

## Sustainable Transport for Remote Island Communities

Thomas Schönberger and Neil Ferguson, University of Strathclyde,  
Colin Young, Argyll and Bute Council, and Derek Halden, Derek Halden Consultancy Ltd.

### 1 Introduction

This paper outlines ways to make remote island communities in Western Scotland more accessible, while aiming for options with minimal CO<sub>2</sub> emissions to contribute to Scotland's intended transition to a low carbon economy. The underlying analysis considers current policy challenges to provide more frequent connections to remote island communities in response to a growing public need for better accessibility while at the same time becoming less reliant on public subsidies for supporting sustainable growth on remote Scottish Islands.

These challenges are analysed based on experiences in Argyll and Bute Council in Western Scotland to then serve as a basis for similar discussions in other areas with scheduled ferry and air services in Western Scotland and across the world.

### 2 Background

In recent years the majority of the remote island communities in Scotland have grown in population size. Table 1 presents the Census data of 2001 and 2011 and shows that in this period the population on some islands in Western Scotland has grown significantly. For Argyll and Bute, the 2011 Census identified that approximately 17.7 per cent of the population in the Council area live on the populated islands<sup>1</sup>.

**Table 1: Population Development of selected Islands in Western Scotland according to the 2001 and 2011 Census**

Council Area	Island	2001	2011	% Change 2001-2011
Argyll & Bute Council	Coll	164	195	+19
	Tiree	770	653	-15
	Mull	2667	2800	+5
	Colonsay & Oronsay	113	132	+17
	Iona	125	177	+42
	Islay	3457	3228	-7
	Jura	188	196	+4
	Lismore	146	192	+32
Comhairle Nan Eilean Siar	Barra	1078	1174	+9
	South Uist	1818	1754	-4
	Benbecula	1219	1303	+7
	North Uist	1271	1254	-1
	Harris & Lewis	19918	21031	+6
Highland Council	Skye	9232	10008	+8
	Small Isles	125	144	+15

To support population growth and to further promote vibrant communities on remote Scottish islands frequent transport connections for residents and visitors are essential. While the growth of digital based business, education, services and communication has significantly changed the opportunities to those based on islands, it has also driven continued increasing expectations of connectivity and the need to

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enable the quick and convenient movement of individuals and goods. Frequent, convenient and time efficient transport links are key to island communities to provide business and leisure travel opportunities, access to services not available on the island, to import food and raw materials and export finished products. This transport is also important to those wishing to do business on or visit the islands, including day trips, and for public and private sector organisations providing services to the island communities, for example utility providers, NHS and the Council.

Over time, the economies of many of the islands has moved towards having a significant tourist / visitor element, this has resulted in a number of islands now having a significant percentage of residential properties as second homes, in some cases as high as 40%. This, combined with the centralisation of services as part of service rationalisation, cost reduction and specialisation of staff has reduced the viability of providing services based on a number of the islands. As such, many of these services are now provided by staff based elsewhere on a regular visiting basis, further emphasising the importance of transport links to ensuring the continued sustainability of smaller island communities.

An emerging demand for daily connections to more islands has been shown in reports like the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018) based on results of surveys of residents, businesses and visitors. Among other results for community and business needs this report concluded that residents and visitors of the islands in the Argyll and Bute Council want scheduling changes for air connections to better coordinate with the ferry timetables to allow travel between mainland Scotland and these islands every day on at least one of the two services, have same day return options with long enough stays for business and social purposes and an option for spending long weekends on and off the islands (DHC, 2018). To best address these demands the current pattern of ferry and air connections to remote island communities in the Argyll and Bute Council require a coordinated expansion. The review suggests how a combination of ferry and air services and more targeted marketing of flight options to non-regular and unaware user groups has the potential to enhance already existing social and economic benefits of these connections (DHC, 2018).

Scotland's intended transition to a low carbon economy aims at creating sustainable economic growth for all but translating policy into practice requires further work. While Scotland as a whole has already met its next annual climate change targets (Scottish Statutory Instruments, 2010), this means that growing demand for more frequent connections to the islands in Western Scotland places a greater responsibility on planners and operators to provide potential access improvements to these remote island communities as sustainably as possible. To enable carbon neutral growth, more efficient transport technologies, an optimized operation of ferry and air service combinations and improved infrastructure in the air and on the ground are needed. Hence, planners looking at providing better access to remote island communities need to determine how to deploy the most efficient vessels and aircrafts available in optimized operational patterns regarding their timetables and frequencies to foster economic growth for all with the lowest CO<sub>2</sub> emissions possible.

A previous analysis of the relative performance of different ferry and surface transport options revealed for connections to Orkney in Northern Scotland that surface transport in combination with shorter and more fuel efficient ferry sailings can result in lower CO<sub>2</sub> emissions per passenger and vehicle-km (Baird, 2011). This suggests that options responding to the growing demand for more frequent connections to remote islands in the Argyll and Bute Council also require a careful evaluation regarding their environmental impact to identify policy options and ferry and air service combinations with minimal CO<sub>2</sub> emissions.

A look at subsidies paid for Transport Scotland's ferry services reveals that spending on ferries increased by 115 per cent in real terms between 2007/08 and 2016/17 due to the expansion of services, vessel replacements, and the introduction of the Road Equivalent Tariff<sup>i</sup>, while there has only been a marginal growth of 0.3 per cent for passenger numbers and an 16.8 per cent increase of car numbers (Audit Scotland, 2017). Moreover, this tariff reduction was reported by island residents as a cause for

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capacity problems during peak tourist seasons (DHC, 2018). Most ferry routes in Scotland are subsidised under public service obligations (PSO). These national schemes for ensuring the financial viability of transport connections have the objective to provide residents and visitors with links between remote communities and main centres of mainland Scotland, complemented by many other commercial and community run services. (Audit Scotland, 2017).

For air services to remote island communities in Western Scotland there are also PSO contract schemes between airlines and local authorities to provide the financial viability of these routes. The air service of Hebridean Airways to Coll, Tiree and Colonsay is supported as part of national PSO agreements<sup>iii</sup>. The review of Argyll and Bute Public Service Obligation Air Services shows that since the last tender of the PSO for flights in the Argyll and Bute Council subsidy per passenger has grown, while passenger numbers have decreased after 2016 and a reduction in ferry fares has resulted in increased competition with air (DHC, 2018). In addition, some commercial services have an air service discount scheme for remote island and mainland communities so that residents can buy tickets with a 50 per cent discount<sup>iv</sup>. For a limited national budget, service expansions in the Argyll and Bute Council must therefore consider this context of the development of ferry and air service subsidies to ensure proper, efficient and effective spending of public money.

