ADVANTAGED BY LOCATION

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ABSTRACT

Currently, minerals development in the peripheral areas of Scotland might be considered to be disadvantaged by location, mainly because of very small local demand and the high cost of transportation to get product to external markets, the high cost of importing energy, a dwindling local skills base and because of the perception that environmental constraints preclude against minerals development in environmentally rich and scenic areas.

The author takes the view that environmentally sensitive mineral development is entirely possible and that these areas of Scotland can become advantaged by location by the increased use of sea transport and by synergies with other developments, principally renewable energy, and so bring substantial wealth creation potential to communities and provide sustainable industries that contribute to the common good.

To achieve this a new paradigm needs to be articulated, centred on changing people's opinion about the future viability and acceptability of mineral development, to be achieved via an amalgam of democratic, technical and institutional frameworks based on active dissemination of knowledge of 'what is' and fostering imagination of 'what can be'. This paper often provides personal opinions and considers how the mineral industry in the peripheral areas of Scotland could develop and grow, with reference to the Norwegian minerals industry; and how a new paradigm might be achieved to change people's perceptions toward the industry.

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INTRODUCTION

Scotland hosts a diverse range of potentially valuable minerals, many of which have been developed in the past and some of which are being developed today. The technical and geological detail is not widely known or understood however by many lay people. Thus, many people have only a limited knowledge of the potential of the minerals industry in Scotland and so are unlikely to be able to form a proper view of what the future might hold and what checks and balances are needed. Indeed, given the growth of strong 'green' lobbies in recent years, many today may question if a Scottish minerals industry is sustainable or indeed viable in the face of limited local demand and increased international competition in the export market. It is not surprising therefore that there is mixed support for minerals development and some downright opposition.

The author believes that with a local, valuable resource, you are advantaged by location. There is a need to educate local people and government to see that mineral occurrences, developed sustainably and in an environmentally acceptable way, can lead to great social and economic benefits. Achieving this will require active (dynamic) education and new institutional frameworks to help people see 'what is' and 'what can be'.

The recycling of minerals is encouraged to lower the demand for virgin materials. However, this can be both technically and commercially challenging and so demand for virgin aggregate continues to rise. Both developing and developed economies need minerals to sustain their industries, and the European demand for non-energy minerals exceeds 4 billion tonnes each year (European Minerals Conference 2010 Delegates, 2013). Actively developing Scottish mineral resources to meet this demand would produce a major export industry and the stimulus for sustainable economic development of Scotland's peripheral communities.

An example of a successful mineral industry is in Norway. Approximately 98 million tonnes of mineral resources were extracted in 2012, representing a total production value of NOK 12.7 billion (*c.* £1.27 billion). The total export value was NOK 7.4 billion, representing 58% of the overall value (NGU, 2013). Table 1 shows the breakdown of production and export values by commodity. As shown, between 59-97% of all commodities are exported, with the exception of only 23% of gravel and hard rock aggregates. The Norwegian mining and quarrying industry employs about 5981 full-time employees at a total of 1180 producing

Commodity	2012 Production value (NOK)	2012 Export value (NOK)	Percentage exported (%)	Key export products
Gravel and hard rock aggregate	5.1 billion	1.17 billion	23%	-
Metallic ores	3 billion	2.7 billion	90%	Ilmenite, iron and nickel
Industrial minerals	2.8 billion	2.2 billion	79%	Calcium carnonate slurry, olivine and nepheline syenite were key
Natural stone	889 million	524 million	59%	NOK 427 million relates to larvikite
Coal	826 million	804 million	97%	-
Peat	68 million	Unknown	Unknown	-
Total value	12.7 billion	7.4 billion	58%	-

Table 1. *Mineral production and export values in Norway, 2012. (NGU, 2013).*

quarries/mines, with the industry being strongly represented along the coast.

There are similarities and differences between Scotland and Norway (environment and geography, geological setting, mineral type and quantity etc) and it is unclear whether a Scottish minerals industry could approach that of Norway, but the example does show that a minerals industry with a strong coastal presence in fairly remote locations, that relies heavily on sea transportation, can thrive.

