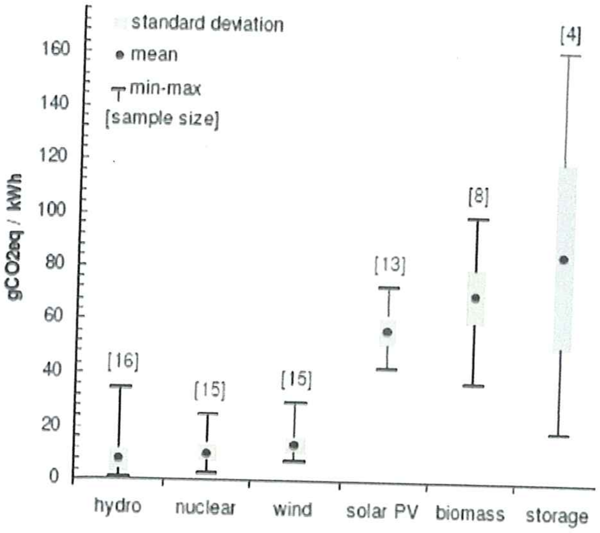
Cost-Benefit analysis

Introduction

Much has been made of photovoltaic electricity from arrays of solar panels as a cost-effective source of "clean energy". However, several reviews (Aman *et al.* 2015, UNECE 2020, Tsoutsos *et al.* 2005, Lu *et al.* 2022, Kwak et al. 2021) have identified multiple hazards and the shortcomings in these assumptions.

Perhaps we should begin by stating that GHG emissions during the life cycle of photovoltaic solar panels are considerably higher than for hydro-electric or wind generation (Fig. 1; Gibon *et al.* 2022); the entire land area used to produce a megawatt of PV electricity (2.7ha) is more than twice that of hydro-electric (Fig. 2; UNECE 2022; Aman *et al.* 2015), the 'levelized cost' of power generation is 3x the cost of hydroelectric electricity (Fig. 3; Aman *et al.* 2015), and within the life-cycle of solar panels the toxicological risks and cancer rates are higher for pV power than other forms of electricity generation (Fig 4) because of the large volumes of high-risk materials used within the technology.



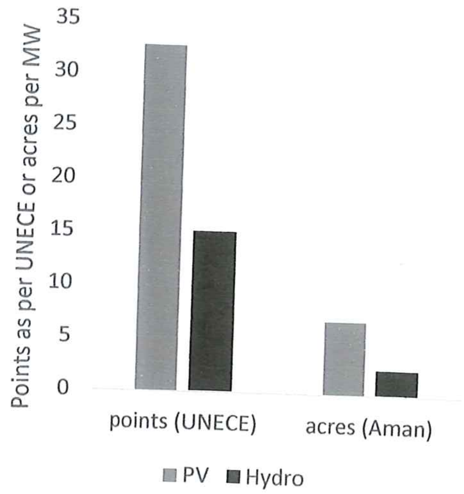
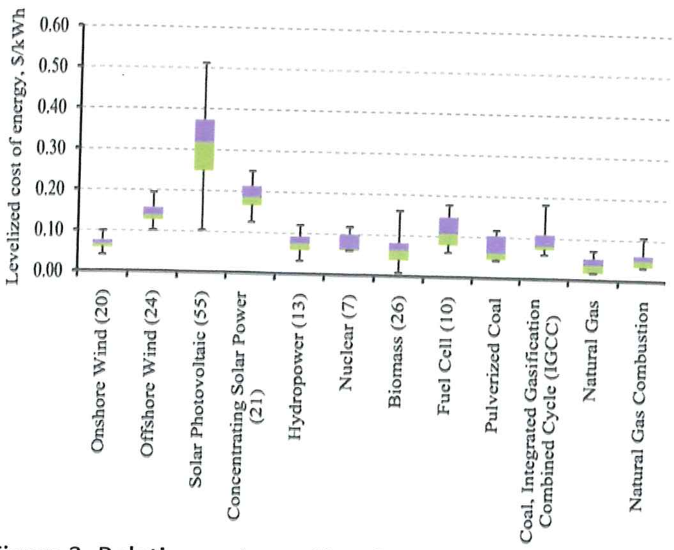


Fig. 1. Relative GHG emissions from power sources. Fig. 2. Land area for PV solar and hydroelectric



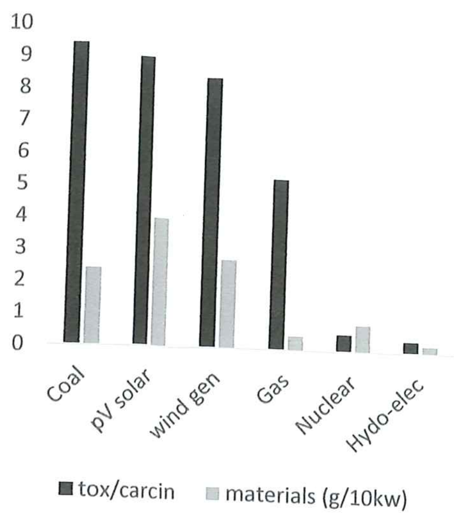


Figure 3. Relative costs per Kw of power. Figure 4. Cancer rates with power type & materials used