The initial purpose of the Review of Argyll and Bute Public Service Obligation Air Services (2018) was to support the retendering of Argyll and Bute Council's PSO Air Service, serving Coll, Colonsay and Tiree, as well as the 'Scholar flights' operated to transport secondary school pupils from Coll and Colonsay to Oban High School on a weekly basis. As the time of the study, the incumbent operator of the PSO Air Service also operated a service to Islay on a commercial basis which was not included within the scope of the study. Due to a compressed timescale for the tendering process in order to ensure a continuity of service, the retendering process was begun prior to the full results of the review being available, although the review was provided to potential tenderers during the tender process. Unfortunately, the first procurement process did not receive any compliant tenders, in part due to the Council seeking service options based on a fixed price due to budget restrictions. As such, a second procurement process had to be undertaken, this closed in May 2019 with the new contract expected to start in October 2019.

### 3 Methods

This study first considers how to provide improved transport network coverage to the islands in the Argyll and Bute Council best aligned with transport policy aims. In particular to help appraise the accessibility needs for the islands the emissions impacts of timetable, frequency and capacity changes are considered.

The transport CO<sub>2</sub> emissions and fuel consumption levels for different vessels and aircrafts operated on these routes are compared using data from current service operation in other areas of Western Scotland.

In response to the needs for more frequent services, particularly to Coll, and Colonsay identified in the Review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018), the following scheduling changes are evaluated for a better pattern of synchronised ferry and air services for residents' and visitors' needs:

- daily connections by ferry or air service
- return options on the same day with a long enough stay on the islands and on mainland Scotland respectively to do business or make a social visit
- the opportunity to make long weekend trips with outbound connections on Friday afternoon and return options Sunday afternoon

Options to meet these needs are then evaluated regarding their implied CO<sub>2</sub> emissions for an island community to identify policy choices for the lowest carbon ways leading to these planning goals.

In a final discussion concluding this study the results and implications of the analysis are evaluated in the context of subsidy per passenger by air and ferry and the growing national funding and accessibility needs. These insights are used to identify opportunities for a sustainable economic and environmental development of ferry and air services to remote island communities in Western Scotland.

## 4 Data Collection and Analysis

### 4.1 Current Ferry Services

For ferry connections to remote island communities in Western Scotland Table 2 shows routes running between mainland Scotland and the Western Scottish islands Coll, Tiree, Mull, Colonsay and Islay and the primary vessels used on these routes with their vehicle and passenger capacities. These ferry links operated by Caledonian MacBrayne (CalMac) provide both passenger and vehicle access to those island communities.

**Table 2: Ferry Routes to Western Scottish Islands and Primary Vessels**

Route	Primary Vessel	Type of Vessel	Passenger Capacity (persons)	Vehicle Capacity (vehicles)
Oban – Colonsay – Port Askaig (Islay) - Kennacraig	Lord of the Isles	Large ROPAX ferry	506	56
Kennacraig – Port Ellen / Port Askaig (Islay)	Hebridean Isles	Large ROPAX ferry	494	68
Tobermory (Mull) – Kilchoan	Loch Linnhe	Small double ended ROPAX ferry	199	12
Oban – Coll – Tiree	Lord of the Isles	Large ROPAX ferry	506	56
Oban – Craignure (Mull)	Isle of Mull	Large ROPAX ferry	962	80
Lochaline – Fishnish (Mull)	Loch Fyne	Small double ended ROPAX ferry	200	36

In this vessel classification, ROPAX denotes a vessel to carry passengers, passenger vehicles and freight vehicles. In general, a type designation groups ferries with similar route requirements like speed, passenger and vehicle numbers and manoeuvrability, and route restrictions such as the depth of water, the dimensions of piers and arrangements of the shore infrastructure (Scottish Government Ferry Review, 2010).

Figures 1 and 2 map the origins and destinations of above named routes to islands in Western Scotland. The first map shows the northern part of the operated area with Oban, which is the major port on mainland Scotland, and Lochaline and Kilchoan in adjacent areas and peninsulas of mainland Scotland. On the Isle of Mull, ferries arrive and depart from Craignure, Fishnish and Tobermory. West of Mull are the islands Coll and Tiree. Lismore and Iona in the map are not considered in this analysis. The southern part of the area in figure 2 shows Kennacraig on mainland Scotland, Port Ellen and Port Askaig on the Isle of Islay and Colonsay in the Northwest. Again, Jura and Gigha are not part of the analysis.



