Emerging Uses of Geosynthetic Floating Covers in the Energy Sector

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ABSTRACT

There are emerging applications in the energy sector, adapting geosynthetic floating cover technology for various renewable energy processes, including generation, storage and saving functions. Climate change has seen a significant focus on renewable energy generation and storage, carbon emission reduction, conserving water resources, and reducing the environmental impact of the energy industry. Water utilities have significant experience with floating covers in reducing the energy required in water treatment and to capture biogas at wastewater treatment plants. Utilities are now combing floating cover and photovoltaic solar power knowledge to transition to become energy generators rather than energy consumers. Large scale energy storage applications are now emerging using heated and chilled liquid storages, with insulated floating covers. This thermal energy is being used to generate electricity through an Organic Rankin Cycle engine or to provide direct heating. Trends are also changing in the oil and gas industry and floating covers are increasingly being used by the industry to reduce energy consumption and to protect water and the environment. This paper discusses the current applications, current developments, and future trends.

INTRODUCTION

Geosynthetic floating cover technology has been accepted by water utilities throughout the world as an economical solution to protect the quality of potable water since the late 1960's (Gersch, 2019). In the 1980's the technology was adapted for odor control on wastewater impoundments. The odor control cover technology was then adapted very quickly to accommodate the capture of biogas, which was seen as a waste product and disposed of in flares. As global climate studies gave a better understanding of the atmospheric warming effect of methane, the biogas cover was adapted to suit re-use of the biogas in boilers and electrical co-generation plants.

Climate change has seen more severe weather events. Longer, more severe droughts have been occurring in both northern and southern hemispheres and are generating more demand for covers to conserve water, particularly in the energy sector. Water conservation in the traditional energy sector has come under scrutiny and the use floating covers for evaporation control are becoming more widespread. The same influence of climate change has also driven more severe storms, particularly in equatorial regions. Rainwater can become contaminated in process water storages and can affect water chemistry of the process water and an increase in demand for rain collection covers has again been witnessed in the energy sector, particularly in sub-tropical and tropical regions. During reviews of available areas for installation of photo voltaic solar panel installations, water storages have

been identified as ideal locations with large, unshaded areas, often located close to electrical transmission networks, and often located adjacent high energy intensity industries. With Government and Corporate focus on achieving net zero carbon emissions, the investment in renewable energy generation globally has increased, and floating solar has become increasingly adopted where existing land usage limits available alternative options. Emerging renewable energy technologies using large scale thermal energy storage will see the adaption of floating cover technology once again. The timeline of adoption of floating covers in various applications can be seen in Figure 1.

DISCUSSION

Potable Water Covers:
The use of floating covers by water utilities has demonstrated the capacity to protect potable water from contamination, reduce chemical dosing of disinfectants, reduce water losses and therefore reducing pumping costs (Barry, 2007) (Spang, Manzor, and Loge, 2020). The use of floating covers in this sector is widely accepted and there is no need to discuss this application in this paper any further.

Wastewater (Biogas) Covers:
Biogas is generally a mixture of methane, carbon dioxide and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment (FGI, 2022). The precise composition of biogas depends on the digestion process and the type of feedstock.