These facets of solar power cast a shadow over long-term use of solar technologies as a primary form of electricity within New Zealand. The other facet of USSP facilities (Utility-Scale Solar Power) that has been recognized in the UK for some time, is the ill-advised use of productive farmland for "solar farms". Here we provide a synopsis of the costs of using 1st grade irrigated farmland at Brookside for USSP and the costs associated with using foreign investment to establish arrays of solar panels. Costs are further exacerbated by lost production on adjoining land (i.e., secondary effects) from reduced honey production around the solar farm, poor pollination of crops by bees, bird damage to crops, and reduced milk production on adjacent dairy farms (*see* electromagnetic fields) as high voltage electricity from the USSP farm is transmitted along roads and rights-of-way,

Analysis

i) Suitability of land for establishing solar arrays

There have been various methods employed in America and the UK to try and mitigate against inappropriate use of productive land for solar energy production. These include:

a) Appropriately siting solar arrays on unproductive land. The 1st article in Bayar's "10 best-practice guidelines for solar development" is to focus on non-agricultural land or land which is of lower agricultural quality.
b) Assigning a BMV-value ('best and most valuable') to land in the UK on a scale from 1-5; where highly productive lands (zoned 1-3) are retained for farming, and only those scored at 4-5 are covered with USSP-facilities. This process has resulted in 23 applications for establishment of USSP-facilities being declined in the UK over the past 12 months (Guardian 2022);
c) In the USA, resesearchers established the ability of productive land to sequester carbon outweighed the reduced carbon emissions from solar energy. A data-base programme was developed for assigning land to ongoing farming or establishment of USSP-facilities (Calvert *et al.* 2015). Professor Heiniger (an agronomist at North Carolina University) has repeatedly written about the need to retain productive farmland and preserve soils.
d) In Puerto Rico good agricultural land was increasingly used for solar farms until there was insufficient land remaining for food production; this now requires the nation to import 85% of its food (Santiago *et al.* 2022).

ii) Lost agricultural production

The export receipts for dairy farming in 2022 were $22.1 billion from 2,221,459 ha of land (i.e., $9,948.4/ha). So, given those numbers 258ha yields $2,566,691 in export receipts each year or **$89,834,185** during the lifetime of the Brookside solar array (i.e., 35 years). These are lost export earnings as opposed to the internal production of electricity for domestic consumers.

To offset lost dairy production on irrigated Brookside soils, the applicants have indicated they will run sheep under the arrays of solar panels on parched clay loams that produce very little vegetative growth during summer. If sheep were farmed on the irrigated land with a clover, ryegrass mix, then around 18 stock units could comfortably be run per hectare. However, the land will not be irrigated with a solar array on it. Given that a) the soils are a Waterton clay loam and typically get very dry over summer, and b) rates of photosynthesis by grasses not receiving direct sunlight are reduced; c) the soils will lose total nitrogen and total organic carbon (*see* Food-web dossier) and become more compacted with the passage of time; then the stock units of sheep per hectare is likely to drop to around 6-7 per hectare during summer. Exports of red meat (beef, mutton, lamb, venison, goat) and wool in 2021 were worth $10.39 billion. Of this $3.353 billion was lamb, and that value was raised to

$4.2 billion by mutton and wool. This export revenue was generated from approximately 4.4 million hectares of land. This equates to an export yield of $954 per hectare. This figure of course must be moderated by dry unproductive soils and the areas of land on 258ha that are lost because they are assigned to trees to screen visual impacts and physical structures. The export yield (i.e., processed meat, processed wool, and processed by-products sold offshore) under solar arrays may be only $5-600 per hectare or around $137,500 *per annum*. In the lifetime of the solar farm (35 years). This equates to **$4,812,500** over the 35-year lifespan of the project.

The difference in export receipts from dairy farming on irrigated land and dryland farming of sheep under solar panels during the 35-year lifespan of the project is **$85.022** million in lost export revenue. This same sort of thing is happening over the length and breadth of New Zealand with solar farms. Inevitably the balance of trade (i.e., exports minus imports) will slowly slide into the red as more-and-more land is allocated to electricity production at USSP facilities. Solar farms will put a big dent in the nation's export receipts. The proposed USSP-facility at Brookside is one of these.

Advocates for solar farming will say the lost export earnings are justified by increased power production. However, it is not cost-effective use of good farmland. In the UK, **23** developments of USSP (utility-scale solar power) were declined between 2021 and July 2022 because they either "threatened biodiversity" or were on the "Best and Most Valuable (BMV) lands ('Guardian' 25 August 2022 & 'Guardian' 17 November 2022). In the UK, BMV-values for land are graded 1–5, with planning guidelines preventing solar development on lands rated 1-3. It is a very sensible arrangement that here in New Zealand would prevent the foolish conversion of grade 1 irrigated farmland at Brookside with "high" export earnings capacity into land that will earn little in export revenue over the next 35-years as a solar farm (*see* 'Democracy').

