x 10km

Carbon Steel



CRA Mechanically Clad

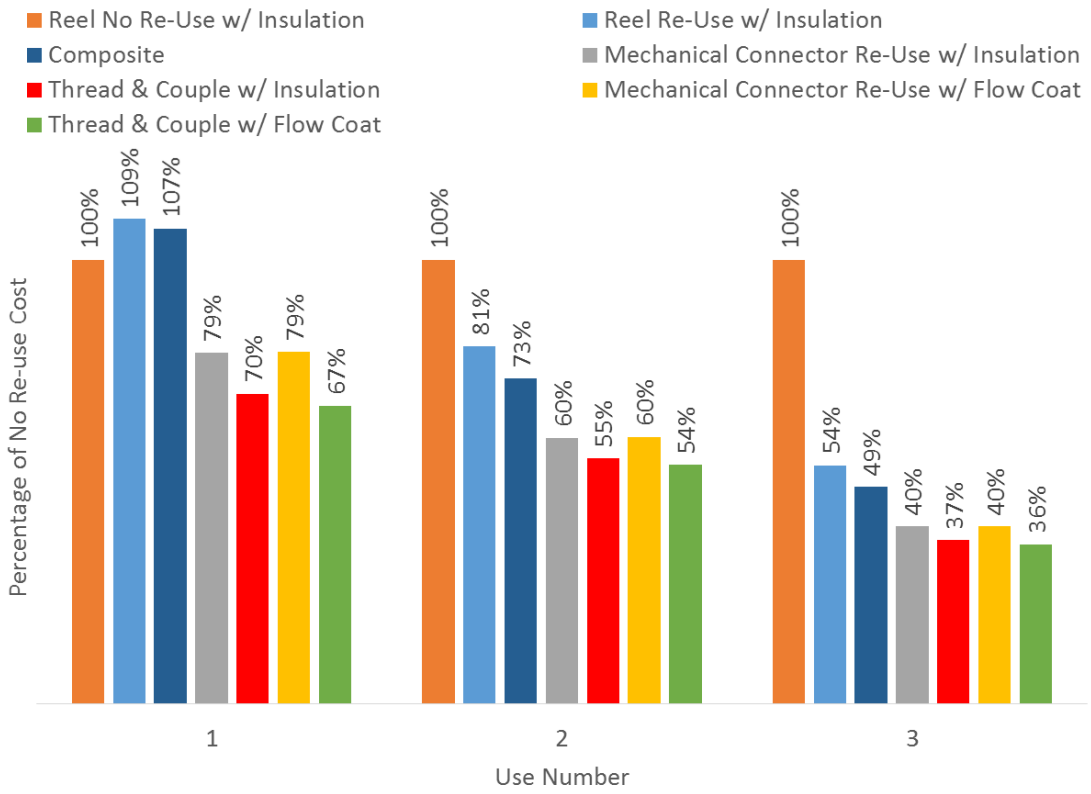


- **20km sees a further small reduction on re-use**

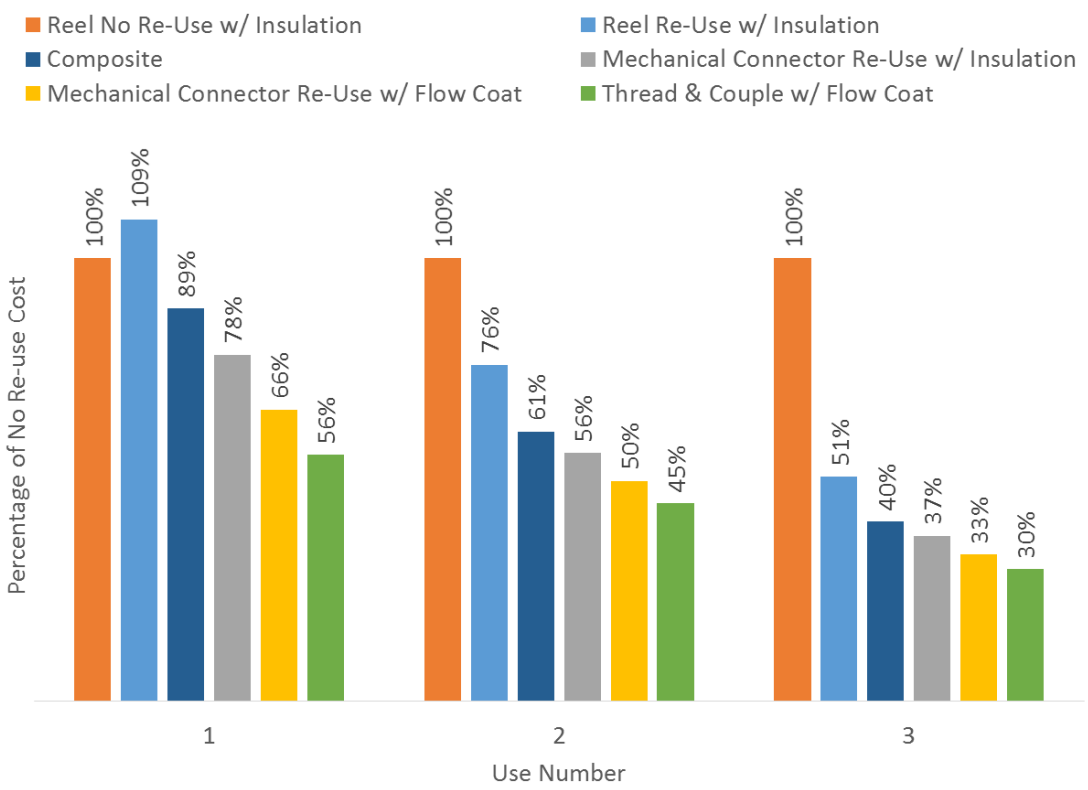
© Crondall Energy Subsea Ltd 2015
All rights reserved