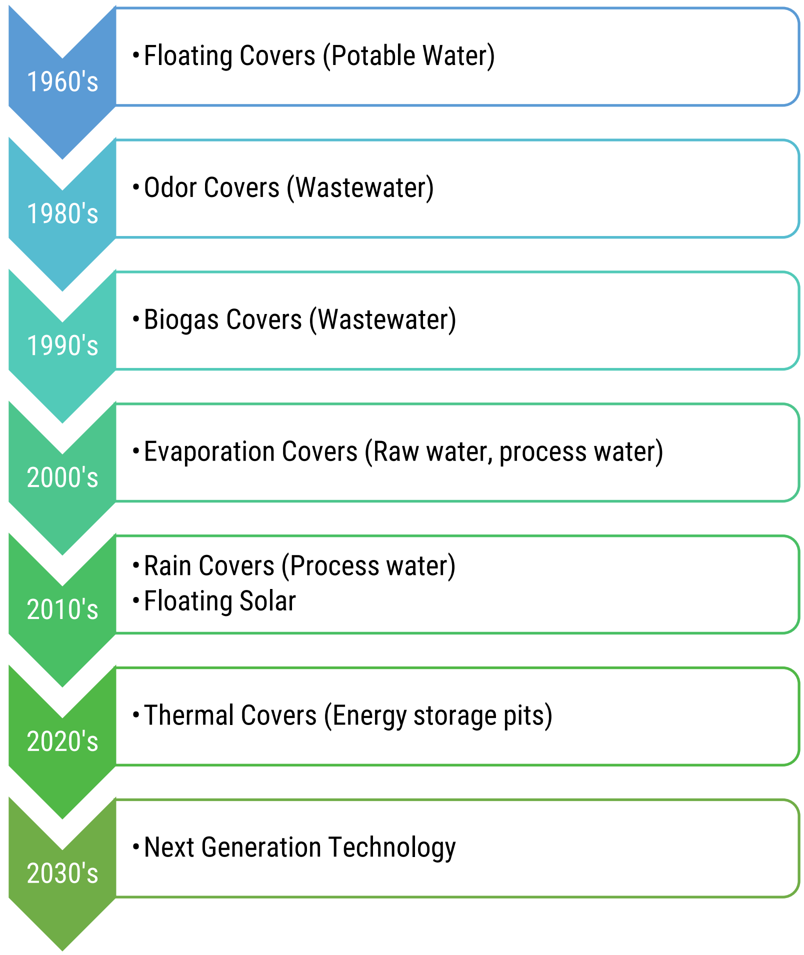

Figure 1. Geosynthetic Floating Cover Adoption Timeline

The potential for biogas production has been recognized for many years, however, it has been seen more as a bi-product of treating waste water rather than a resource. The capture of biogas from anaerobic lagoons at wastewater treatment plants has generally been used to appease neighboring communities by reduce obnoxious odors. It should be noted that biogas from municipal solid waste landfills have been managed in a similar way. An investigation by the International Energy Agency found of the potential 570 million tons of oil equivalent biogas generated globally, only 6% was being captured and used, leaving a huge potential resource yet to be exploited (International Energy Agency, 2020). Methane released into the atmosphere is 28 to 36 times more potent a greenhouse gas than carbon dioxide, absorbing much more energy while it exists in the atmosphere (International Energy Agency, 2021). As a result, Local, State and Federal Governments in various countries have enacted a mixture of incentives and regulatory requirements to promote the capture and beneficial re-use of biogas, either to provide heat energy for industrial applications or in electrical co-generation plants. An early adopter has been Melbourne Water at the Western Treatment Plant, processing unscreened raw municipal effluent using biological anaerobic and aerobic treatment processes. The two large anerobic lagoons are covered with geomembrane covers and captured methane is used to generate 70,000 megawatt hours of renewable electricity annually, making the treatment plant self-sufficient with excess power exported to the energy grid (refer Figure 2.). There are now numerous examples where wastewater treatment plants use biogas to power a substantial percentage of their electricity, heating, and cooling requirements on a smaller scale. Methane is now being seen as an energy source, rather than a waste bi-product, with even waste water channels now being covered to capture fugitive biogas emissions (refer Figure 3.).

Figure 2. HDPE Floating cover on the anaerobic section of a wastewater treatment lagoon capturing biogas and eliminating odors. An energy company has an offtake agreement with the municipal water authority to use the gas to generate electricity. Victoria, Australia. (Image: Melbourne Water, 2021)

Figure 3. CSPE Floating cover on a channel at a Wastewater Treatment Plant capturing biogas and to eliminate odors. South Australia.