Initially, production data from mineral producers in Norway were collected by the Directorate of Mines (Bergvesenet (BV)) and the Geological Survey of Norway (Norges geologiske undersøkelse - NGU) and were published annually in 'Norway's mining production' and 'Mineral resources in Norway', respectively. Since 2006, the annual overview has been published in collaboration between NGU and BV (NGU, 2013). This collaboration between a government department and the geological survey demonstrates the importance of the industry and their commitment to developing it. The data also assists county and local authorities, and industry in ensuring optimal land-use planning, including paying the appropriate attention to mineral reserves in production, and to resources which may be important in the future.

Scottish Minerals Resources

Scottish minerals resources have been investigated extensively over the years both by government sponsored studies (Smith, 1989; BGS, 2006 and The Scottish Government, 2007), locally (for Highland and Island Enterprise and its predecessors by Robertson Research Ltd., and others), and by industry.

A series of reports were commissioned in the mid 1980's from the British Geological Survey (BGS) by the then Scottish Development Department, dealing with selected bulk mineral resources that might be exploited including hard rock aggregate, silica rock and silica sand, talc, limestone and dolomite resources (Grout and Smith, 1989 and Smith, 1989). These reports conclude that there are considerable resources of these materials capable of supplying most end uses and with potential for export through the development of coastal quarries.

A study from the Highland Regional Council (HRCDD, 1990) shows that north-west Scotland (and the Western Isles) contains a wide variety of minerals including gold, silver, platinum, copper, lead, zinc, molybdenum, barite, tin, aluminium, magnesium, beryllium, chromite, iron, manganese, talk, fluorspar, graphite, sulphur, coal, peat, limestone, dolomite, phosphate, potash, refectories, abrasives, glass sand, diatomite, rock wool and rock suitable for use in the building and roadmaking industries. The study also shows the Highland Region has resources suitable for hard rock aggregate including a site at Glensanda that was readily accessible by ship. Figure 1 shows the various hard rock and metalliferous deposits identified, respectively.

The production of natural stone paving and stone cladding was a main industry in Scotland and demand for such products is increasing worldwide and being met mainly by exports from China and India. Also, currently emerging technologies such as E-glass (a specialist form of glass fibre) may require new mineral sources. Both may provide opportunities for the expansion, re-opening or creation of quarry sites in the future, in addition to the various other mineral opportunities highlighted.

While this general development potential was recognised by Highland Regional Council in the 1990's, there is today, no direct promotion of minerals development by the Highland and Western Isles Councils. Though the economic potential of minerals development is recognised and included in regional development plans, the councils are generally reactive to industry proposals, not proactive.

