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An Investigation into the Possible Reasons for Slow Uptake of Marine Energy Project Development and Utilization in New Zealand

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ABSTRACT

In this paper, we aim to investigate the possible reasons for slow uptake of marine renewable project developments and utilization in island country like New-Zealand. New-Zealand sources its electricity for primary consumption majorly from renewable sources of energy. Out of the 81% of renewable energy production, 57% is contributed from hydropower generation plants. In the past years, hydropower plants have reached saturation point and the government must invest into other forms of energy to achieve its target of sourcing 90% energy from renewable sources. One such source identified was marine energy, but out of the 6 projects finalized, none ever progressed. After intense literature review and interviews, it was clear that before investing into such projects, having countries own research Centre is very important. It would not only provide skilled manpower but also locally develop market to assist faster project developments. Communication is another parameter identified under social impact as a barrier towards marine energy developments in New-Zealand.

Keywords: Marine Energy; Renewable source of energy; Barriers

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AN INVESTIGATION INTO THE POSSIBLE REASONS FOR SLOW UPTAKE OF MARINE ENERGY PROJECT DEVELOPMENT AND UTILIZATION IN NEW ZEALAND

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Abstract

In this paper, we aim to investigate the possible reasons for slow uptake of marine renewable project developments and utilization in island country like New-Zealand. New-Zealand sources its electricity for primary consumption majorly from renewable sources of energy. Out of the 81% of renewable energy production, 57% is contributed from hydropower generation plants. In the past years, hydropower plants have reached saturation point and the government must invest into other forms of energy to achieve its target of sourcing 90% energy from renewable sources. One such source identified was marine energy, but out of the 6 projects finalized, none ever progressed. After intense literature review and interviews, it was clear that before investing into such projects, having countries own research Centre is very important. It would not only provide skilled manpower but also locally develop market to assist faster project developments. Communication is another parameter identified under social impact as a barrier towards marine energy developments in New-Zealand.

Keywords: Marine Energy, Renewable source of energy, Barriers

1. Introduction

By utilizing non-renewable source of energy like natural gas, coal, oil etc. for production of electricity, we are rapidly disturbing Earths carbon budget balance which is contributing to temperature rising faster than what organisms can adapt¹ (National Geographic, 2016). This is one of the main reason why we should be looking into production of power through renewable sources of energy. New Zealand is one of the fore runners in materializing this theory with 80.8% of its power generation is from renewable sources of energy² (Ministry of Business Innovation and Employment, 2015).

The government has set itself with a target of getting that contribution to 90% by 2025³ (National Policy Statement, 2011).

Sources for power generation in New Zealand are as follows⁴ (Ministry of Business Innovation and Employment, 2015):

Source of energy	% contribution	Over all contribution
Hydropower	57%	81%
Geothermal	17%	
Wind	5%	
Solar	0.1%	
Bioenergy	2%	
Gas	14.9%	19%
Coal	4%	

Table 1: Source of Power Generation in New-Zealand

¹ <http://nationalgeographic.org/encyclopedia/non-renewable-energy/>

² <http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity>

³ <https://www.mfe.govt.nz/sites/default/files/nps-reg-2011.pdf>

⁴ <http://www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/statistics/electricity>

This data shows us that hydropower generation is a major source of power generation in New Zealand contributing 57% of the total power production. But, does it have the capacity to help achieve New Zealand's target of 90% contribution by renewable sources of energy by 2025?

As per our study and previous electricity generation records, hydroelectricity which is the major source of renewable energy has almost reached its saturation point with its generation showing approximately constant figures for the past 10 years as shown in Figure 2. Few developments in Solar, Geothermal and Wind energy which show positive growth rate which has resulted in our renewable source to rise to 81% today as shown in Table 2. But, Solar, wind and Geothermal energy have their share of limitations when it comes to project capacity which may not help government achieve its goal of 90% electricity generation from renewable sources by 2025.

One resource which remains untapped by New-Zealand government is Marine energy. Marine energy is nothing but converting the kinetic energy of tides or waves in the ocean into electrical energy with the help of different devices which may be on the surface or under water. Marine energy as per study of Aotearoa Wave and Tidal Energy Association (AWATEA), has a potential of more than 8000 MW of power generation capacity in New Zealand⁵ (Underhill, 2016). If we calculate with 25% efficiency of the turbines, it accounts to approximately 17,500GWh of power generation. As per our power requirements, this will account to

41% of total energy required by New Zealand.