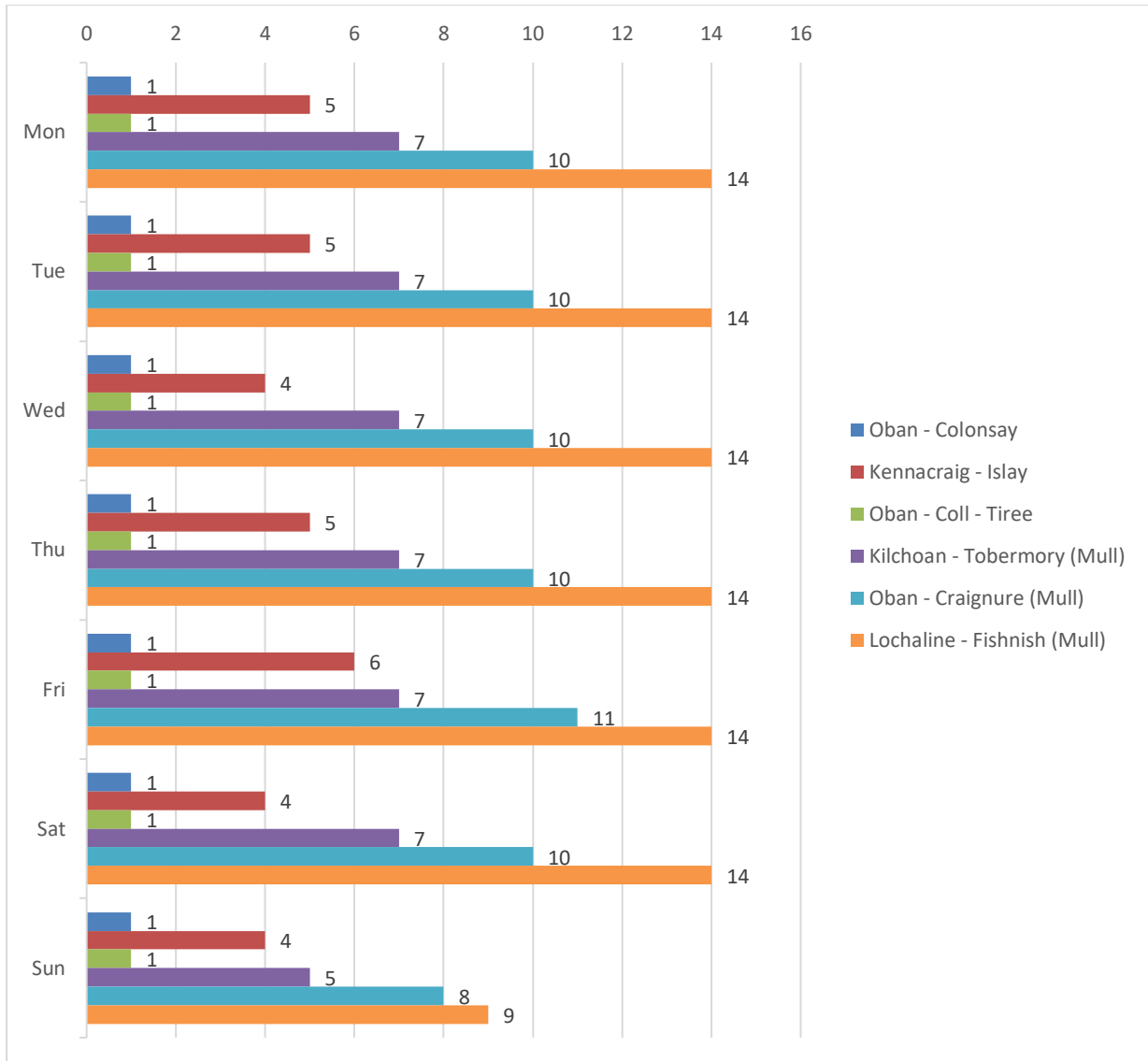
**Figure 1: Northern operational area of CalMac's ferries to the Argyll Islands [based on Caledonian MacBrayne's route maps<sup>vj</sup>]**



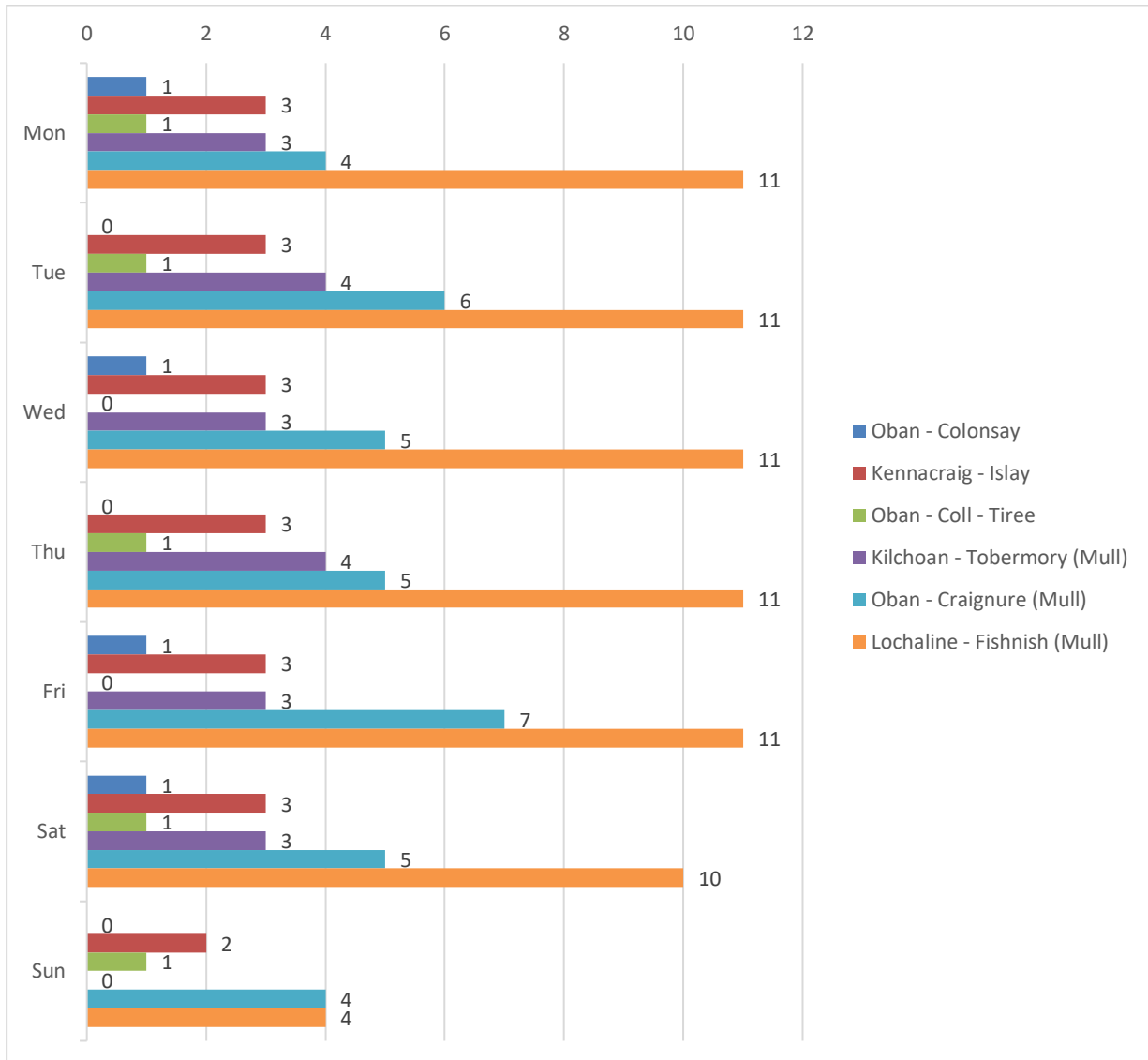
**Figure 2: Southern operational area of CalMac's ferries to the Argyll Islands [based on Caledonian MacBrayne's route maps<sup>vj</sup>]**

These ferry connections run in fixed weekly schedules with timetable periods ending and starting usually at the rotation of daylight-saving time. In Table 3 and 4 the timetables of the routes from Table 2 are described regarding their frequency of service for each weekday.