When we look at overseas case studies, there are reports from other nations that have foolishly embarked on use of USSP facilities on good farmland. Puerto Rico has a population of 2.8 million people and an area of agricultural land amounting to 1,595,866 acres. In pursuit of a clean, green economy 1,216,068 acres of this land was used for solar power leaving an area of land remaining for agriculture of 379,798 acres. Instead of exporting food, Puerto Rico now imports 85% of its food (Santiago *et al.* 2022). Their economy has imploded. The agricultural land is irretrievable because topsoil has been removed, soil productivity is reduced (Heiger 2020, Davis 2020,), and solar panels have been there long enough to contaminate soils with "forever chemicals" that have leached from equipment and pushed Pb^{2+}, other metal halides, and PFAS to hazardous levels in soils). New Zealand should not be making the same mistake. Labour pledged to protect valuable farmland from afforestation in 2020, to protect valuable farmland from urban sprawl in 2022, but is now carpeting good land with USSP facilities.

The development of USSP facilities in New Zealand should only happen when a) they comply with the provisions of the RMA Act, and b) for pragmatic reasons they confer economic benefits and essential utilities to the nation at minimal costs to exports.

iii) Foreign investment

The costs of foreign investment to the New Zealand economy are mainly in the form of a growing current account deficit. For the reader to understand how foreign investment impacts the national economy we will use the example of banks.

To demonstrate the shortcomings of this foreign investment we will briefly use the example of the banking industry. Banks throughout the nation were New Zealand-owned until 1986 (BNZ, Rural bank, DFC, POSB, Trustbank, CSB, etc.) but were progressively sold to the big four Australian banks between 1986 and 1995. The big 4 Australian banks collectively made a profit of $6.584 billion during the year ending June 2022, and a profit of $47.453 billion during the past decade (Table 1).

Table 1. A decade of profits by the big four Australian banks in New Zealand.

Year	ANZ	ASB	BNZ	Westpac	Total ($millions)
2013	1,030	699	788	714	3,231
2014	1,711	806	850	941	4,308
2015	1,771	859	1,038	911	4,579
2016	1,542	913	913	851	4,219
2017	1,780	1,069	937	909	4,695
2018	1,986	1,177	1,029	936	5,128
2019	1,825	1,191	1,022	964	5,002
2020	1,344	958	1,132	552	3,986
2021	1,920	1,321	1,546	934	5,721
2022	2,299	1,418	1,817	1,050	6,584
Total	**17,208**	**10,411**	**11,072**	**8,977**	**47,453**

On average bank profit is only around 2.6% of GST, but those profits have contributed to a sizeable portion of the nation's current account deficit throughout the new millennium (Fig 2).

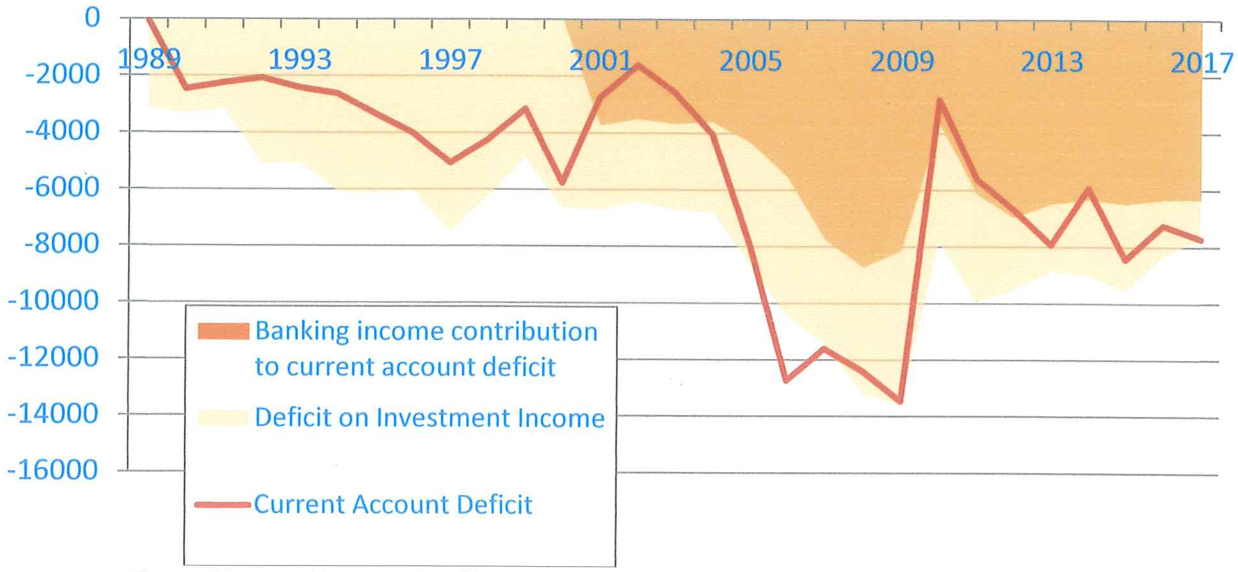


Figure 2. New Zealand's current account deficit following asset sales during the period 1989–2017.