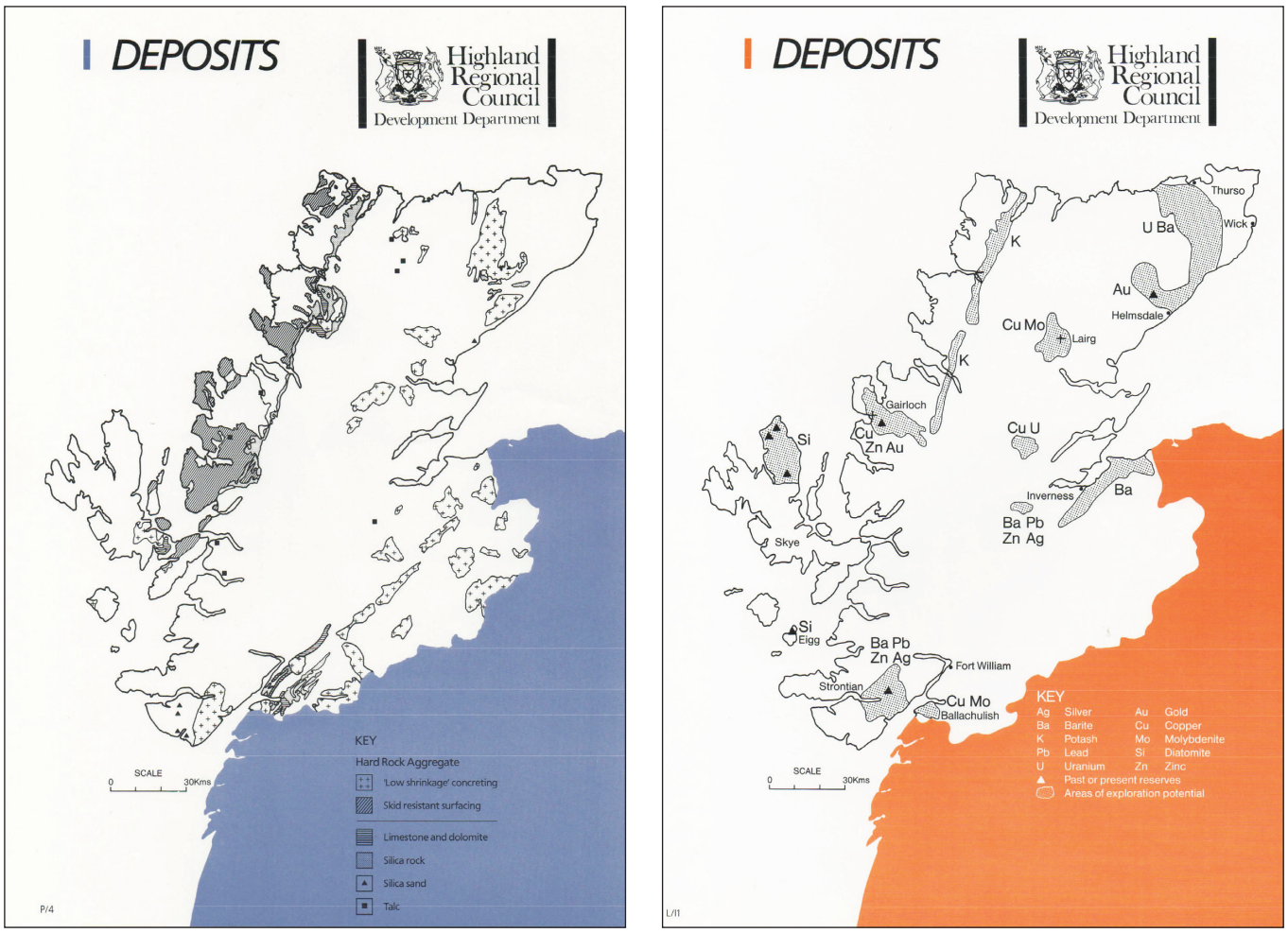

Figure 1. *Mineral deposit and exploration potential locations in Scotland. Left: hard rock deposits, and right: metalliferous deposits (HRCDD, 1990).*

Issues Affecting Mineral Development

Location

The development of Scotland's resources, particularly those in peripheral areas can be hampered by multiple factors, often relating to their location, including:

- Mineral development has to take place where the mineral is located, and the development has to take place at a scale that makes economic sense, matching supply to demand in competitive markets, sometimes with strong international pressures. The mining and quarrying industry requires large investments, significantly more real capital per employee than the industrial average and there may also be high costs for environmental mitigation. As such the resource has to be large enough and of sufficient quality to justify the investment.
- The largest operating cost effecting development of Scotland's peripheral areas is generally transportation of the product to market and unless sea transport is available this can stop a project, except for the very highest value products.
- Energy usage is normally significant with an extractive operation and can be a high proportion of operating costs. If the location is isolated, bringing in the required power can be expensive and/or environmentally challenging.
- The absence of skilled local labour can involve additional travel costs and/or relocation costs for employees and additional training costs.
- The largest development risk though is associated with the difficulty of achieving planning consent and satisfying environmental concerns. This can involve very considerable front end spending on impact assessments, mitigation studies, and quantification of benefits and planning costs, with significant uncertainty of outcome under current regulations.

All of the above are relative to location and in order to become advantaged by location, these issues have to be addressed.