In 2007, New Zealand government formed Marine Energy Deployment Fund (MEDF) which is administered by Energy Efficiency and Conservation Authority (EECA) to fund \$8 million over a period of 4 years for development of marine energy resources in New Zealand. In all, 6 projects were funded under this scheme namely:

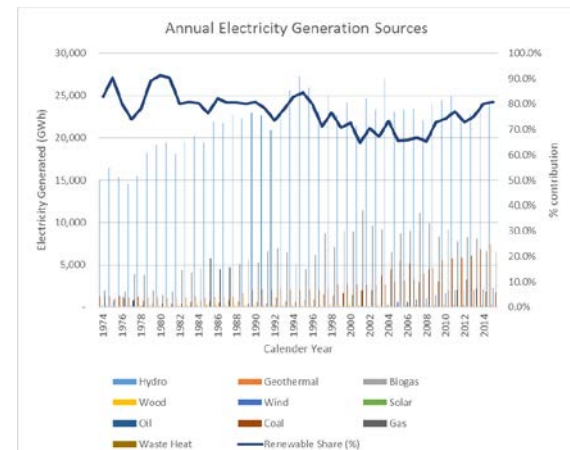


Figure 1: Annual Electricity Generation Contribution by Source in New-Zealand

Table 2: Percentage Growth rate of Power Generation form different sources

<i>Power Generation Source</i>	<i>Power Generated in 2010 (GWh)</i>	<i>Power Generated in 2015 (GWh)</i>	<i>Percentage Growth</i>
Hydroelectricity	24,493	24,283	(1%)
Geothermal	5,546	7,411	34%
Solar	4	33	725%
Wind	1,621	2,333	44%

⁵ <http://www.awatea.org.nz/wp-content/uploads/2016/06/10.-AWATEA-2016-Mike-Underhill-EECA.pdf>

Crest Energy – Kaipara Harbour; Chatham Island Marine Electricity (CHIME); Tangaroa Energy Rakaia Amps – Stewart Island Wave Energy Technology New Zealand (WET-NZ) – Moa Point, Wellington – two projects; Community Leisure Management – Parnell Baths, Auckland⁶ (Underhill, 2016). None of the projects were ever completed and the funding has also stopped.

These facts and figures are strange, given the huge potential of marine energy in New Zealand, why would government stop or

2. Literature Review:

The first serious discussion and analyses of renewable power source in New-Zealand emerged during 2007 when former Prime Minister announced a national target of 90% renewable electricity by 2020. However, by 2014, there was no significant improvement in the renewable source contribution and was rightly pointed by Michael R.W. Walmsley that hydropower generation has reached its saturation point and any more investment in hydropower plant projects would only increase in Energy Return on Energy Investment (EROI) ratio which is not favorable. According to the author, there is a need to invest in other renewable sources of energy like wind and geo-thermal plants to achieve our targets⁷ (Michael R.W. Walmsley, 2014). But, if we see the contribution of Wind and Geothermal power source in Figure 1, it is not significant and with this rate, we would never be able to achieve our 2020 target. Michael R.W. Walmsley may have underestimated the potential of Marine energy power generation by not mentioning its possible contribution towards our goal. M. Fadaeenejad identifies that wave energy has higher power density, high utilization factor and lower environmental impact as

slow down projects related to development of marine energy. If we are able to find out the exact reasons for slow uptake of marine energy in New Zealand through this paper, we could help project managers to focus on those aspects and speed up the process which would benefit not only New Zealand but also the entire world. Also, the fact that New Zealand is geographically separated from all the other nations, it has to reduce its dependency for power generation on source fuels like crude oil and coal.

compared to other renewable sources of energy. The author highlighted technologies like “Wave Dragon” and “Pelamis” would be best suited for island countries like New-Zealand⁸ (M. Fadaeenejad, 2013). Given the high potential of marine renewable energy, a study was conducted to identify the tidal energy potential of the Manukau Harbour in New Zealand by Terry Moore. Author found that Manukau Harbour has enough tidal energy to make a small distributed generation project of about 1MW⁹ (Moore, 2014). This proves the potential of New-Zealand seas. However, Alistair G.L. Borthwick’s study agrees to the enormous potential of marine renewable energy, but, identifies three challenges like bringing energy to shore, storing it and exporting it cost effectively. Apart from these reasons, the author rightly stresses the major reason for uncertainty in the marine technology is that there is no ocean data gathering campaigns which may provide vital information of seabed roughness, wave surface elevation, tidal currents, eddies and turbulences which according to us is extremely crucial for success of any engineering design or technology