In addition to banking, the value of logs exported by largely foreign investors from forestry plantations during the period 1992-2019 amounts to $115.2 billion, the loss of tourist revenue from foreign investment during the years 2015-2019 amounted to $21.877 billion, the income lost from foreign investment in telecommunications during 1992-1999 amounted to $17.85 billion, etc., etc. Does the nation need further foreign investment in public utilities (e.g., electricity generation) as well? Furthermore, is this a path that merely adds to an ever-increasing loss of GDP *per capita*? Short-sighted attitudes to foreign investment by politicians have contributed markedly to the slide of GDP *per capita* for 'Kiwis' from 3rd in the world (1953) to 30th in the world (2022).

What does this mean long-term for New Zealand? Although the balance of trade (i.e., exports minus imports) has been in decline with increased population growth since 2008, the nation still runs a slight trade surplus. However, what is rapidly going south is the current account deficit. This deficit is a combination of both interest on overseas debt ($308 billion in 2021) and profit-taking from foreign investment. As discussed above, the benefits of foreign investment in electricity are likely to be very short-lived. On the other hand, long-term costs to the nation are likely to be quite substantial and amount to hundreds of billions of dollars.

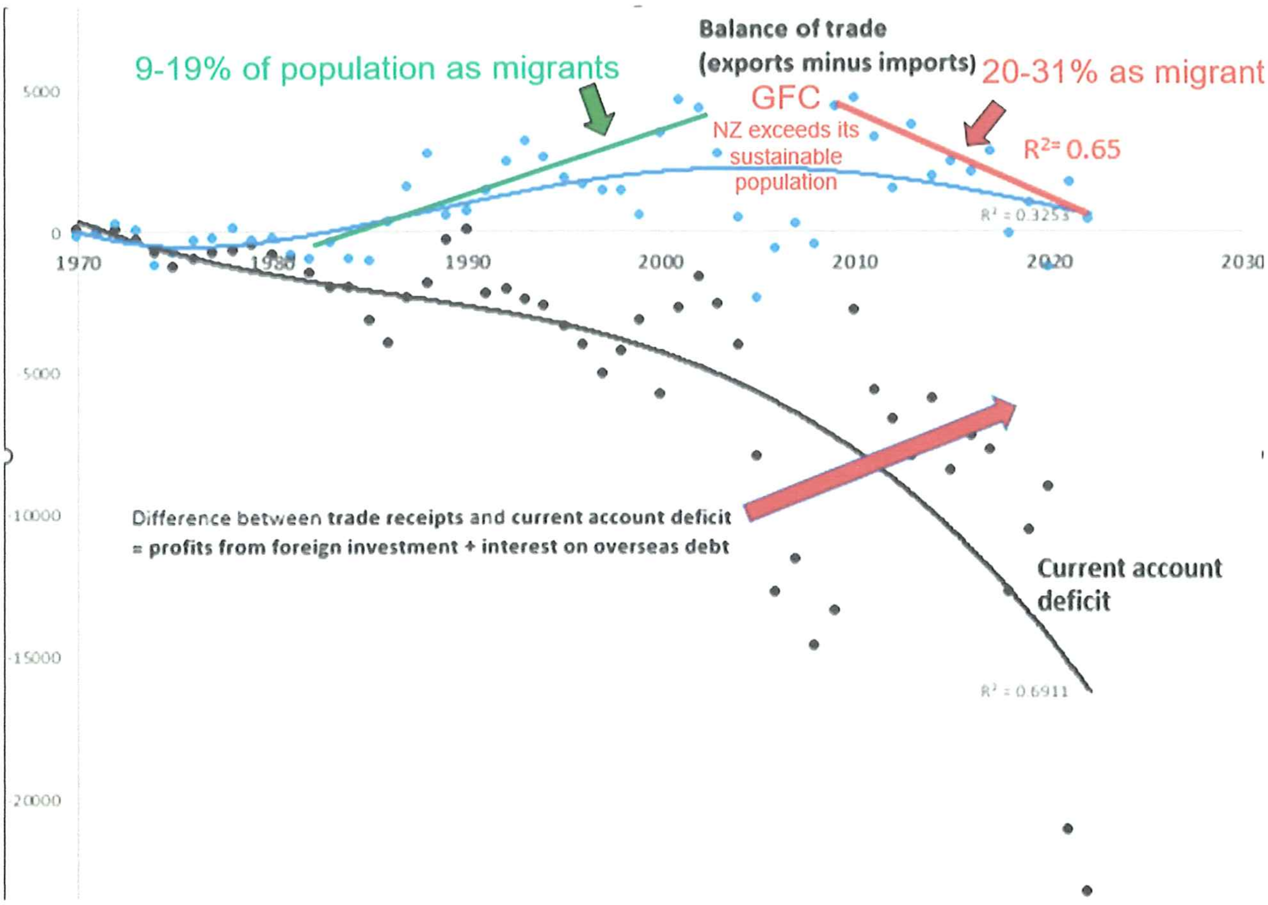


Figure 3. **The balance of trade (exports minus imports) and New Zealand's current account deficit during the period 1970-2022.**

The submission against the proposed development of solar arrays did not include an assessment of the costs of foreign investment. The economics of utility-scale solar power (USSP) have been assessed for New Zealand (Miller 2021). The information from the Miller report to MPI, and costs of establishing solar farms elsewhere in the country was used to estimate input costs and likely returns on investment (Table 2.)

