Cold Water Pipe

What are the state of the art technologies?

The CWP must meet a number of requirements

Quantifiable technical drivers:	Anticipated quantitative loading	*Dominant driver?*	Met in LM design?	Basis
Buckling from net external pressure	7.5 psi suction inside CWP at top	**Yes**	Yes	FEA
Bending fatigue from platform motions, including knockdown for long-term seawater immersion	Approx. +/- 4 degrees of pitch or roll, plus surge and sway motions	**Yes**	Yes	Prelim. HARP analysis (10 MW plant) + prelim. test data on fatigue after high-pressure seawater conditioning to saturation
Buckling from platform motions	Same as preceding	No	Yes	FEA
Fatigue from Vortex-Induced Vibration (VIV)	Sheared current profile, approx. 4 fps surface velocity	No	Yes	Several analyses indicate no excitation of CWP in sheared currents
Tensile failure from clump weight and streaming current	CWP + clump weight; current profile	No	Yes	Bending and tension strain calculations
Core collapse from high pressure at 1000m depth	1500 psi	**Yes**	Yes	Venting of hollow core eliminates net pressure on core
Wet weight must be positive but not excessive	CWP & clump weight	**Yes**	Yes	CWP wet density is same as fiberglass/vinyl ester laminate
Corrosion	30-year immersion in seawater at depths to 1000m	**Yes**	Yes	Industry experience with fiberglass/ vinyl ester composites
Also:				
Behavior in service must be very reliable	CWP is single point of failure for OTEC plant	**Yes**	Yes	One-piece CWP eliminates maintenance / repair / failure of joints
Deployment must be low-risk	Very large consideration - Previous OTEC failures have been dominated by CWP deployment	**Yes**	Yes	Fabrication directly from the platform eliminates large risks associated with transport, assembly, upending, etc.
Cost must fit within OTEC plant budget profile	Electricity cost <= $0.25/kwh for 100 MW OTEC plant in Hawaii	**Yes**	Yes	Minimum-cost design through optimization. Materials costs from supplier quotes; recurring fabrication costs from large wind turbine blade data

- **FIRST GENERATION BASELINE: FRP-Sandwich per NOAA/DOE 1980s Design and At-Sea Testing, with horizontal towing and upending in-situ; Gimbal connected.**

- *CWP very likely to be a sandwich pipe, possibility of fiberglass, how do we construct it may be the larger problem?
- Reliability?
- Failure usually at the joints of large composite materials, need ONE piece
- Cross currents and platform rocking cause stress
- Is the CWP design for a 100 year storm?
- Can we realistically temporarily remove the pipe in an emergency? What happens if a storm approaches?

- *One of the largest problems with the CWP includes DEPLOYMENT.
- Fabrication directly off of the platform could be the best option
- *What's new at the table?
- High strength fiberglass-substantial fatigue strength and cost effective
- Vinyl Ester resins-tough, corrosion resistant, experience
- Fabrication processes?
- VARTM, vacuum assisted resin transfer molding, now standard. Allows sandwich core manufacturing and also stepwise manufacturing
- Large protrusion processes, allows for hollow core manufacturing to try and combat press

- Available technologies are out there, rough quotations and specs are available.
- Materials identified
- Engineering methodology available
- Weather is a large concern for CWP depending upon location. De-coupling the pipe when a storm comes through is a possible solution.
- Three state of the art viable designs should be put on a timetable. If the most simple design is set in motion, others will be helped.