Cost Assessment 6-inch x 10 km

Carbon Steel



CRA Mechanically Clad



- **20km sees a further small reduction on re-use**

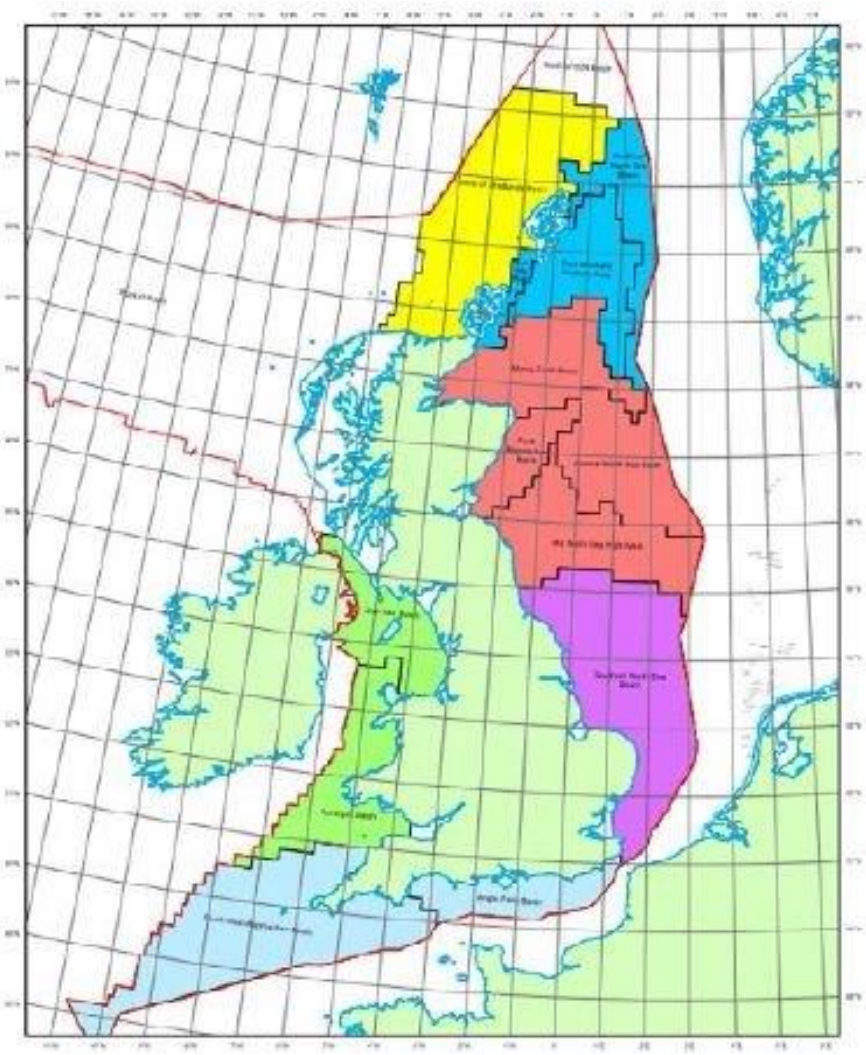
© Crondall Energy Subsea Ltd 2015
All rights reserved

Conclusions

1. Pipeline reuse appears to offer significant savings.
2. Mechanical connectors look attractive. Potential to reduce costs & facilitate reuse but need to demonstrate similar reliability to welded joint.
3. Composite pipe also interesting, especially in smaller sizes. Ideally suited to reuse. Address stability.
4. Advanced coatings could offer CAPEX & OPEX reductions

However

1. All technologies need further investment
2. Commercial models for re-use also required



© Crondall Energy Subsea Ltd 2015
All rights reserved

Thanks for your support

© Crondall Energy Subsea Ltd 2015
All rights reserved

Contact locations

For more information go to

www.crondall-energy.com

WINCHESTER	STAVANGER	SINGAPORE	HOUSTON	ABERDEEN

© Crondall Energy Subsea Ltd 2017
All rights reserved