Table 2. Investment costs and likely returns on investment.

Cost of establishing solar panels ≈ $280 million

Return on investment (10-20%/annum) ≈$42 mil

35yr-revenue from power consumers ≈ $1.47 billion

Cumulative current account deficits from project ≈ $1.1 billion

If this data is reasonably accurate then, foreign investment into USSP-facilities on productive farmland makes no sense at all. The nation loses $85 million in export earnings and **incurs over $1 billion of added current account deficits**. How does any of this benefit the nation? The applicant makes the argument that he is supplying power for 22,000 homes; this is electricity that could be provided in a much more cost-effective way by domestic investment in state-owned electricity.

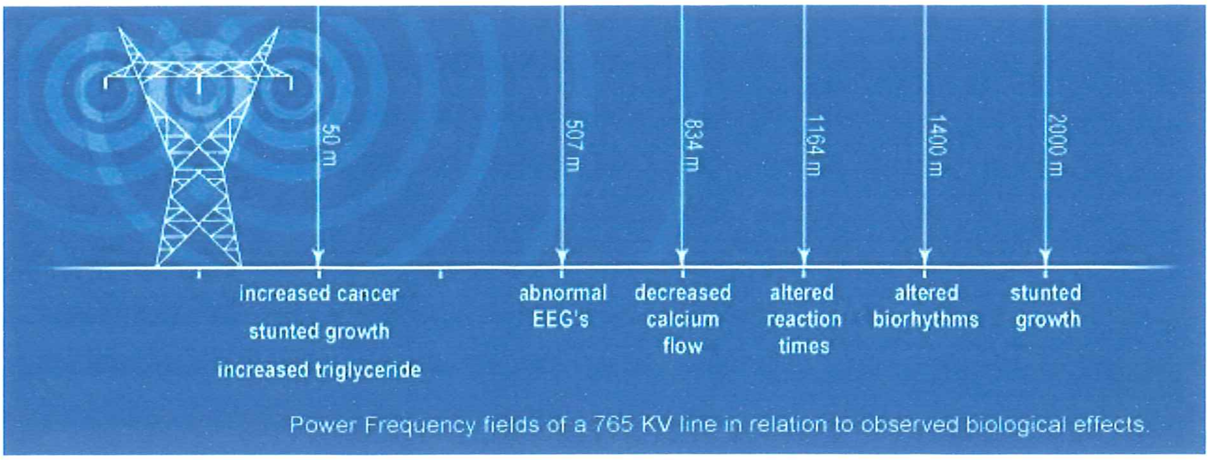
iv) Secondary effects

The secondary effects should not happen under section 5.3.12 of the Resource Management Act and the Town and Country Planning Act. These effects are categorized as 'reverse sensitivity effects'. These secondary effects include: a) reduced bee feeding activity and reduced honey production by apiarists because of electromagnetic fields from both the substation and transmission lines, b) reduced pollination of crops sown by neighbouring arable farmers because of reduced bee activity, and reduced numbers of bees entering and leaving the hive (*see* electromagnetic fields), c) increased bird damage to crops by finches (e.g., sparrows, greenfinch, redpoll, etc roosting in new plantings of trees at the USSP-facility), and d) reduced milk production of cows that are sensitive to electromagnetic fields on adjacent farms and rights of way where power transmission lines are situated (*see* electromagnetic fields report). A report was produced by the applicant on EMF on-site that failed to identify the effects of high voltage at the substation and the effects of transmission lines.

In quantifying the impacts of secondary effects, we will need to interpolate from research outcomes and apply what seems a middle-of-the-road assessment to the case study at Brookside.

1) Honeybees become increasingly agitated, less active, and there is less foraging, and reduced pollination of plants as magnetic fields progressively increase (*see* EMF). Bees are affected by magnetic fields as low as 0.025μT (Walker & Bitterman 1989), are increasingly indisposed and disorientated at 0.26μT and are very agitated and disorientated at 1 μT. Despite, the interpretation of the effects of magnetic fields by KeaX Ltd., the Brookside site generates 160MW of electricity with a Gaussian field of 25-30 μT, which when added to the existing load at the Hights Corner substation gives a total magnetic field of 40-60 μT; a level of magnetic flux sufficient to affect the health of people and invertebrates up to 2km away (Fig. 4)
   In the absence of magnetic fields 2.2 fully functioning hives are required per ha to pollinate white clover (FAR 2007). These should produce at least 90kg of honey per hive or 200kg of honey per hectare, and for crops sown at 6kg/ha the yield should be 940 kg/ha of clover seed in year 1. However, if EMF affects bees, then numbers of clover florets visited drops as does seed produced (Fig. 5.)