Resource value

The mineral resource needs to be large enough to ensure long term business sustainability. This may need to be measured in scores or hundreds of years of potential production and the deposit needs to have sufficient intrinsic market value to underpin the development business plan.

In the oil and gas sector, deposits are attributed an *in-situ* value calculated from the proven volume of material in the reserve and the price likely to be earned from its sale. A similar approach can be applied in the minerals

sector, based either on a gross *in-situ* value by mineral type or based on a discounted cash flow valuation of earnings over the lifetime of the development, this being particularly applicable where value added processing is involved. With this approach it can be demonstrated that many mineral reserves in Scotland would have very high potential values measured in the hundreds of millions of pounds. If aggregate production in Scotland were to reach that of Norway (*c*. 68m tonnes per annum, and Glensanda alone produces nearly 10m tonnes per annum), the value to the Scottish economy would be over £500 million per year. There are few other developments which have the potential to contribute as much as this to the public purse.

Without planning consent, resources represent a significantly reduced value. However, in terms of land use planning, an evaluation of the potential reserve value would allow strategic focus on the most commercially attractive reserves.

Transportation costs

To make products cost competitive, transportation, where possible has to be predominantly by sea, and thus requires access to marine export facilities. A current rule-of-thumb is that road haulage is close to £0.10 per tonne per mile (plus any ferry charges), and this would result in huge haulage costs from peripheral locations. A 500 plus miles journey to central England would add *c*. £50+ per tonne to ex-quarry production costs.

For lower priced minerals such as construction aggregates, their development is only viable if transportation costs can be reduced to a small fraction of this by use of large volume shipping. Even for high value products and value added products it makes sense to maximise use of sea transport such as by piggy-backing on larger volume shipments. This implies that synergistic development would be beneficial.

Thus increased mineral development requires investment in marine infrastructure, which limits development to locations where this is possible. Shipments in the *c*. 1000 tonne range are possible using small coastal vessels (albeit shipping costs are not as low as for bulk carriers) and the facilities needed for these can be more modest, increasing the number of available viable ports.

A number of larger potential development sites at a similar scale to Glensanda have been identified (Wilson, 1993) and several are in regional structural plans.

Synergies with renewable energy development.

In the author's view, creating synergies between mineral development and renewable energy development will contribute the most to communities. The renewable energy potential of Scotland, especially around its periphery, has been well espoused in recent years. The current approach is essentially to connect renewable energy developments into the UK national grid, with the hope that a sufficient network of generation sites can be created nationally such that when there is no wind or tidal flow in one area, there will be generation somewhere else, or to rely on gas generation as back up to the national grid.

An alternative approach that in many locations would be preferable, is to link renewable energy generation to mineral development at a community scale, and to export value added products rather than only raw materials or raw energy, such as cut and polished stone, processed industrial minerals or manufactured products such as concrete sea defence units. Locally generated energy would be used by local industry and for domestic purposes via local distribution networks. Mineral processing is a relatively high consumer of electricity so local power generation may be viable if it could match or exceed demand, and this would require a local capability to store renewable energy for when wind or tide is not available or to rely on grid or fossil fuel back-ups.

Energy storage such as by conventional pumped hydro-electricity is an established technology. Other, emerging storage concepts include pumped tidal lagoons for energy storage (MacKay, 2014), and closed loop hydro-electric storage using engineered caverns (created by vertical crater retreat mining) as the storage reservoirs (Wilson and Boyd, 2011; Boyd, 2011). Being able to provide electricity on demand using schemes such as these is highly desirable. This is believed to be possible at a community scale, and that surplus power could be exported into the national grid via existing connections or new extensions. This approach would largely replace the need for imported power and so remove reliance on expensive or environmentally intrusive transmission networks.