**Table 3: Timetable of Ferry Connections to Islands in the Argyll and Bute Council in Summer**



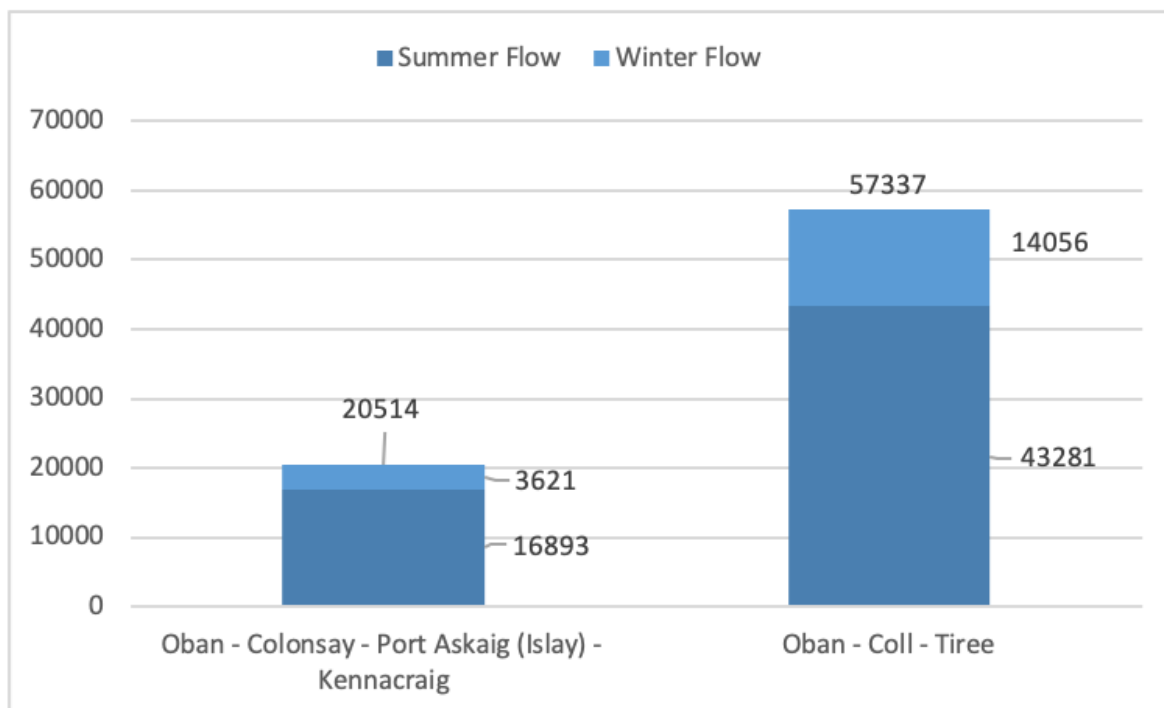
**Table 4: Timetable of Ferry Connections to Islands in the Argyll and Bute Council in Winter**



This shows that while there are three different options with a high frequency of service to Mull, other islands like Coll and Tiree do not get daily connections every day, for example on Wednesday and Friday in winter, and same day return trips requiring a second sailing do not work in most cases for Coll, Tiree and Colonsay, if there is only a single daily connection.

A further look into demand numbers for the routes to Coll, Tiree and Colonsay, which require improved transport network coverage to meet the residents' and visitors' needs identified in chapter 3, shows that similar to the frequency of service also demand is fluctuating throughout the year. Figure 3 shows the demand numbers for the most recent year on the ferry routes to Coll, Tiree, Colonsay and Islay, and compares the summer flows between April and September 2017 with the winter flows between October 2017 and March 2018 based on CalMac's passenger data.





**Figure 3: Summer and Winter Flows on Ferries Routes to Coll, Tiree and Colonsay**

Although this seasonal demand will have an uneven distribution over summer and winter months and individual weeks, it gives an indication of how popular each route is and how this demand is fluctuating during the year.

In total, current ferry services show that gaps in the frequency of service on some routes today impede meeting the needs for daily connections, same day return options and long weekend connections outlined in chapter 3, and therefore there is demand for service improvements.

