1 Brownfields, Bioenergy and Biofeedstocks
2 Green Remediation

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1 SUMMARY

1.1 Brownfields, Bioenergy And Biofeedstocks

Brownfield land exists for which there is no economic case for restoration to conventional functional re-use and/or no realistic prospect for "hard" re-use. All across Europe there are areas of land which have been degraded by past use that are not easy candidates for conventional regeneration, or for which conventional regeneration may not be the most sustainable approach. Such previously developed land included areas affected by mining, fallout from industrial processes such as smelting, activities related to forestry and the pulp and paper industry, areas elevated with contaminated dredged sediments, former landfill sites and many other areas where the decline of industrial activity has left a legacy of degraded land and communities. The extent of contamination may not be sufficient to trigger remediation under current regulatory conditions, and there may be little economic incentive to regenerate the areas affected.

An ideal solution would be a land management approach that is able to pay for itself. The combination of a wider range of risk management approaches with the emerging broad range of non-food uses of land offers great potential for low (or no) cost risk based land management that is stable and sustainable. An important basis for such an approach is to estimate the energy, policy and economical potentials, risks and limitations which to a great extent depend on the available area and technical solutions.

These themes are explored in four presentations in this special session.

1.2 Green Remediation

Green Remediation can be defined as the practice of considering the environmental effects of a remediation strategy (i.e., the remedy selected and the implementation approach) early in the process, and incorporating options to maximize the net environmental benefit of the cleanup action. In addition to an overview of what the state of the practice is in the US and Europe, this panel will focus in energy and climate change considerations at contaminated sites. Themes include:

- Assessment of the wider impacts of contaminated land management and remediation
- Innovative remediation practices that incorporate energy efficiency and cleaner and renewable energy sources to decrease greenhouse gas footprints while achieving cost savings and benefits to local air quality.
- Placing renewable energy generating capacity on contaminated lands
- Can contaminated land management and remediation work in parallel with carbon management?
- Re-using the built environment / re-using materials

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KEYWORDS: non-food-crop, risk based land management, sustainable development, sustainable land management, extensive remediation, green remediation

1 INTRODUCTION

These two special sessions link two important emerging themes for contaminated land management, both connected with improving its sustainability and reducing its cost. The first theme is the integration of risk based land management of large areas with re-use for non-food crops and revenue generation. The second is what is termed “green remediation”, which is the minimisation of the resource and energy intensity of contaminated land remediation techniques.

2 LINKING BROWNFIELDS, BIOENERGY AND BIOFEEDSTOCKS

The increasing importance of biomass for energy production and for manufacturing feedstocks is a worldwide phenomenon (ref). Once lauded as a truly sustainable fossil-fuel/feedstock replacement, there is increasing concern at national and international levels about the environmental, social and economic impacts of greatly expanding biomass production (Friends of the Earth 2008, Greenpeace 2007, Oxfam 2007). A particular concern is land-use conflict between food production, non-food production and habitat. In parallel with this concern is an increasing interest in food safety and concerns over contamination impacts on food production (Van-Camp *et al* 2004). A possible resolution for both concerns is to preferentially grow non-food crops on contaminated areas.

Across Europe are areas of land which have been degraded by past use that are not easy candidates for conventional regeneration, or for which conventional regeneration may not be the most sustainable approach for example because of issues of scale (size of the impacted area). Such “marginal land” included areas affected by mining, fallout from industrial processes such as smelting, areas elevated with contaminated dredged sediments, former landfill sites and many other areas where the decline of industrial activity has left a legacy of degraded land and communities (Bardos *et al* 2001). The extent of contamination may not be sufficient to trigger remediation under current regulatory conditions, and there may be little economic incentive for redevelopment or regeneration of the areas affected.