⁶ <http://www.awatea.org.nz/wp-content/uploads/2016/06/10.-AWATEA-2016-Mike-Underhill-EECA.pdf>

⁷ <http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.apenergy.2014.04.048>

⁸ <http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.rser.2013.08.077>

⁹ <http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.seta.2014.07.001>

deployment process.¹⁰ (Alistair G.L. Borthwick, 2016).

Apart from technical challenges, Marine renewable energy has its share of social and ecological challenges. There is a consensus among social scientist like Paul A.J. Bonar that most people support renewable energy projects, but when it comes to deployment, it faces denials from the locals. This behavior is termed as NIMBYism i.e. Not In My Back Yard which is true¹¹ (Bonar, 2015). Similar, results were discovered by Jiska De Groot when the author conducted survey and interviews with island community people in UK. The result portrays that 82.1% of the respondents were highly in favor of using renewable energy to generate electricity, but, when it came to deployment of marine energy project in their vicinity, the acceptance dropped down to 40%¹² (Groot, 2016). However, Bouke Wiersma's findings completely contradict with NIMBYism. Author argues that visual impact plays a very different role in offshore renewable energy developments. According to authors, offshore wind farms which are visible from the shore often run into opposition while others that are onshore do not as they are considered fitting in well visually and as place enhancing¹³ (Wiersman, 2014). According to our analysis, I would disagree with Mr. Bouke Wiersma's findings that visual impacts play a different role. The theory of NIMBYism holds true even in New Zealand community where concept of wind turbines was initially accepted for deployment but later faced stern opposition from locals after finalizing the project location. This could also hold true with Marine energy project deployments.

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<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/J.ENG.2016.01.011>

¹¹

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.rser.2015.03.068>

¹²

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.ijome.2016.01.007>

With social impacts, identification of ecological impacts of marine energy developments is vital. Paul A.J. Bonar noted that, apart from visual impacts, some projects are denied on the basis of environmental and materialistic grounds, Example, impacts on marine life and fishery business. It is rightly quoted by the author that due to limited knowledge on the ecological impacts of marine energy projects, it is difficult to estimate the level of damage possible to the environment. He argues that it is also possible to have a positive impact on the ecology like artificial reef and biofouling¹⁴ (Bonar, 2015).

Several studies investigating the impact of noise created by marine energy converters have been carried out in recent past. According to Joanne K. Garret research on sound levels in Falmouth Bay which is affected by local shipping as well as natural sources like weather conditions and marine organisms, it was observed that during installation process, the local sound levels considerably increased with a median difference of 8.5dB¹⁵ (Garret, 2014). However, in one of the research done by Paul A. Lepper, which measured the noise radiation from wave and tidal energy converter devices was found relatively lower when compared with some construction activities such as marine pilling and seismic air gun surveys. This data is used by author to prove that there is minimal impact on aquatic life. But, environmentalist doubt the quality of data collected due to unique challenges like environment self-noise, high level of background noise and wide variety of devices¹⁶ (Paul A. Lepper, 2015).

¹³ DOI: 10.1002/wcc.282

¹⁴

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.rser.2015.03.068>

¹⁵ DOI: 10.1007/978-1-4939-2981-8_39

¹⁶ DOI: 10.1007/978-1-4939-2981-8_74

Recent evidence suggests that there is no major impact on marine life when it comes to deployment of marine energy converters. Andrea Copping set up cameras at SeaGen tidal project in Strangford Lough, North Ireland and posited that noise produced by energy converters had no effect on marine life. Similar outcomes were reported for different sites like Mississippi river and Cobcooks Bay. However, author agreed to observe behavioral changes in the aquatic life like not approaching the turbine when its speed increases¹⁷ (Copping, 2014). In addition to the work of Andrea Copping, Haley A. Viehman collected data for 22 hours which included two tidal cycles by setting up a camera in commercial scale turbine in Cobcooks bay. It was observed that the probability of fish entering the rotating turbine decreased by over 35%. Smaller fishes had greater probability of entering the rotating turbine as compared to larger fishes. The authors findings suggested that fishes' behavior in response to tidal turbine appeared similar to response to obstacles such as trawls¹⁸ (Viehman, 2014).