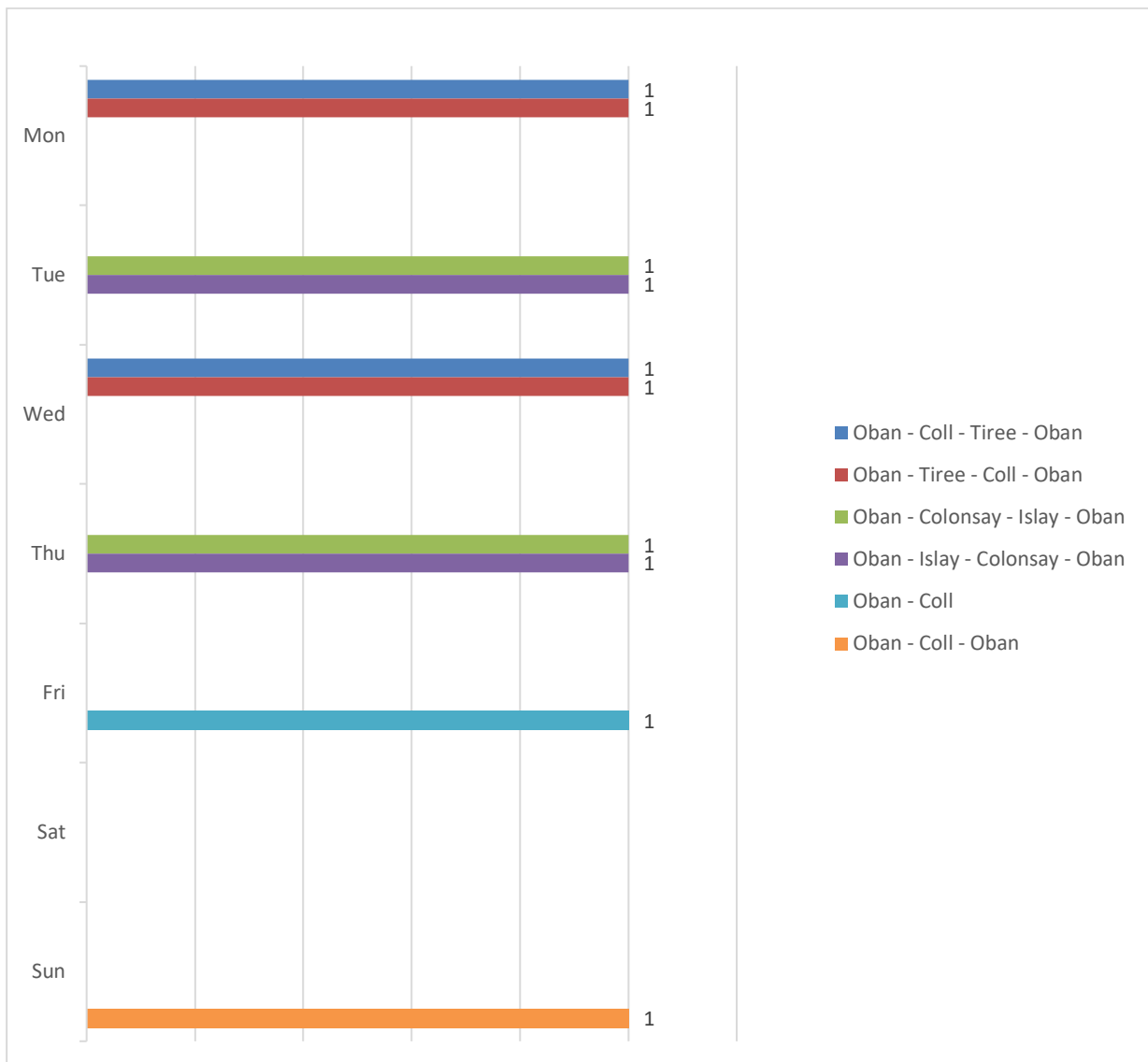
## 4.2 Current Air Services

In addition to ferry connections, in 2008 started flights to the islands of Coll, Tiree, Colonsay and Islay from Oban Airport. As these are still relatively new routes, a settled operational pattern consistent with sustainable growth is still missing (DHC, 2018). The connections provided by Hebridean Air Services Ltd run on two routes. Both routes are operated by a single nine seater BN2B-26 Islander aircrafts which is powered by two Lycoming piston engines running on Aviation gas and have currently has an average seat occupancy of about 40% according to the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018).

These aircrafts fly from Oban to Coll and Tiree and back to Oban once every Monday and Wednesday in the morning and in the opposite direction in the afternoon. On Tuesdays and Thursdays, there are flights on the route from Oban to Colonsay and Islay and back to Oban in the morning and from Oban to Islay and Colonsay and back to Oban in the afternoon. In addition, in summer on Friday and in winter on Saturday there are flights from Oban to Coll and Colonsay and back, repeated on Sundays, for high school pupils from these islands attending Oban High School. Seats on these flights not occupied by school pupils are available to members of the public, enhancing the service for other travellers. For the current timetable running from 31 March to 15 May, the frequency of flights on each week day is presented in table 6.



**Table 5: Timetable of Flights between Oban, Coll, Tiree, Colonsay and Islay**



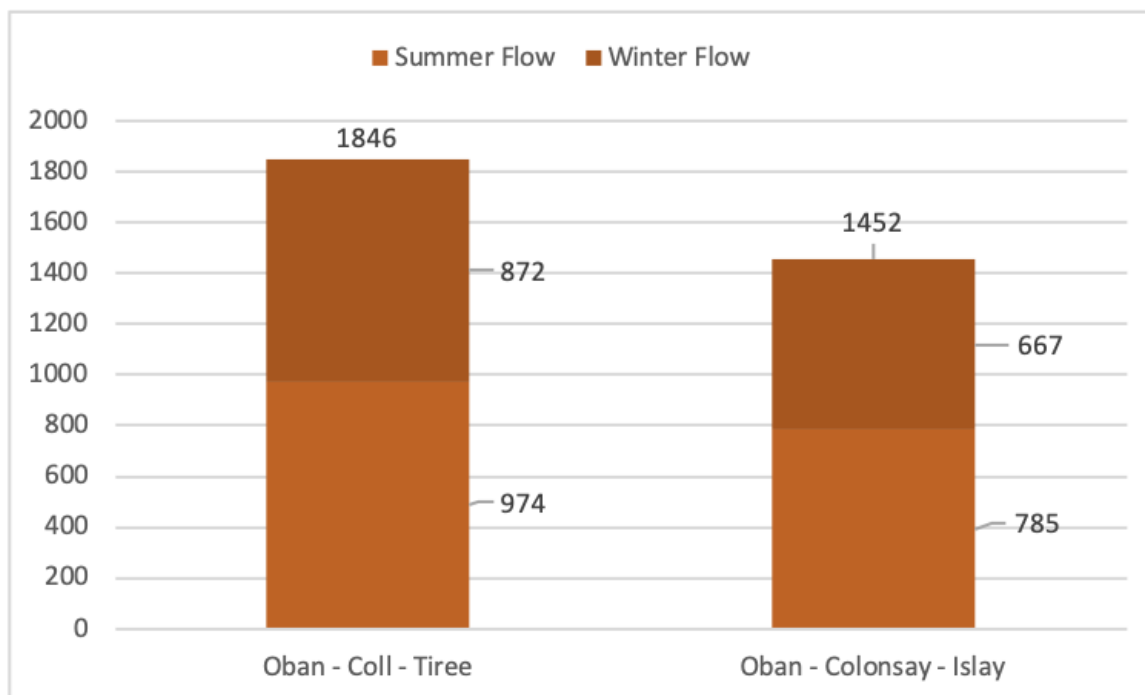
With these flight times there are air service options on the specific week days for visits

- from Oban to Coll for 6 hours
- from Oban and Coll to Tiree for 5 hours
- from Oban to Colonsay for 7 hours
- from Oban and Colonsay to Islay for 6 hours
- from the islands to the mainland for almost 4 hours on the Coll/Tiree route and almost 5 hours on the Colonsay/Islay route

Moreover, with shorter journey times, a different weather disruption profile independent of wave directions and heights and additional connecting options the air service enhances the accessibility of remote islands in the Argyll and Bute Council area provided by ferry timetables. Similar to the ferry connections, weather conditions and other disruptions leading to cancellations result in a lower number of actually flown flights in comparison to what is actually scheduled.

Figure 4 presents the demand numbers from October 2017 to September 2018 on the two flight routes Oban – Coll – Tiree and Oban – Colonsay – Islay, and compares the winter flows from October 2017 to

March 2018 with the summer flows between April and September 2018 based on passenger data provided the Argyll and Bute Council.



**Figure 4: Summer and Winter Flows on Coll-Tiree and Colonsay-Islay Air Service Routes**

Therefore, without changes regarding the frequency of service and timetable also the air service alone does not meet the needs for daily connections, same day return options and long weekend connections to Coll, Tiree and Colonsay.