The current wholesale price of electricity is *c*. £50/MWh mainly reflecting existing low cost fossil fuel generation. Many coal stations are coming to the end of their life, and there is potentially an energy gap looming within the next 5 to 10 years. The Contract for Difference (CFD) strike price being negotiated for future nuclear power is *c*. £90-£100 /MWh. Onshore wind receives renewable energy subsidies of about £45/MWh making the real wholesale cost *c*. £95/MWh. Offshore wind current costs *c*. £140/MWh and embryonic tidal power is more expensive, in the order of £300/MWh (figures current in late 2014 as reported widely in the media). This situation, in the short term is likely to lead to an increased reliance on gas to fill the energy gap. Despite gas price volatility and questions about security of supply (fracking aside), it is possible that new gas power stations will be built at least in England. It is likely therefore that the cost of electricity will rise to at least £90-£100/MWh in the medium term. Long transmission distances and associated new investments may increase this further, bringing the costs of developing a locally generated and stored energy supply within reach.

Media portrays that government is becoming increasingly aware of this cost situation and that energy pricing and the development of a forward energy policy is becoming a major political issue.

Onshore wind power is viable at *c*. £90/MWh and costs are falling as the industry become more mature. In future, onshore wind power may become the cheapest generation option in relative terms, especially if generated and used locally and linked to a local energy storage capability.

Renewable energy generation projects require construction minerals (concrete, road base etc.) and especially for offshore wind; tidal lagoons and barrages

that consume large volumes of rock. If this demand is not met from Scotland, it may be met from Norway, with the associated benefits going there. It seems logical to link mineral development to renewable energy development, both strategically at the national level and locally in the context of creating sustainable communities, especially as many of the environmental concerns are similar for both industries.

Complementary industries; hydrogen generation.

Much has been postulated in recent years about the possibility of developing a future 'hydrogen economy' using hydrogen as a fuel and to generate electricity (fuel cells etc.), indeed in Norway a 'hydrogen road' (HyNor) exists from Stavanger to Oslo. That project is linked to the Scandinavian Hydrogen Highway Project (Scandinavian Hydrogen Highway Partnership, 2016), aiming to expand the concept regionally. Historically, hydrogen has been made by reforming hydrocarbons but increasingly it is being formed by Polymer Electrolyte Membrane (PEM) electrolysis of water at low temperatures and linked to renewable energy generation. There is also ongoing research into high temperature electrolysis and new cathode/anode materials.

This emerging technology of PEM hydrogen generation has the potential to make a positive impact on peripheral communities in Scotland. It might be possible to use any surplus, locally generated renewable energy to create hydrogen which could be stored and used locally in hydrogen fuel cells to supplement peaks in electricity demand or to power project or community vehicles. If developed at a suitable scale it could be exported (by sea). A by-product of the process is oxygen which can be used for example to oxygenate water in fish farms and so enhance fish growth rates. Mineral developments could be structured to create the facilities for hydrogen production including underground storage caverns.

The point to be emphasised is that once a profitable industry (mineral development) is established then other developments become synergetically possible; especially links to energy usage and piggy-back transportation of value added goods (manufactured concrete products such as sea defence units, processed minerals, agricultural products, fish products, secondary processed food products, sea weed, sea salt etc.). This further underlines the need for a holistic approach to sustainable community development.

Skills

The minerals industry provides good quality jobs; including managers, engineers, technologists, and trades and labour, and supports employment in the community. The Norwegian minerals industry currently supports some 5000 direct jobs. Similarly, marine transport and renewable energy offer high quality jobs and there is potential for the resurgence of other industries and new industries. However, a skilled workforce is necessary for these ventures to prosper.

Many skilled and young people have moved away from peripheral communities. Migrating jobs back to communities and filling skill gaps would require the demonstration of economic sustainability as a stimulus to people returning or relocating (possibly requiring government support over a transition period), or to the re-engagement and retraining of local people, with ongoing skills development.

Environment and planning

Issues around protection of the environment are of considerable concern for both minerals development and renewable energy. Sustaining communities where people value and are connected to their surroundings is necessary, as is working to change many people's perceptions that minerals industry is a blight on the environment. This issue is also one of effective land use planning where communities and local democracy have a say in what can be.