These results were contradicted by the experiment of Matthew K. Pine. The author conducted experiment of noise impact on metamorphosis of crabs. The findings suggest that the time to metamorphosis (TTM) when exposed to natural noise is 21-31% lower as compared to no noise; 38-47% lower as compared to tidal turbine noise and 46-60% lower compared to sea-based wind turbine noise treatment. This proves the effect of anthropogenic noise effect on metamorphosis of crab and hence changing the benthic ecosystem in areas where turbines are installed¹⁹ (Pine, 2015). However, this was laboratory based experiment and its practicality is yet to be tested at actual sites. According to us, we should compare the TTM of crabs with

natural sea bed noise and not with no noise. Since it is not expected that there will be no natural noise. We are very sure that this would then have very minimal impact on the benthic ecosystem in areas where turbines are installed.

John Van Der Melen carried out a model study to evaluate the potential environmental impact of tidal energy extraction in the Pentland Firth at large special scales (>100kms) using 3-D hydrodynamics biochemistry model. A realistic 800 MW scenario and a high impact scenario with massive expansion of tidal energy extraction to 8 GW scenarios were considered. The realistic 800 MW scenario suggested minor effects on the tides, and undetectable effects on the biogeochemistry. The massive expansion 8 GW scenarios suggested effects would be observed over hundreds of kilometers away with changes of up to 10% in tidal and ecosystem variables, in particular in a broad area in the vicinity of the Wash. There, waters became less turbid, and primary production increased with associated increases in faunal ecosystem variables. Moreover, a one-off increase in carbon storage in the sea bed was detected. This study suggests positive environmental effect²⁰ (Melen, 2016).

Considering certain impacts, it was suggested to push the wave farms further away from the shore with expected result of minimizing the impact. But, this assumption was contradicted by study done by G. Iglesias. According to authors findings, locating the farm further away from coast will not result in reduction of absolute impact but would rather change its impact area. Hence confirming that farm-

¹⁷

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.ocecoaman.2014.04.002>

¹⁸ 10.1007/s12237-014-9767-8

¹⁹

http://link.springer.com.ezproxy.aut.ac.nz/chapter/10.1007/978-1-4939-2981-8_104

²⁰ doi:10.5194/bg-13-2593-2016

to-coast distance is not panacea that will solve all the impacts²¹ (Iglesias, 2014).

David Benson conducted a study to assist resolving issues with environmental impact assessment (EIA) of marine renewable energy installations. Author observed and rightly noted that the major problem with EIA are predicting a significant impact, monitoring detects significant impact and cumulative impacts. The author suggested that expert judgement be incorporated in certain instances which would help in paradigm shift towards strategic assessment and systematic planning if the potential conflict between marine renewable energy installations and marine biodiversity are to be maintained²² (Benson, 2014). Studies relating to resolving environmental impact are scanty and that there are more fewer studies focusing on environmental risk evaluation. Andrea Copping worked towards development of environmental risk evaluation system by following simple framework which divided the potential risk into three categories namely, Episodic like vessel impact, Intermittent like Blade strike and Chronic like Chemical reactions. These risks were then rated on likelihood and impact based on few case studies on actual sites and evaluated. According to authors findings, the risk of vessel impact which could cause oil or other harmful liquids to spill is very minimal. The analysis examined the shipping record for the area to establish the frequency with which these incidents can happen. Though the probability was very low, such incidences can be mitigated by providing enhanced training to tug and barge operators, adequate nautical chart marking and notice to mariner's announcements. An analysis was undertaken to estimate the likely addition of toxicity from anti-biofouling

coatings used on ocean energy devices for scenarios of tidal energy development in Puget Sound and wave energy development on the Oregon Coast. Using background levels of toxicity for the two water bodies, the analysis concluded that the risk of additional toxicity would be small in Puget Sound and negligible contributions to water and sediment of the Oregon Coast. In the risk of encounter between tidal turbine blades and southern resident killer whales, there is no specific case recorded as it is suspected that due to the noise made by the machine, the whales avoid coming in contact with the turbines. But there is a contradicting theory stating that the noise may also attract the whales. So, a study was done simulating the impact of turbine blades on whales. They concluded that it won't have serious injuries other than bruises on external skin. The designed framework provides preliminary assessments for these risks and acts as a framework granting future data on direct interactions of ocean devices with environment²³ (Copping, 2015).