Figure 2. **Possible health effects at different distances from high transmission lines.**



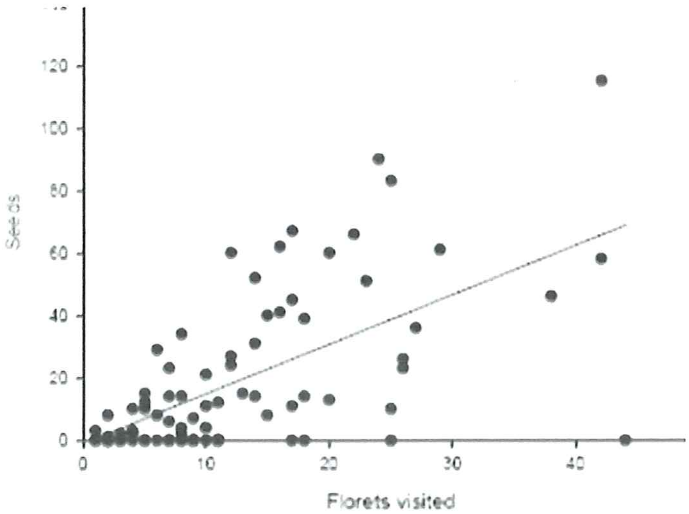


Figure 5. Seed production in relation to clover florets visited by bees (FAR 2007).

In a scenario where EMF reduces bee foraging behaviour by 30% then clover yields may be reduced by 2-300kg/ha ($1300/ha) and honey production by around 80kg/ha ($500/ha). Radish, bean, and pea yields have the potential to be similarly affected, and these crops are all of higher value. To a certain extent diminishing yields can be offset with more hives (3-4 /ha), but this does not completely offset diminished foraging and rates of pollination. In a study in Poland, wild bees completely avoided areas near high transmission lines (Twerd *et al*. 2021). There is not enough detail to definitively put a figure on strengths of magnetic fields from transmission lines and lost production on the 'Clairmont' property owned by the Casey's, but it could be as high as $1000/ha on some crops.

2) Bird damage to crops increases in relation to the distance trees are from food (Fig. 5). For wheat the worst feature that can adjoin a crop are trees, because this is where fasted and satiated birds' roost. For wheat in the first 40m out from a hedge the farmer is losing 14% of his seed. Wheat yields are typically 9 tonne per ha and the price is $650 per tonne; so, birds take around $820/ha around the perimeter of a paddock, from a crop that is worth $5,8500/ha.

Figure 5. Average bird damage per hectare

Distance	House sparrow damage on wheat			
	Location			Mean
	Buildings	Field crops	Trees	
10 m	15.60	11.00	19.20	15.27a
20 m	13.40	9.40	16.00	12.93ab
30 m	2.20	0.00	11.80	4.67bc
40 m	1.40	0.00	8.80	3.40c
Mean	8.15b	5.10bc	13.95a	9.07

If we look at radish, yields are typically around $10,000/ha and bird damage is higher at around 20% losses. This amounts to $2,000/ha. In short, the trees around the solar farm will have a major impact on the cropping farm next door.

It would not be unreasonable to expect losses on the Casey cropping farm alone to amount to $30-50,000 with the solar farm next door. This equates to at least $1.5 million over the 35-year period of the project.

3) Dairy cows are sensitive to the electromagnetic fields produced by transmission lines. Several studies have evaluated the effects of low frequency electromagnetic fields like that produced by transmission lines on dairy cattle. The sources of the electromagnetic fields have varied, but all share a common denominator of low frequency electromagnetic fields affecting production and animal health. At the request of dairymen, veterinarians, and county extension agents in Michigan, Kirk et al. investigated stray current on 59 Michigan dairy farms. On 32 farms, stray current sources were detected. Where voltage exceeded 1 V alternating current, and this increased the numbers of dairy cows showing abnormal behaviour in the milking facility and increased the prevalence of clinical mastitis. Recovery from the stray current-induced abnormalities were related to the type of abnormality and the magnitude of the exposure voltage. Burchard et al. in a small but well-controlled alternating exposure study of non-pregnant lactating Holstein cows found a longer oestrous cycle in cows exposed to a vertical electric field of 10 kV/m and a uniform horizontal magnetic field of 30 μT at a frequency of 60 Hz, compared to when they were not exposed. Rodriguez et al. also found that exposure to EMF may increase the duration of the bovine oestrous cycle. Burchard et al. evaluated effects on milk production in Holsteins exposed to a vertical electric field of 10 kV/m and a uniform horizontal MF of 30 μT at 60 Hz and found an average decrease of 4.97, 13.78, and 16.39% in milk yield, fat corrected milk yield, and milk fat, respectively in groups exposed for 28, 56 and 84 days respectively, and an increase of 4.75% in dry matter food intake. Buchard et al. in two experiments investigated blood thyroxine (T4) levels in lactating pregnant and non-lactating non-pregnant Holstein cows exposed to 10 kV/m, 30 μT EMF and found a significant change depending on the time of blood sampling in exposed groups. They concluded that exposure of dairy cattle to ELF-EMF could moderately affect the blood levels of thyroxine. Hillman et al. reported that harmonic distortion and power quality itself could be another variable in bovine sensitivity to stray current. They found behaviour, health, and milk production were adversely affected by transients at the 3rd, 5th, 7th, and triple harmonic currents on utility power lines after a cell tower was found charging the ground neutral with 10+ V, causing the distortion. After installing a shielded neutral isolation transformer between the utility and the dairy, the distortion was reduced to near zero. Animal behaviour improved immediately and milk