Scottish planning policy gives guidelines and requires local authorities to make provision for minerals development, and that development should be 'plan-led, with succinct development plans setting out ambitious, long term visions for their area.' (Scottish Executive Development Department, 2006). However, present practice appears essentially to be reactive to industry proposals with little active encouragement for minerals development in current regional plans. This is in contrast to the situation 20 or 30 years ago when there was a programme of exploration and cataloguing of minerals potential in Highland Region and the Western Isles, and an expectation that there would be growth in minerals development. Indeed, many of the ideas and initiatives around at that time (coastal super quarries, sea highways etc) appear to have been adopted and developed in Norway, while they have fallen away in Scotland.

That major minerals developments can be undertaken with environmental sensitivity is manifestly true, Glensanda for instance, and similar major operations in Norway. These are not totally environmentally benign but have well-structured development plans and close monitoring. This should be especially true for smaller or more specialist operations. However, the perception by industry is that the anti-development lobby has become so strong that several development proposals have been abandoned (super quarry at Lingerabay on Harris for instance) or postponed because of the cost and difficulty of bringing them forward at the present time.

Landscape planning, flora and fauna mitigations and marine ecology are all established sciences. Preparing the various Environmental Impact Assessments and making those representations though can be cripplingly expensive during the planning process, especially if a public enquiry is involved. In the authors view, this is because of the adversarial nature of the planning process which is wholly unhelpful if parties are allowed to gravitate to polarised positions rather than coming together positively to develop a satisfactory proposal.

A solution to this situation could be in undertaking academic led research to seek out consensus and espouse practical ways of addressing environment concerns including giving examples of how suitable approaches may be applied, to different scales of development, and specifically to suit Scotland; where the above pre-requisites of adequate resource and the possibility of marine transport exist. The studies should be pro-actively exposed to the public to build confidence

that appropriate developments are possible, how and in what conditions they might take place and to give assurance that suitable safeguards will be put in place. This would be an ongoing process with a report produced annually and including feedback from public bodies, business and the community and differs substantially from the public's normal involvement in mineral development matters where they respond reactively to scrutinise (or support) detailed mineral development proposals put forward by developers during the planning application process.

New Frameworks To Encourage Mineral Development

The author believes that environmentally sensitive mineral development is entirely possible and that the peripheral areas of Scotland can benefit from the increased use of sea transport and from synergies with other developments; particularly renewable energy, so as to bring substantial wealth creation potential and to provide sustainable industries that contribute to the common good. To achieve this a new paradigm needs to be articulated, which is centred on changing people's opinion about the future viability and acceptability of mineral development, to be achieved via an amalgam of democratic, technical and institutional frameworks based on active dissemination of knowledge. In particular, mineral development should be linked to renewable energy development and transportation by sea, and should include the creation of new value adding industries so as to move away from the simple export of raw materials to include more value-added products. Sustainability should also be considered and at a community level to cover four areas;

- making things better today;
- doing it efficiently with the wise use of money and resources and with synergies to associated developments;
- banking for the future (despite exploitation of a none renewable resource)
- and fairness. This latter point requires sharing of risks, rewards and impacts and needs to exist within the democratic context.

The author believes that it is necessary to alter Scotland's development policy to include pro-active support for minerals development. This will require the creation of new institutional frameworks as outlined below;

A new Scottish Minerals Department

In Norway, mineral development has come to be seen as a prime component of sustainable development for coastal communities. A significant contributor to achieving this has been the collaboration between the Norwegian Geological Survey (NGU) and the Department of Mines (BV), and the publication of the annual overview report (NGU, 2013). The NGU operates in a similar way to the BGS, which has published many reports and studies related to the mineral resources of Scotland. However, there is no BV equivalent in Scotland which is mandated to promote mineral development, and currently this falls partly to the Scottish Government, to Scottish Enterprise (SE) and Highlands and Islands Enterprise (HIE). Their involvement is in supporting commercial developers once a development prospect is raised. Although SE and HIE are very supportive in this role, they have no current mandate to be pro-active and to seek out potential developers. Industry bodies like the Quarry Products Association (QPA) do their best to support the concept of sustainable minerals development but essentially they represent the interests of their existing members.