In some countries (e.g. the UK and Germany) some of this land has been managed with “soft” restoration, e.g. to grazing or “country parks. In the Netherlands a number of areas have been elevated by the addition of sediments and may have problems of contamination for which conventional remediation is unsuitable. In Sweden the priority has tended to be on “intensive” approaches to sites in urban regions, and other degraded land has tended to be left alone. The amount of land remaining degraded over the long term remains a matter of concern as the degradation remains a blight on local populations, and there are strong quality of life, social and political arguments for some form of action.

An ideal solution would be a land management approach that is able to pay for itself. Biomass from coppice or other plantations has long been seen as a possible means of achieving this goal. While a number of biomass remediation projects have been supported, these have tended to rely on using phyto-extraction as a risk management approach (Riddell-Black 2002). However, this approach to managing contaminated marginal land has not been widely adopted because of concerns over the transmission on heavy metals, both in the harvested biomass, and through mobilisation in dissolved organic matter from added organic matter , and the very long treatment times and uncertain performance of the technique for metal removal from soil (Bardos *et al* 2001).

More recently risk management approaches linked to containment, stabilisation and perhaps biodegradation have begun to be seen as better options for phyto-remediation that avoid the transfer of contaminants into biofuel fractions (r3 and AEA 2004). There is also increasing interest in the management of risks from an ecological perspective. In addition, a wider range of non-food crop options are increasingly feasible including bio-diesel (oil seed rape), bioethanol (straw, wood, grains) and fibre crops (e.g. hemp, flax) as well as higher value "bio-feedstocks" (Royal Society 2007). Improvements in market management, such as the sale of heat energy as MJ rather than as wood chip allow for greater profitability; and also the creation of local management businesses to ensure the maximisation of local economic benefits. *The combination of a wider range of risk management approaches with the emerging broad range of non-food uses of land offers great potential for low (or no) cost risk based land management that is stable and sustainable and is therefore the focus of this project.*

This approach also contributes to policy goals related to renewable energy, the beneficial re-use of organic wastes and potentially carbon management. It provides a means of restoring economic activity and overcoming issues of blight. It offers opportunity for rapid enhancement of landscape and longer term recovery of local land values. It integrates well with mixed projects, e.g. with some reuse for built development and some for amenity.

3 THE REJUVENATE PROJECT

During spring 2008 a European project ("Rejuvenate") including partners from Germany, UK, Netherlands and Sweden will begin to explore the feasibility of a range of possible approaches to combining risk based land management (RBLM) with non-food crop land-uses and organic matter re-use as appropriate. The project will include the identification of a "matrix" of potential opportunities worthy of further development in the UK, Germany and Sweden and in a wider European context, and assess how verification of their performance might be carried out and identifying what requirements remain for future research, development and demonstration. Initial findings from this project will be presented in Milan June 2008.

3.1 Identification of opportunities and barriers

Rejuvenate aims to identify generic opportunities for and barriers to combining non-food crop production with risk based land management for economically marginal degraded land (i.e. areas of degraded land that have remained under utilised for protracted periods of time). Opportunities will be categorised based on compatibility with:

- risk management problems
- land areas
- biocrop markets
- materials re-use opportunities

A range of potential non-food uses might be combined with risk based land management (RBML) strategies, including energy crops (such as coppice, rape seed and grains) and fibre crops (such as hemp and flax) and crops bio-feedstocks such as corn starch. The RBLM strategies adopted may include some intensive measures to deal with acute short term source control. However, the focus of this project is on RBLM for dealing with residual contamination and/or diffuse contamination, for example from atmospheric fallout, where more conventional management approaches are not feasible. The types of RBLM intervention that might be compatible with a non-food land use include:

barriers such as cover using plant-soil systems to prevent direct contact and dust blow; biological processes of stabilisation / degradation; management of subsurface redox and pH conditions to limit contaminant mobility; and use of plants and soil management to control infiltration to groundwater. It may be possible that there are risk management synergies possible with some crops. For example, the shallow rooting habit of willow coppice may have particular advantages in establishing a cover able to prevent direct contact.