production, which had been suppressed for three years, gradually returned to normal within 18 months. Other reports indicate that solar panels elevated above cows can provide benefits in the form of shade. However, cost-benefits have not been adequately assessed in terms of lost pasture production, potential soil contamination by leachates from damaged solar panels, and lost milk production in comparison to the benefits afforded by shading. Lost dairy production is difficult to quantify. The effects on cows maintained permanently near high transmission lines was around 15% drop in milk production (Burchard *et al.* 2003). However, cows will not be permanently pastured with magnetic fields of 30μT and will walk in and out of high intensity magnetic fields. Given this scenario it would not be unreasonable to expect lost milk production within 100metres of transmission lines taking 160 megawatts of electricity down the Brookside-Dunsandel Road to be down around 5% of milk yield. That is a figure of $500 per annum for each 100-m of road, or $105,000 for the farms affected between Heights Corner substation and Dunsandel. During the 35-year project this is a loss of $3.7 million.

v) <u>Costs to local community</u>

These are apportioned to two separate issues. The first is the loss of aesthetics, the annexation of the peace and quiet of a 'rural amenity', and the imposition of an industrial zone over the fence of residents. The 2nd is the loss of property values as a result of photovoltaic noise and visual impacts.

1) Almost everyone at Brookside lives in the rural area for a reason. That reason is the lifestyle, the tranquillity afforded by wide open spaces, the peace of mind that comes with an absence of monotonous noise, and the sense of nature provided by farm animals, ornamental trees, and expansive gardens. It is an area with a historic background of dairy farming, cropping and pastoral farming. The rural amenity is much valued by everyone living within the community, and that is why almost all (94%) signed a petition against the development of an array of solar panels. The maintenance of that environment is covered by section 5, subsections 7(c) amenity values and section 7 (f) on quality of the environment. The largest single cost to the Brookside community is the loss of that rural amenity because 2 landowners became tired of farming. Those people should have sold up if they no longer wanted to farm, rather than put the community through the awful ordeal that local residents are now confronted with, and the loss of their 'rural amenity'.

2) Loss of property values. It has been estimated by real estate agents that the solar farm writes around 15% off the value of small holdings and house values in the district. The residents of the area would expect that the Selwyn District Council should immediately discount the value of rates by 15% that are paid should this development somehow come to pass. This is outlined in the section of the RMA on financial assistance, where rates relief is an option for those on "affected lands".

vi) <u>Costs of recycling aged infrastructure, and the refurbishment of farmland</u>

The estimated cost of recycling a standard solar panel to remove metals that are toxic to the environment is currently $30 per panel. At Brookside it is planned that there will be 52 panels installed on each table of panels. There will be 5,844 tables established throughout the 3-stage development. That amounts to 303,888 panels at an estimated $9.12 million to recycle the metals in solar panels.

The literature indicates per- and polyfluoroalkalyl substances (PFAS) are increasingly polluting drinking water and every ecosystem on the planet. They are found throughout wildlife in Africa, in most ecosystems in Europe, and are prolific in Asia (*see* 'hazards summary'). The heavy metals in e-waste also present a significant hazard as leachates if they are placed in landfills. The RMA applicant must indicate how this waste is going to be managed and the associated costs.

Finally there is the issue of lithium-ion batteries. These are extremely hazardous and produce some very insidious leachates. They cannot be placed in a landfill. How will this be managed?

If we take the figure for the costs of recycling solar panels and add 50% then we may have a conservative estimate of the cost of recycling ($13.5 million). Who pays for this? Will it be another levy against the ratepayer. Furthermore, once the harmful contaminants have been taken out of e-waste, where does the council put around 500 tonnes of unwanted glass, and other non-compostable refuse?

These are all reasonable questions for which the RMA assessor, administrators and policymakers must provide answers.

vii) Project summary

We have a project that has lost the nation $85 million in on-site export earnings, lost the nation a further $5.2 million from the secondary effects caused by the USSP-facility (viz. lost production on adjoining land); the project has potentially exported over $1 billion of revenue from electricity consumers to foreign banks that adds to the current account deficit; and it may potentially cost ratepayers a further $13 million for disposal of e-waste. Therefore, the total costs to the nation are around $1.2 billion dollars over a 35-year period.

To this must be added the lost aesthetic values of a quiet rural amenity at Brookside and a drop in property values.