Evaporation Covers:

In many locations around the world, annual evaporation rates are significantly higher than rainfall, for example, the majority of central Australia has annual evaporation rates over 3000mm while annual rainfall is in the vicinity of only 150mm (Australian Bureau of Meteorology, 2022), making evaporation losses a major factor in water supply. Average evaporation rates for oil and gas regions in Australia and North America are shown in Table 1. Evaporation losses exacerbate water license competition, higher water extraction costs, increased pumping energy requirements and increased likelihood of long-term environmental impact on ground water. Analysis of energy intensity for water sourcing, conveyancing, treatment and distribution by water companies average 610 kWh/million liters in a municipal setting (Young, 2015). Any savings in water use therefore result in meaningful energy savings.

There is an emerging trend of using floating coves to conserve the water resource to eliminate losses due to evaporation, particularly in the exploration of oil and gas reserves, due to the direct cost of sourcing and supplying water, and to improve resource companies' environmental stewardship during exploration and development activities. Oil and gas companies have started to modify the use and operation of their infrastructure to move away from short term temporary uncovered storages at rig sites to more centralized medium term covered storages supplying water across larger distances to a network of drill sites (Fraser and Killian 2015). These storages tend to be in service for shorter durations than municipal water storages and are typically designed with budgetary considerations as per the example shown in Figure 4.

Month	Moomba, South Australia (Australia) monthly (mm)	Roma, Queensland (Australia) monthly (mm)	Texas Water Development Board (USA) monthly (mm)	San Joaquin District, California (USA) monthly (mm)
January	492.9	319.3	68.6	41.15
February	403.2	240.8	84.6	33.53
March	387.5	241.8	141.7	142.24
April	252	186	182.6	134.87
May	161.2	136.4	190.5	194.82
June	111	96	227.8	299.72
July	120.9	108.5	235.7	257.05
August	170.5	142.6	212.9	268.73
September	246	210	165.9	153.16
October	328.6	266.6	132.1	106.68
November	396	276	98.0	74.68
December	474.3	300.7	74.9	29.72
ANNUAL TOTAL	**3544.1**	**2524.7**	**1815.3**	**1736.3**

Table 1. Average Evaporation Rates for Oil & Gas regions in Australia and North America

In addition to the adoption of floating covers in the more traditional energy industry, with global focus on renewable energy and storage, pumped hydro storages are increasingly being seen as a feasible method of achieving large energy storage, however in areas with net evaporation loss climates, evaporation covers are also being evaluated. The major challenge to be overcome in these types of applications will be the very high flow rates and volume changes and the associated hydraulic forces on the underside of the covers.

Figure 4. 0.75mm proprietary polyolefin floating cover on a coal seam gas raw water storage to eliminate evaporation, reducing water supply and pumping costs. Texas, USA (Image: Layfield Group)

Rain Covers:

A novel use of floating covers is emerging in the traditional Oil & Gas energy sector in sub-tropical and tropic equatorial regions. Typically, process water ponds in this sector of the energy industry contain traces of hydrocarbons, salts and other contaminates that require treatment. To reduce the water inventory requiring treatment, energy companies are installing rain covers prior to the onset of the wet season, preventing rainfall from intermingling with the process water. The rainwater is discharged through stormwater infrastructure, and at the commencement of the dry season, the geosynthetic covers are removed. Due to the seasonal nature, the covers tend to be less complex fabricated from lighter weight geomembranes and have been adapted for earthen pits and tanks (refer Figure 5. and Figure 6.) The use of rain covers also maintains the water chemistry of the process water in applications where the chemistry is critical.

Figure 5. 0.75mm proprietary polyolefin rain cover on a coal seam gas frac storage to eliminate rainfall intermingling with stored fracking liquid. NT, Australia. (Image: MPC, 2018)

Figure 6. 1.00mm proprietary polyolefin floating cover on syngas process water to eliminate odors and rainfall ingress. Qld, Australia (Image: A. Gersch, 2015)

Floating solar:

Floating covers and pontoons are also being adapted to carry photovoltaic solar panels. This adaption has been a relatively simple process as it has simply merged two existing technologies, and while there are some additional capital costs over stand-alone technology there are several very distinct advantages with floating solar.