The objective will be initiated by identifying long term problems of degraded land (i.e. areas of degraded land that have remained under utilised for protracted periods of time) considered important by the project team and based on experience in UK, Germany and Sweden. Agronomic information about different non-food crops and a range of *possible* "extensive" RBLM scenarios for the problem sites identified will be compiled. Opportunities for linkage will be assessed with the aim of identifying a range of *possible* RBLM scenarios that include a non-food productive use of land. For each scenario an assessment will be made of likely effectiveness of human health, water and ecological risk management over short, medium and long periods; possible environmental benefits and impacts particularly impacts of nutrients on the water environment; applications for the non-food crop envisaged; wider environmental value, e.g. re-use of organic materials, soil carbon management, ecological rehabilitation; key technical factors affecting suitability, e.g. climate, minimum economically feasible crop management unit.

Opportunities will be assessed for their likely levels of profitability (classified as "bands"), levels of project risk, know-how requirements, compatibility with other forms of re-use such as built development and amenity. For bio-energy crops particular attention will be paid to "second generation" biofuel opportunities which are seen as offering higher energy yield per unit land area with lower environmental impacts.

Opportunities will also be assessed for their state of development, identifying also what verification measures might be required to appraise human health risk management and other performance goals such as revenues generation and ecological risk management.

3,2 Key benefits and impacts

Rejuvenate will also assess the key benefits and impacts for non-food crop land use that might influence decision making for future management of economically marginal degraded land, taking into account regional perspectives. The aim is to provide outline decision support guidance for selecting non-food-re-uses for marginal land, adapting the "opportunity matrix" on a regional basis. The aim is to find a simple scheme that can be used to classify possible opportunities / solutions as a strong solution, a possible solution and also regions and areas where it is an inappropriate solution.
The results will be based on interviewing representatives of stakeholder groups in Germany, Sweden and the UK such as regulators, land-use planners, land-owners; suppliers (e.g. of organic matter), agronomists and sectoral organisations working in the non-food crops arena. Their views will be solicited about what aspects of a combined RBLM / non-food crop approach would encourage their interest, and which would not, and of these which are most significant.

An ambition is to try and approach this discussion from the perspective of sustainable development, including the three elements: environmental, economic and social.

The most immediate risk management benefit is likely to come from pathway management via some combination of containment (cover); hydraulic containment (managing water movement); stabilisation from added organic matter such as sewage sludge; root exudates); stabilisation through management of soil redox and pH and degradation of some contaminant types. The effectiveness of a strategy for risk management will depend on its control of direct contact, air (dust-borne and voc) and water pathways. Effects may be become apparent at different times, e.g. immediate? – containment; short to medium term – stabilisation; and medium to long term - biodegradation. Effectiveness may also be linked to issues of maintenance and verification (including long term monitoring where needed), and the possibility of introducing new pollutant linkages may need to be considered. For example, risk management may be self maintaining as long as cultivation and organic matter input continues; verification may require a "lines of evidence" approach akin to MNA (monitored natural attenuation); and a possible new pollutant linkage is via the transfer of contaminants to products.

The importance of potential wider environmental benefits such as limiting use of non-renewable resources in RBLM itself and the avoidance of remediation process emissions, wastes and materials transport, productive use of land for renewable resources (feedstocks, energy, fibre etc), potential biodiversity benefits, opportunities for landfill avoidance – including by the creation of opportunities for the re-use of organic matter, soil carbon management will also be discussed.