#### 4.3 Accessibility Gaps of Current Services

Sections 4.1 and 4.2 show that Coll, Tiree and Colonsay and Islay are remote island communities in the Argyll and Bute council area with both ferry and air service connections to further discuss regarding service expansions. In contrast to Mull and Islay with multiple ferry connections and daily sailings, these islands are the ones that can principally benefit from timetable and frequency of service changes responding to the needs identified in the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018). This demand to allow travel between mainland Scotland and these islands every day on at least one of the two services, have same day return options with long enough stays for business and social purposes and an option for spending long weekends on and off the islands is evaluated in Tables 6 and 7 for a standard week of the ferry and air service timetables in summer and winter to assess to what extent this demand is already covered by current connections and the available frequency of service.

**Table 6: Current Accessibility Provided by Current Ferry and Air Service in Summer**

Island	Daily connections by ferry or air service	Return options on the same day	Opportunity to make long weekend trips with outbound trips on Friday afternoon and return options Sunday afternoon
Coll	Yes	No, only on Monday and Wednesday by air service	Yes, but limited capacity on weekend flights for commuting pupils.
Tiree	Yes	No, only on Monday and Wednesday by air service	No.
Colonsay	Yes	No, only on Tuesday and Thursday by air service	No.
Islay	Yes	Yes	Yes

**Table 7: Current Accessibility Provided by Current Ferry and Air Service in Winter**

Island	Daily connections by ferry or air service	Return options on the same day	Opportunity to make long weekend trips with outbound trips on Friday afternoon and return options Sunday afternoon
Coll	Yes, but limited capacity on days with only flight option.	No, only on Monday and Wednesday by air service	Yes, but limited capacity on weekend flights for commuting pupils.
Tiree	No, no connection on Friday and limited capacity on days with only flight option.	No, only on Monday and Wednesday by air service	No, there is no connection to Tiree on Friday.
Colonsay	No, no connections on Sunday and limited capacity on days with only flight option.	No.	No, there is no return option on Sunday.
Islay	Yes.	Yes.	Yes.

The above highlights several of the most important accessibility gaps as follows:

- In winter, there is no ferry or air service connection to Colonsay on Sunday. Currently only during term time, there is a late notice option to use the unoccupied seats of the scholar flights in non-scholar directions.

- There are no possibilities to make return trips to and from Colonsay on the same day throughout the year except with the flights on Tuesday and Thursday in summer.
- Connections between Coll and Tiree and mainland Scotland are not available on Friday in winter.
- For Coll and Tiree, same day return options for personal and business trips in winter are only on the flight days Monday and Wednesday.

Temporary or permanent low frequencies of one service can especially then become problematic when disruptions interfere operations. Service interruptions or delays can for example be caused by bad weather, in accordance with safety procedures or through operational delays at the harbour facilities (Transport Scotland, 2018). Hence, multiple sailings on the same day or a combination of ferry and air service connections can provide more resilient accessibility to the remote islands in the Argyll and Bute Council.

#### 4.4 Environmental Profile of Current Vessels and Aircrafts

The vessel and aircraft types currently used on the routes to Coll, Tiree and Colonsay provide different ways of closing the previously determined gaps and are associated with a range of wider effects including CO<sub>2</sub> emissions. The levels of fuel consumption and CO<sub>2</sub> emission for these vessels and aircrafts are presented in Table 8. For the ferries' fuel consumption rates of marine gas oil, the predominant fuel used for CalMac's vessels, type E vessels emit 2.75 kilograms CO<sub>2</sub> per consumed litre of marine gas oil and type C vessels 2.65 kilograms CO<sub>2</sub> per litre. The conversion rate for the AvGas used by the aircraft is 2.1994 kilograms CO<sub>2</sub> per litre. For the further analysis of the aircraft, operation with maximum take-off weight (MTOW) is assumed, as even low load factors only result in marginal changes of the aircraft's overall weight.

**Table 8: Fuel Consumption and CO<sub>2</sub> Emissions of Vessels and Aircraft**

Primary Vessel	Type of Vessel	Passenger Capacity (persons)	Fuel Consumption (litres / hour)	CO <sub>2</sub> Emissions (tonnes / hour)
Lord of the Isles	Large ROPAX ferry	506	710	1.953
Hebridean Isles	Large ROPAX ferry	494	580	1.595
Loch Linnhe	Small double ended ROPAX ferry	199	50	0.133
Isle of Mull	Large ROPAX ferry	962	750	2.063
Loch Fyne	Small double ended ROPAX ferry	200	80	0.212
BN2B-26 Islander	Twin-engine aircraft	8	97.6	0.215

While the ferries and aircrafts also emit other greenhouse gases, their global warming potential has like CO<sub>2</sub> an exact correlation to the fuel consumed. That is why it can be translated in CO<sub>2</sub>-equivalent values

according to the Kyoto gases conversion rates from the IPCC report of 2007<sup>vii</sup> and is not included as a separate factor for evaluating the environmental impact of options in this analysis.

#### 4.5 Appraisal of Low Emission Options to Improve Accessibility

The identified needs for more frequent services to Coll, Tiree, Colonsay and Islay as described in the background of this study, require changes for more frequent or better synchronised ferry and air services and can be realised with different vessel and aircraft options, which in turn result in different amounts of emitted CO<sub>2</sub> greenhouse gas.

Therefore, in response to accessibility improvements and for minimising the environmental impact of this growth there are different policy choices needed. The following steps describe how the goals of having every day the possibility to get on and off remote islands in the Argyll and Bute Council either by ferry or by air service and the additional request for creating the opportunity to make return trips on the same day with a long enough stay for business or social visits need to be evaluated in political decision making.

For travelling between Oban on mainland Scotland and the islands Coll, Tiree and Colonsay in Argyll and Bute Table 9 shows in addition to the different vessel and aircraft options from Table 8 two alternative vessel and aircraft options with their passenger capacities and levels for fuel consumption and CO<sub>2</sub> emissions. Besides the vessels already in use today MV Filla currently operated in Shetland on the route to Skerries is an option of a small single ramp ROPAX ferries with the primary focus on transporting passengers (CMAL, 2010). It has been introduced in 2003, has a capacity for 30 passengers and nine cars, and a fuel consumption of 265 litres MGO per hour. Moreover, in addition to the BN2B-26 Islander aircraft used by Hebridean Air, an alternative aircraft operated by LoganAir on routes to islands in western Scotland and other international destinations is the DeHavilland 6-400 Twin Otter.