1. Floating solar utilizes existing open space and does not require allocation of land which would normally be used for other purposes.
2. Ponds and lagoons are generally very open and no shading from vegetation occurs on the PV modules.
3. There is no vegetation management required, typical of ground mounted solar PV installations.
4. The micro-climate over a large mass of water is cooler and therefore the P.V. modules operate at higher efficiency than roof mounted or ground mounted P.V. modules.
5. Many water storages are associated with energy intensive industries with high energy demand e.g. water treatment plants, and the power generated can either be used in these plants, or exported into the electricity network.

Open water floating solar (P.V. modules mounted on a network of pontoons) has been the most popular to date with over 250 installations in over 30 countries globally (refer Figures 7. and 8.). Many water users and water utilities are turning to this technology in their effort to achieve carbon neutral goals (Climate Action, 2017) and as cost efficiencies are being achieved through the widespread adoption of solar generation, capital costs have come down dramatically (PV Magazine USA, 2020).

Figure 7. Open water floating solar (CN) (Image: Climate Action, 2017)

Figure 8. Open water floating solar (CN) (Image: PV Magazine USA, 2020)

Insulated covers:

Insulate covers are being used as a cost-effective way of reducing heat loss in open lagoons or tanks to either maintain biologic activity and as a very efficient way of storing excess energy. Biological wastewater treatment processes slow down with colder temperatures, and this can cause significant problems in cold climates. Insulated covers have been installed on waste water lagoons to reduce temperature loss and maintain biological activity through the winter months.

An emerging technology is to store excess energy in thermal pits by heating water up to 90°C. The hot water is then used at a later time, either as a direct heat source for industrial or municipal applications (AalborgCSP, 2019). To efficiently store the water, heavily insulated covers are required to maintain the energy in storage pits. This requires the use of specialized high temperature polyolefin materials suitable for continuous operating temperatures above 80 deg C, and chemically resistant to the corrosion inhibitors and disinfectants typically used in these types of application.

A unique application of this technology is currently being adapted in Australia, essentially using the thermal pits as a heat battery for thermal hydroelectric power generation. During daylight hours a mirror array focusses sunlight on high efficiency photovoltaic cells generating electricity. The PV cells are water cooled with the heat generated being stored in a large thermal pit, while electricity generated by the PV cells is either dispatched into the electricity grid or used to chill water in a second thermal pit. During periods of low solar irradiance or at night, the thermal energy differential from the hot and cold pits is used to generate dispatchable electricity using an organic Rankine cycle engine. Thermal Hydro is a low cost, large scale, long duration energy storage system. The system relies heavily on geosynthetic geomembrane materials capable of withstanding hot (or cold) continuous operating conditions, high UV exposure on the top surface of the covers, and incorporating substantial thermal insulation properties (Fairhead and Pece, 2022).

Figure 9. Bi-modal HDPE insulated floating cover on a thermal pit storing hot water for power generation using a thermally driven Organic Rankine Cycle (ORC) engine. Victoria, Australia.

Figure 10. Insulated floating cover on a hot water thermal pit. Marstal, Denmark.

CONCLUSION

While floating covers have been used for the last five decades in protection of water and the environment, there has been significant growth in the adoption of floating cover technology in various energy applications, both in the traditional energy sector and with emerging energy generators. While fossil fuel consumption is expected to decline as the world transitions to renewable energy sources, the oil and gas industry is embracing floating covers to reduce the carbon footprint associated with exploration and extraction and to improve their environmental stewardship. The biogas industry has also embraced floating covers to capture and store biogas. The IEA estimates the industry is set to grow 40% over the period to 2040 as every region around the world has significant scope to produce biogas and/or biomethane, with the largest opportunities being across the Asia Pacific region. With a global focus in achieving net zero carbon emissions by 2050, the use of renewable energy has created new opportunities for floating covers, demonstrated by the adoption of floating solar installations and more recently the use of thermal energy pits to store heated and chilled water. It is the authors opinion that more floating cover applications will emerge in the coming decade as new technologies are developed requiring large scale liquid storage facilities.

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