Experts consider economic viability of the marine renewable energy project as one of the major barrier for its commercial deployment. Few studies suggest that with development and deployment of marine renewable energy projects, it would help countries economy to be more independent on fluctuating fossil fuel prices. G.J. Allan rightly states that it would create employment opportunity in the country like Scotland and would have non-negative impacts on development of other sectors and hence boosting economy²⁴ (G.J. Allan, 2013). On the contrary, when it comes investment and project cost, marine renewable energy production looks far-fetched. S. Astariz in his study identified four major cost in budgeting for wave

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<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.renene.2014.03.059>

²² <http://dx.doi.org/10.3389/fmars.2014.00075>

²³

<http://link.springer.com.ezproxy.aut.ac.nz/article/10.1007/s12237-014-9816-3>

²⁴

dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.marpol.2013.05.003

energy plant namely, (i) Pre-operating cost, (ii) Construction Cost, (iii) OPEX and (iv) De-commissioning cost. After considering all the particulars, onshore/nearshore wave energy plant costed between 90-140 €/MWh and offshore wave energy plant costed between 180-420 €/MWh. Considering the highest cost of non-renewable source of energy being 60 €/MWh, wave energy converters is an expensive affair. The author concludes by stating that it could only be affordable if it would be subsidized by the local government²⁵ (S. Astariz, 2015). In addition to the findings, D.S. Jenne calculated Levelized cost of energy (LCOE) analysis of marine energy converters reference models published by USA as a step to share knowledge. The LCOE considering 10MW commercial project for different reference models are RM1 - \$0.42/kWh; RM2 - \$0.31/kWh; RM3 - \$0.98/kWh; RM4 - \$0.48/kWh; RM5 - \$0.98/kWh and RM6 - \$1.47/kWh. As per authors findings, Tidal energy converters cost less as compared to wave energy converters since they are more mature. The author also highlights that further possible reduction in LCOE could be achieved by improving OPEX and CAPEX strategies²⁶ (Jenne, 2014). The above findings are consistent with study done by Vincent S. Neary which concluded with similar findings²⁷ (Vincent S. Neary, 2015).

Several studies investigating co-location have been carried out on merging wave energy converters with wind energy converters. C. Perez Collazo has rightly identified the advantages of having a combined harnessing approach. Author

observes the advantages of co-location as follows: 1) Enhanced energy Yield, 2) Better predictability, 3) Smoother power output, 4) Common grid infrastructure, 5) Shared logistics, 6) Common structure or foundation system and 7) Shared operation and maintenance cost²⁸ (Collazo, 2014). Similarly, Francesco Tavera Pinto stated that It is of paramount importance to bring the LCOE of MRE production further down to a level where it can compete with traditional energy sources on an equal footing. As per authors recommendation, hybrid energy converters that allow harvesting two or more renewable sources at the same time under the same structure would allow important synergies and savings. This clearly implies that the author is in favour of co-existence of MRE with offshore wind energy farms²⁹ (Pinto, 2015). S. Astariz findings on the same subject of co-location suggest that energy cost is reduced by 50% as compared to stand alone wave farm when integrated with offshore wind farm³⁰ (Astariz, 2015).

There is a misconception of people living on islands that deployment of marine renewable energy project would disturb their fishing grounds affecting their livelihood. Katherine L. Yates conducted a simulation study to assess trade-offs and co-existence opportunities. Her findings suggested that if renewable energy targets were increased beyond 81%, it would impact both fishing as well as marine protected areas. But, in case of co-existence, increase in targets did not affect either activities. Infact, results showed 11% reduction in cost for pot fishing business³¹ (Yates, 2015). The above simulation was

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<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.rser.2015.01.061>

²⁶ <http://www.nrel.gov/docs/fy15osti/64013.pdf>

²⁷ <https://vtechworks.lib.vt.edu/handle/10919/49211>

²⁸ <http://www.sciencedirect.com.ezproxy.aut.ac.nz/science/article/pii/S1364032114008053>

²⁹

<http://scitation.aip.org.ezproxy.aut.ac.nz/content/aip/journal/jrse/7/6/10.1063/1.4939086>