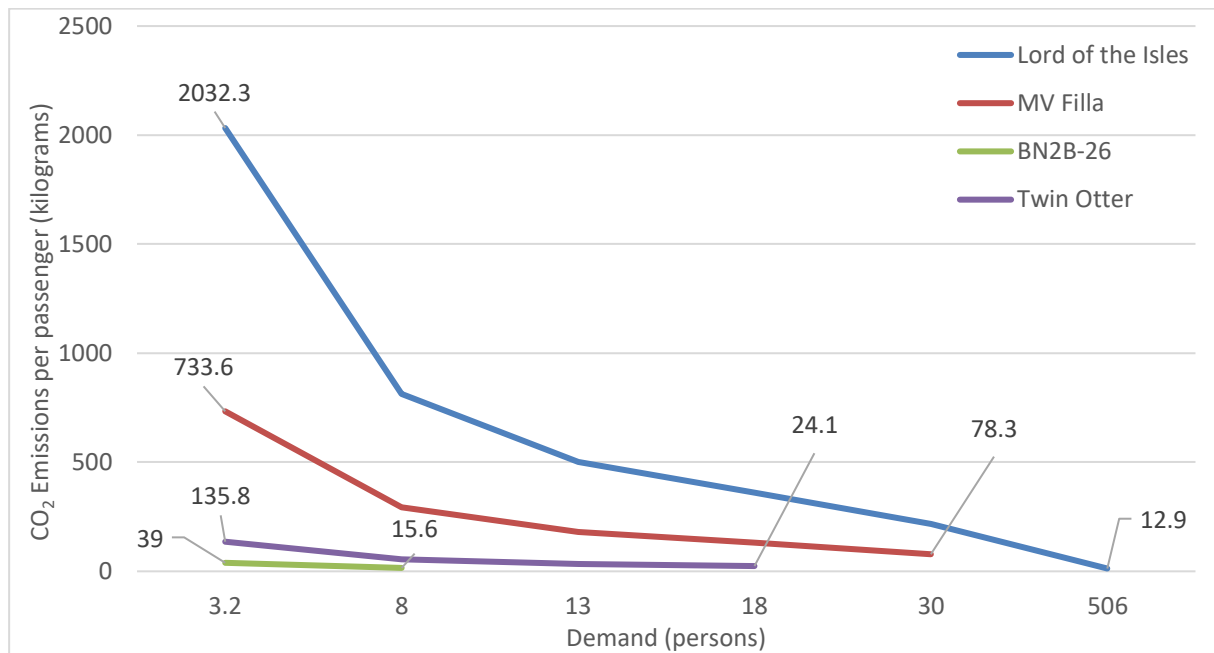
**Table 9: Vessel and Aircraft Options**

Vessel / Aircraft	Type	Passenger Capacity (persons)	Fuel Consumption (litres / hour)	CO <sub>2</sub> Emissions (tonnes / hour)
MV Filla	Small single ramp ROPAX ferry	30	265	0.705
DeHavilland 6-400 Twin Otter	Twin-engine aircraft	18	340.7	0.749

For the ferry service, the long-term perspective is to use vessel configurations with low CO<sub>2</sub> emissions by using liquid natural gas, biodiesel or hybrid propulsion, which is directly taking advantage of the decreasing CO<sub>2</sub> emissions per kilowatt in Scotland's national grid (CMAL, 2010), while the aircraft industry is on the cusp of introducing electric aircraft options which come with the potential of being less dependent on available fuel resources and can be charged locally with renewable energy<sup>viii</sup>.

For the route-specific appraisal of sustainable options to improve accessibility connections do also depend on their duration per sailing or flight. For responding to the emerging demand of being able to access Coll and Tiree besides the connections from Glasgow also directly from Oban on a Friday during the winter schedule outside of school terms, closing this gap requires the following considerations.

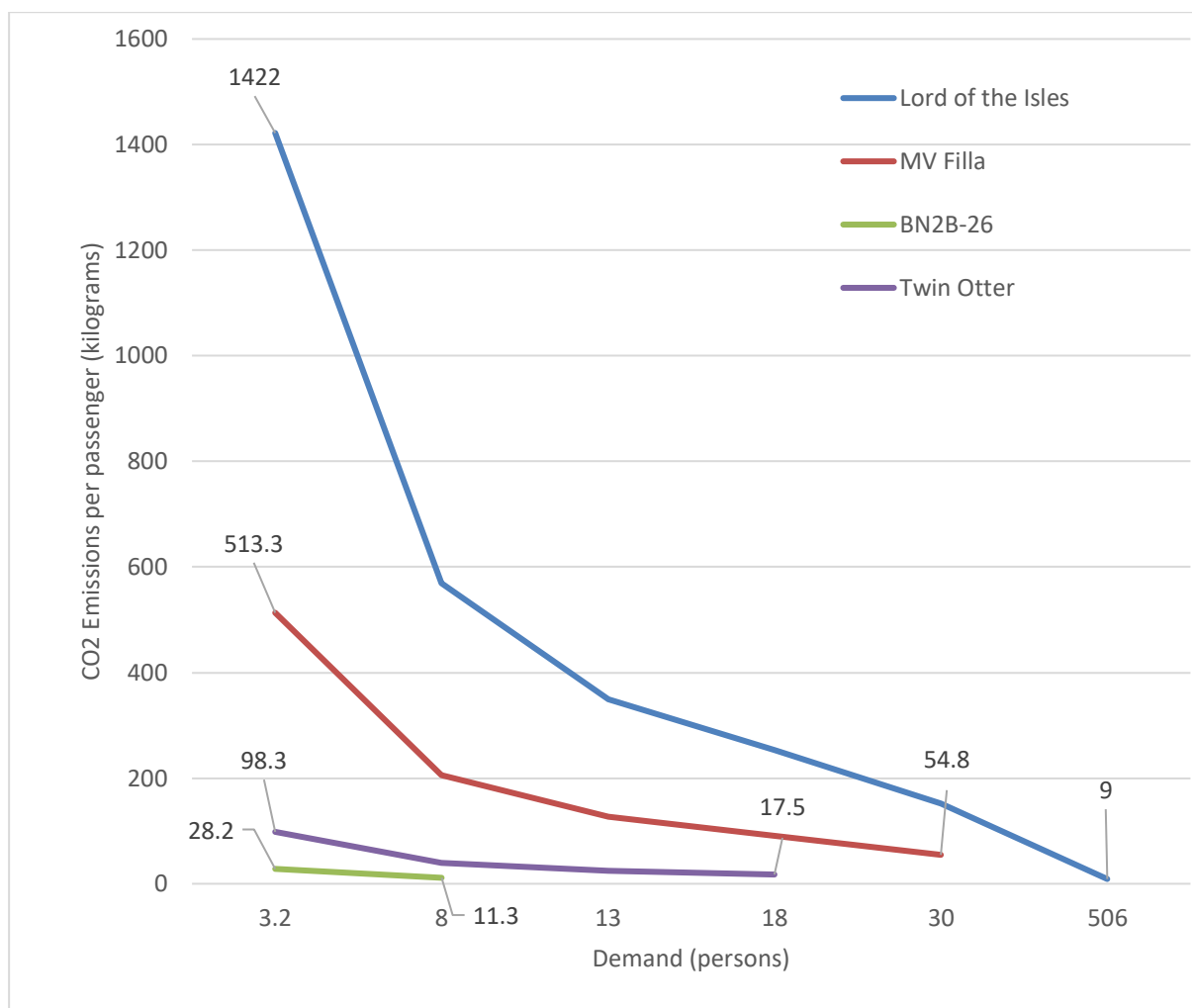
A scheduled sailing on this route takes 3.33 hours and a one way flight along the route Oban – Coll – Tiree 0.58 hours. Therefore with the Lord of the Isles as the vessel currently in operation on this route, 13.0 tonnes of CO<sub>2</sub> are emitted on a return sailing on this route, while an additional flight of the an BN2B-26 Islander aircraft emits 0.249 tonnes of CO<sub>2</sub> on a round trip. Therefore, under the assumption that the emerging demand for this additional connection is mostly for transporting passengers different demand levels result in other CO<sub>2</sub> emissions per passenger. This is shown in Figure 5 for the current and alternative vessel and aircraft options on routes from Oban to Coll and Tiree.