None of this makes any sense. Any analyst would tell the applicant that his project is not in the best interests of the national economy. If it is to proceed, then the applicant must find some unproductive land for his USSP-facility (Heiniger 2015, Davis 2020). Puerto Rico , semi-arid land on the Port Hills or Canterbury foothills, and make use of that. He will not be affecting the health and wellbeing of Brookside community, and will in essence be out of sight and out of mind.

Summary

At Brookside the cost-benefit analysis undertaken above demonstrates that the economics of the proposed development do not make it a worth-while project for the national economy.

The corporate body established to implement development, the shareholders in the project, and a few individuals motivated by greed and/or or a 'free lunch' will benefit, but everyone else loses. The electricity consumer loses because this form of power generation is likely to push up electricity prices. New Zealand trade loses because USSP-facilities at Brookside are on productive agricultural land and thus it reduces export earnings. The economy loses badly because foreign investors scalp electricity consumers and export profits from the domestic economy into foreign banks, and in doing so increase the nation's current account deficit. The environment loses because leachates from solar panels (e.g., Pb, Ag, Al, Si, Cu, Ni, Cl, Br, Cd, Ga, Cr, In, NH_4, I and PFAS) accumulate in soils and then bioaccumulate in the food web; and this results in an ever-increasing risk of toxic effects on sensitive body organs, increasing risks of carcinogenic effects, and elevates ecotoxicity in both aquatic and terrestrial habitats (*see* hazards).

Results of cost-benefit analysis indicate USSP facilities should only be established on unproductive land if they are to be a viable source of electricity into the future, and these amenities should be constructed by domestic revenue (e.g., Cullen fund, other superannuation schemes, and term deposits). Furthermore, the 'hazard' assessments (*see* hazards), effects of electromagnetic fields, noise impacts on residents (*see* acoustics summary), the impacts of unsightly solar panels on the landscape within a rural amenity *(see* visual impacts), and the impacts on the food web (*see* food-web dossier) all indicate that USSP should never be established within a rural community where there is a plethora of people (viz. the likes of what exists at Brookside).

The other dimension to farming practices is the sequestering of carbon in soils by cropping and bio-organic farming. Calvert *et al.* in his synopsis of the biodynamics of sequestering carbon using d-base analysis, indicates that on fertile soils it is better to crop soils and sequester organic carbon, than generate energy with low carbon emissions. In the final wash his analysis demonstrated farming fertile soils is "greener" than generating low-carbon electricity.

The graphs outlined in the introduction indicate that if the New Zealand government wants zero-carbon emissions during electricity generation without a loss of export earnings, then ideally, they should be promoting hydroelectric generation again. Unfortunately, with privatisation of electricity, none of the $8.7 billion in dividend payments to shareholders during 2014-2022 has been reinvested in further hydroelectric generation, but instead found its way into the pockets of shareholders. There are still opportunities through the Cullen fund: the high dams planned and designed by engineers in the 1980s at Beaumont and above Balclutha could still happen; Manapouri could be restructured, and there exists further scope on the Waitaki (all rivers with guaranteed high-water volumes).

If solar energy is a way forward, then USSP-facilities must be located on semi-arid or arid lands throughout New Zealand. The UK has attempted to address this problem by assigning BMV-values (Best and Most Valuable lands) in a range from 1 (best land) to 5 (unproductive land); with USSP-facilities only deemed suitable for lands scored 4–5 on this scale (see 'Democracy'). The land at Brookside is irrigated grade-1 fertile soils and should never be used for this type of enterprise. Once good land has been consigned to solar energy, then it is difficult to recover that land for farming. The leaching of heavy metals and PFAS (polyfluoroalkyl substances) from solar panels causes a bioaccumulation of hazardous materials on soils that enter the food web and a) are toxic to soil organisms, b) result in soil compaction, c) reduce organic matter in soil, d) alter the carbon-nitrogen balance in soils, e) reduce vegetative growth, and f) change soil pH. The heavy metals (e.g., Pb, Ag) and PFAS that have accumulated on soils are readily taken up by plants (e.g., Li *et al.* 2020) and then ingested by livestock, which a) affects animal health, and b) creates residues in meat and milk (*see* hazards). Plants grown in soils under solar panels (e.g., herbs, vegetables) should not be used for human consumption because they too contain high levels of toxic heavy metals and PFAS (Lu *et al.* 2022). The concept of "solar farms" is a misnomer that should be completely dispelled in New Zealand before agricultural produce is exported with detectable levels of heavy metal and PFAS contaminants.

This brings us to the clean-up at the end of the Brookside project where: a) no provision has been made in the RMA application for the expensive recycling of solar panels (they are too dangerous to be thrown into landfills; *see* hazards), and b) no provision has been made in the RMA application for the removal of contaminated topsoil on farmland and the sourcing of new topsoil so it can once again be farmed. The costs are high for the disposal of aging infrastructure (old solar panels, used batteries, etc) that is not easily recycled. Under the 'Sustainability Act' the applicant must make provision for waste disposal. Added to this is the refurbishment of contaminated soils so land can once again be farmed. These combined costs are likely to exceed any revenue that leased land has generated for farmers over a 35-year period.

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