³⁰

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.renene.2015.05.028>

³¹

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.jenvman.2015.01.045>

supported in real life by Kieran Reilly. The author conducted a survey and found that 40% of fishermen agreed that marine renewable energy needs to be developed, 45% disagreed and 15% stayed neutral. The most positive finding of the survey was that 70% of the fishermen community believed that fishing and marine renewable energy projects could co-exist. However, the main perceived impact by the fishermen is the loss of access to traditional fishing ground. In such cases, the author suggests that data be collected on frequent fishing grounds and not select that site for development of the project. Some of the other concerns of fishermen are impact on some fish species during construction phase of the project resulting in reduced catches³² (Kieran Reilly, 2015). The concerns raised by fishermen community are valid and could only be resolved if they are a part of the process. Paul A.J. Bonar rightly suggested in his findings that stakeholders must be included in the decision-making process. This may prove costly but in longer run, but local knowledge helps developers to identify concerns and potential conflicts early in planning stage when it is easier to implement changes or consider alternatives (Bonar, 2015).

Governance plays a vital role in attracting investors to invest in marine energy projects. R. Bucher studied on creation of investor confidence and came up with some relevant findings. According to the authors research, strategic drivers for reaching maturity and creating investor confidence are i) System engineering: since most of the delays and additional cost to the project are due to uncertainty of device performance. ii) Standardization: There is no standardization of technology which is making it difficult to have base and develop

more on. iii) Knowledge sharing: Every individual project is working as a separate entity and there is no sharing which is also a barrier when moving towards maturity of the technology. iv) Maximizing collaboration: which is similar to knowledge sharing where in developers need to share and collaborate with others findings and build on it. v) Off shore development experience and vi) Risk management: minimizing risk by collaborating with stakeholders and sharing risk³³ (R. Bucher, 2015).

It is also seen that many countries have similar governance policies in place for offshore renewable energy projects like ones for inland wind farm projects. Glen Wrights research in terms of rights of ownership suggests that there is need for a more nuanced discourse on trends for private rights in oceans. Such evolution is necessary if marine governance policies are to effectively support new industries progress the blue economy and ensure health of oceans³⁴ (Wright, 2014). In addition to Glen Wrights findings, Yen-Chang compared experience on marine governance of UK and Canada and suggested development of an integrated management organ. He also asserted previous researches of public participation for environmentally friendly development of a marine renewable energy industry. The author also concluded that apart from stringent environmental assessment process, transparency of these projects approval processes should also be increased³⁵ (Yen-Chang, 2016).

Glen Wright is of the opinion that development of negative environmental impact and scientific knowledge is slower in pace as compared to the technology and

³²

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.marpo.2015.04.001>

³³

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.renene.2015.11.033>

³⁴

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.marpo.2014.10.021>

³⁵ doi: 10.1093/jwelb/jwu039

the industry due to limited practical experience and notoriously difficult marine environment to study. Author says that cost is a major concern for the investors in Environment Impact Assessment (EIA) process. According to the author, EIA process should do more to incorporate all available knowledge and permit deployment of devices that can permit new knowledge³⁶ (Glen Wright, Strengthening the role of science in marine governance through environmental impact assessment: A case study of the marine renewable energy industry. , 2014). In addition to this research, Glen Wright conducted a research on industry perspective on the Scottish marine governance framework which stated that there is a need to assist the developers in production of data, and to demand only the data which is necessary and potentially useful. One way author suggests is to focus on impacts rather than stressors. Author says that as policymakers, they should bear in mind that certainty and stability are crucial for supporting investments which would in-turn support project development³⁷ (Glen Wright, 2014). Glen Wright in one of his research established a legal research agenda for ocean energy development. Author identified elements required for legal research agenda as follows: 1) International laws: There are no international laws in space for use of ocean beyond international boundaries. However, all the ocean energy projects are within 12miles of the coast which requires only regional laws. But factoring it for future projects is very important. 2)Environmental impact and liabilities: There are chances that government may relax rules in pursuit of carbon mitigation goals and therefore causing harm to ecosystem. According to author, lack of baseline data and notoriously difficult to study marine environment

presents a major challenge for developing framework for EIA and approving any project. 3)Rights and ownership: Internationally, no one owns the oceans. But with growing requirement of sea space, there is a need to lay down laws for sea space internationally. 4) Consenting Processes: It should address scale of development and level of risk posed in particular by imposing more permissive procedures for small scale and time limited developments in areas of low environmental sensitivity. 5) Managing ocean space and resources: prioritising and keeping coexistence strategy in mind would help sustainable and continuous growth opportunity for marine energy developments³⁸ (Glen Wright, 2015).