The author believes that a new organ of government; a Scottish Minerals Department should be specifically charged with promoting minerals development, and working in collaboration with the BGS and with industry. This body could compile and publish information annually as per the Norwegian model. The department could report to the Scottish Government, likely into the department for Finance, Employment and Sustainable Growth. As an interim measure it could be created in embryo within the Scottish Government in order to set out its future purpose and mandate, and to prepare an initial report, ideally before 2016. Alternatively, it might be organised in future as a separate Advisory Non-Departmental Public Body (ANDPB) reporting to Scottish ministers.

Environmental mitigations

The second framework relates to the pro-active development of environmental mitigation strategies with the intention of identifying what realistically will be required by way of environmental provisions and giving confidence to potential developers that sensible development proposals will gain planning approval, notwithstanding the need for close environmental scrutiny and effective planning controls as are already contained in Scottish Planning Policy. This should be academically led, possibly as an association of Scottish universities including the University of the Highlands and Islands (UHI). In future, this might also become a new ANDPB reporting to Scottish ministers, and separate from the existing environmental protection agencies such as the Scottish Environmental Protection Agency (SEPA) and Scottish Natural Heritage (SNH).

The work would likely involve commissions to catalogue examples of successful mitigations and undertake research projects into possible applications in the Scottish context, again with the publication of an annual report and periodic topic reports. This would be significantly different to the mandate of SEPA and SNH in that the emphasis would be on the active promotion of successful methodologies, including identifying alternative technologies and promoting demonstration trials. This could be extended to include links to other developments such as renewable energy, ports development or complementary industries, where there is a need for an imaginative coming-together of ideas to articulate 'what can be'.

This could also include investigations into effective stakeholder engagement strategies including values mapping, knowledge transfer processes and collaborative decision making techniques; essential strategies for equipping communities with the knowledge, skills,

attitudes and motivation to organise working and living arrangements and so avoid scaremongering and false assertions which might otherwise hamper effective planning and compromise effective democracy.

Banking for the future

The development of mineral resources should contribute substantially to the Scottish economy and together with renewable energy development might become the engine for the economic revitalisation of Scotland's peripheral areas. This will require proper financial modelling and monitoring in order to focus support for investment and to decide how best to reinvest monetary benefits; banking for the future. Many areas of potential minerals development will have decades or hundreds of years of exploitable reserves provided markets are sustained. However, the world is ever changing so financial development needs to proceed in parallel with commercial, technical and environmental development. Consideration may be given to making a contribution from minerals income towards a regional development fund or a national sovereign wealth fund. However, arrangements for this and the magnitude of sums potentially involved are unclear at present, as is the likely timing of when support for development will turn into monetary returns. As such, establishing an embryo advisory body to manage this aspect of development and to recommend on its future shape and structure is recommended. Initially this could be established within the department for Finance, Employment and Sustainable Growth and could possibly be amalgamated in the future with the Scottish Minerals Department.

Conclusion

The peripheral areas of Scotland are already advantaged by location because of their proximity to valuable minerals resources. In order to release this value, it is necessary to adopt a new paradigm in which mineral development is proactively encouraged by authorities and is seen as the economic driver to sustainable community development particularly for coastal communities where sea transport is possible and by synergies with renewable energy development and energy storage.

The author contends that an unbalanced pre-disposition against minerals development has been allowed to develop which needs to be redressed. This will require positive action to demonstrate to the public that acceptable environmental mitigation can be achieved and that sensible development proposals will meet with public approval and so are likely to achieve planning consent. The concept suitably summarised by Burnham (1950) is that successful resource development 'largely rests on the development of dynamic educational procedures which help people see 'what is' as a stepping stone for 'what can be'.'

The Norwegian example shows how this can be achieved with appropriate government support.

The Madrid Raw Materials Declaration (European Minerals Conference 2010 Delegates, 2013) demonstrates the growing demand for minerals in Europe. Peripheral areas of Scotland could be developed to serve this demand, creating a substantial export industry, to the overall benefit of Scotland and particularly to allow development of sustainable communities.

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