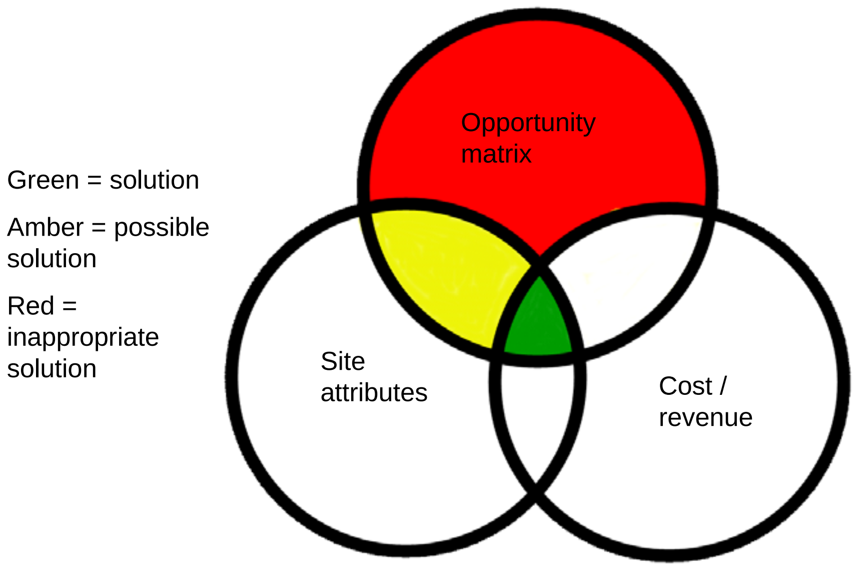
From an economic perspective this general approach to RBLM can make use of relatively low cost techniques employing conventional agricultural equipment and know-how that is widely available in Germany and the UK. The use of techniques that can be widely applied by a relatively large number of people is an important sustainability issue, and the project will focus here rather than on opportunities that are highly specialised and resource intensive.

Wider economic opportunities include the rapid initiation of economic re-use of land with the potential for revenue generation that can be set against long term site management costs (e.g. for monitoring); an enhancement of landscape which may have an improving effect on land value both for the area being treated and its surroundings; and also the avoidance of large short term “intensive” remediation costs which may damage the economic resources of both authorities and businesses.

From a social perspective this type of “soft” approach is likely to find easy acceptance (e.g. compared with invasive or intensive techniques) and may bring about rapid quality of life benefits from improved landscape surroundings and living conditions. Wider social opportunities include local community engagement and involvement with a project that can demonstrate local benefits; a range of skilled and unskilled job opportunities it might create; Opportunity for job and business creation and the enhancement of local living conditions, for example by including amenity features such as waling or cycling trails.

The results will not be a thorough analysis, but a starting point for the interviews and discussions in order to achieve information about regional perspectives (such as local bio-energy market interests) and local interests that are likely to strongly influence what factors underpin decision making.

Combining an understanding of decision making influences with an understanding of the nature of the opportunities available and their state of development will allow us to make an approximate ranking of the likely attractiveness of different RBLM / non-food crop approaches at least on a national basis, and potentially to a regional level. This would be summarised as a simple “traffic light” colour scheme could be used to indicate likely regional interest, such as “green” = strong appetite; “yellow” = a weak appetite, “red” = no or limited appetite. The goal is to identify “win-win” solutions to risk based land management that can combine effective risk control with a sustainable re-use of economically marginal land, appropriate to the region. This simple decision tool is intended to highlight potential opportunities (e.g. “green”), as illustrated below.