Approach towards development of marine renewable energy is critical for its successful implementation. Mark Healy studied the impact of MARINET initiative which included 12 European on the development of marine renewable energy. MARINET is nothing but knowledge and research sharing database on marine renewable energy developments. MARINET initiative has streamlined testing process of new technology which has resulted in numerous projects being implemented around Europe. According to author, the only reason why European nations are ahead in development of marine renewable energy projects is because of MARINET³⁹ (Henry, 2015).

Considering all the literature, it is clear that marine renewable energy has tremendous potential and extremely useful for island countries like New-Zealand. It was clear that New-Zealand government initiated the process by identifying sites and provided funds for the deployment of projects. What

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<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.ocecoaman.2014.07.004>

37

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.marpo.2015.12.014>

38

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.marpo.2015.09.030>

39

<http://dx.doi.org.ezproxy.aut.ac.nz/10.1016/j.ijome.2015.06.002>

could have been the reason for not even a single project commencing.

3. Research Methodology:

Our research methodology will be based on literature reviews of 45 articles published across the globe regarding marine energy projects deployment and various barriers towards its successful implementation. We have cover articles related to the field of social research, environmental impacts, economic scenarios/case study, research based on co-location strategies of wind and wave farm, co-existence with fishing, renewable project and marine protected areas, Governance strategies/changes required and recommended approach for project deployment.

We will also be getting inputs from local fishing community and officials from Aotearoa Wave and Tidal Energy Association (AWATEA) to validate our research findings.

4. Discussion & Conclusion

In literatures referred for this paper, it was evident that many authors have their conclusions that marine renewable energy is not a mature technology and still needs improvement. But, if every nation would think like this, there would be no development at all. We believe that all technologies are always in the phase of improvement and same is the case with Marine renewable energy. European nations are so successful with marine renewable energy, the only reason being their collaboration. They have a European Marine Energy Centre (EMEC) which is a hugely successful in attracting wave and tidal energy devices for testing. They also have established MARINET which shares all the knowledge and latest development in the field. This encourages new ideas and concepts which in turn boosts development of marine renewable energy in Europe.

New Zealand should also first focus on having their own research Centre which would encourage development and enable

testing. This would not only help in faster development but also include benefits like small scale testing and demonstration, employment opportunity, vertical linkage and agglomerate economies. This would also encourage investors.

Addressing social impact is also a major part of marine renewable energy development in New Zealand. With previous project sites not getting consent of resource from government due to objection from the locals caused the project to delay which resulted in investors to back out from the project. It is found that most of the objections are due to lack of communication between the locals and the project developers which results in myths and hence giving rise to unwanted obstructions. Transparency should be maintained at every stage which would enable smooth functioning of the project. With previous research proving that fishing and MRE projects can co-exist, there should be no cause of worry for locals as there will be minimum impact to existing businesses like fishing. The theory of NIMBYism should also be put to rest, as marine energy projects are mostly underwater and hence causing minimal visual impact. But, all this is only possible if there is clear link of communication between all stakeholders. The social impact parameter was validated when we interviewed the local fishing community people regarding development of marine renewable energy developments in their fishing grounds. Most of the respondents initially were against any kind of man made developments in their fishing grounds. They were not sure about its impact of their business and hence rejected the thought of project development. As we discussed about the fact that such project would have no impact what so ever on their activities and in reality, would act as an artificial bed that would attract life, made them come on board with the idea of such project developments.

Economic viability of marine renewable energy is also one of the critical barrier for its deployment in New Zealand. The cost of power produced from Tidal energy converters is over \$500 NZ for 1MW power whereas the wholesale electric price is around \$100 NZ. This difference is estimated to reduce in next few decades. This means that government support in the form of subsidy is utmost important for the success of such project. It was also seen that most of the project cost escalated here in New Zealand due to lack of support infrastructure like availability of spare parts and skilled manpower. These things could be taken care of once we have a research facility here like one in Europe which will encourage infrastructural developments and create a conducive environment for the projects to develop by ultimately bringing the costs down.

5. References

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