**Figure 5: Demand based CO<sub>2</sub> Emissions per passenger on Ferry and Air Service Routes from Oban to Coll and Tiree**

Therefore, demand for this additional sailing or flight plays an important role. Currently, with an average passenger capacity utilisation of 13 passengers on the ferry route and 3.2 passengers on flights to Coll and Tiree and emission levels for full capacity utilisation of each vessel and aircraft, low passenger demand seems to be most sustainably served regarding the emitted CO<sub>2</sub> emissions by additional flights with appropriate capacities. For higher demand and up to 30 passengers also a smaller vessel can be a more sustainable alternative to another sailing of the Lord of the Isles vessel.

For the same vessel and aircraft options but with another route, Figure 6 shows the demand based emissions per passenger on the route from Oban to Colonsay with a one way sailing time of 2.33 hours and flight duration of 0.42 hours. This appraisal of low emission options shows that again flights are the most environmentally friendly option for low demand and for ferry demand up to 30 persons the MV Filly vessel is more sustainable the Lord of the Isles.



**Figure 6: Demand based CO<sub>2</sub> Emissions per passenger on Ferry and Air Service Routes from Oban to Colonsay**

Therefore, policy options for minimal CO<sub>2</sub> emissions depend strongly on how much demand can be generated for additional connections. Here, the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018) suggests that air service demand can be increased by more targeted marketing of flight options to non-regular and unaware user groups.

To also create an opportunity to make return trips between Coll, Tiree or Colonsay and mainland Scotland on the same day with a long enough stay for business or social visits in addition to providing one access option to Colonsay on Sunday, the same demand based considerations can be used to determine the resulting amount of CO<sub>2</sub>, but a further discussion of the resulting trip lengths is needed, especially if the ferry or aircraft makes a stopover on the island instead of scheduling a second connection on the same day. For example for the connection from Oban to Coll and Tiree a four hour stopover of the ferry will offer a 6 hour stopover option in Coll but the full turnaround creates a very long total duration of 11 hours, which might not be attractive to all user groups. In comparison a five hour stopover of the plane on this route in Tiree makes a 5.5 hour stopover in Coll possible and sums up to a total duration of only 6.5 hours. If night time sailings or flights should be avoided, this will then also make it possible to respond to the demand for long weekend trip options, if these flights are scheduled accordingly.



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## 5 Discussion

The results of the considerations for policy options to close the gaps of more frequent connections to Colonsay on Sunday shows exemplary that for demand levels up to their maximum capacity air service options result in this case in lower per passenger and round trip emissions, if this additional connection does not also require the transport of cars. These demand based insights must be discussed in the context of the subsidy per passenger by air and ferry currently paid to ensure proper, efficient and effective spending of public money for serving these accessibility needs.

With subsidy levels exceeding £ 200 as described in the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018) and £ 136.8 million subsidy that CalMac has received in 2017 for a total transport volume of 1.4 million cars and 5.2 million passengers the costs and expected revenues for this additional connection must be seen in the context of resulting average subsidy costs per return flight or sailing coming with each vessel and aircraft option for the before discussed demand numbers.

These subsidy levels show the context of how much public money is needed to ensure the financial viability of these connections. On the other hand, the current cost of flights at £65 each direction without discounts in contrast to a return fare of £ 15.20 per passenger on the ferry route from Oban to Colonsay suggest that the identified market compatible air fare increase to £ 70 per passenger in the review of Argyll and Bute Public Service Obligation Air Services (DHC, 2018) would still keep additional air connections affordable for the users and could bring subsidy levels of air and ferry connections closer together.

## 6 Conclusions

The findings of this study suggest that there are different demand-based alternative options to offer more frequent connections to remote island communities with both air service and ferry connections in Western Scotland. For small demand numbers of additional connections without the need to also transport vehicles, additional flights result in way lower CO<sub>2</sub> emissions compared to additional ferry connections with a lot of potentially unutilised passenger capacity.

A fundamental aspect of this analysis is the context of currently paid subsidies for ferry and air services in Scotland. To ensure proper, efficient and effective spending of public money, policy choices for additional flights should beyond environmental aspects also consider market compatible fare increases.

These insights can be a discussion point for future tender processes for air services under PSO contracts, and a stimulus for identifying opportunities for a sustainable economic and environmental development of ferry and air services to remote island communities in Western Scotland in the discussion of policy options.

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<sup>i</sup> <https://www.argyll-bute.gov.uk/info/population-where-we-live>

<sup>ii</sup> <https://www.transport.gov.scot/public-transport/ferries/road-equivalent-tariff/>

<sup>iii</sup> <https://www.transport.gov.scot/public-transport/air-travel/lifeline-air-services/>

<sup>iv</sup> <http://www.airdiscountscheme.com>

<sup>v</sup> <https://www.calmac.co.uk/calmac-summer-timetables>

<sup>vi</sup> <https://www.calmac.co.uk/calmac-summer-timetables>

<sup>vii</sup> [https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29\\_1.pdf](https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf)

<sup>viii</sup> <https://www.magnix.aero>