4 GREEN REMEDIATION

As part of the U.S. EPA's goal of improved environmental stewardship across its programs, the Agency has begun examining opportunities to integrate sustainable practices into the decision-making processes and implementation strategies used to remediate and manage contaminated lands. Three major efforts under this umbrella will be presented at ConSoil; 1) Green remediation, 2) soil amendments for impaired lands, and 3) renewable energy on contaminated lands. 1) Green remediation strategies seek to maximize the net environmental benefit of contaminated site cleanup. A key goal is the reduction of a cleanup project's "environmental footprint," which can considerations such as reducing air pollutants from site operations, reducing energy inputs or using renewable sources, adopting technologies that minimize waste generation and following practices that recycle materials used or generated on the project, and avoiding the disruption of natural habitats or considering ecorestoration. 2) EPA has also initiated an effort, working with multiple partners across the country, to identify opportunities to recover scarred mine lands thru the use of soil amendments that accelerate the soil profile recovery process, helping restore damaged ecosystems, reduce negative impacts from surface water runoff on adjacent water bodies, and possibly provide a source of carbon sequestration as the soil profile matures and soil carbon content increases across thousands of acres of damaged land. 3) A third effort focuses on the developing options to generate renewable energy on contaminated lands. Efforts are underway to identify and develop a suite of options such as solar and wind farms as well as biomass and other renewable energy sources that require extensive land areas. Placing these on sites that have reuse restrictions due to contamination concerns offers several benefits such as expanding the pool or renewable energy source while preserving "greenfields" that would otherwise be used to locate the generating capacity.

4.1 Green Remediation: Reducing the environmental footprint of site cleanup projects. US EPA speaker – Carlos Pachon

Green remediation builds on environmentally conscious practices already used across business and public sectors, such as erosion-control and waste minimization, but more strongly encourages use of state-of-the-art methods and products designed to reduce activity footprints. Key opportunities for implementing greener practices include:
Core elements of green remediation include:

1. Energy requirements to power treatment systems: Minimizing the carbon and energy footprints of cleanup projects by increasing system efficiencies, using renewable energy sources, and incorporating innovative approaches such as the use of combined heat and power systems.
2. Air quality: Minimizing sources of air contaminants from site operations by using clean diesel equipment, employing dust mitigation practices, and minimizing fugitive emissions form treatment systems.
3. Water requirements and impacts on water resources: Minimizing freshwater consumption, recycling water to the greatest extent possible, and preventing impacts on water quality in nearby streams and other water bodies.
4. Land and ecosystem impacts: Using minimally invasive technologies such as in-situ treatment or passive-energy technologies where possible, reducing project impacts such as noise, light pollution, and avoiding the disruption of natural habitats or considering ecorestoration.
5. Material consumption and waste generation: Adopting technologies that minimize waste generation and following practices that recycle materials used or generated on the project.
6. Long term stewardship actions: Installing renewable energy to power long term cleanup systems, using passive sampling approaches, and integrating the cleanup and reuse designs when cleanup actions involve long term stewardship requirements.

Greener remediation requires close coordination of the cleanup process and reuse planning in terms of both life cycle management as well as daily operations. Reuse plans and goals influence the choice of remedial action objectives, cleanup standards, and the cleanup schedule. In turn, those decisions affect the approaches for investigating a site, selecting and designing a remedy, and planning for future operation and maintenance of a remedy to ensure its protectiveness.

Site reuse and site cleanup can mutually support one another by leveraging infrastructure needs, sharing data, minimizing demolition and earth-moving activities, reusing structures and demolition material, and combining other activities that support timely and cost-effective cleanup and reuse. Early consideration of greener remediation opportunities offers the greatest flexibility and likelihood for related practices to be incorporated throughout a project life cycle. While early planning is optimal, greener strategies such as engineering optimization may be incorporated at any time during site investigation, remediation, or redevelopment.

Best practices of green remedation apply to all phases of site assessment, remediation, and redevelopment, including emergency response actions, site investigations, remedy construction, operation of treatment systems, monitoring of treatment processes and progress, and site close-out. Implementation of best practices may be formally documented in primary documents required for U.S. regulatory purposes, including records of decision, feasibility studies, and five-year reviews. More detailed practices can be incorporated into project documents such as site management plans and state or local permit applications for construction and operation.

4.2 Solar Powered Remediation in Sensitive Areas Sytze Keuning, NL

Bioclear performed a remediation study and wrote a containment plan for a contaminated aquifer on Ameland. The location specific requirements for the site stated that the remediation system should cause minimal disturbance to the surroundings and should be able to operate independently.

Ameland is one of the West Frisian Islands off the north coast of the Netherlands and consists mostly of sand dunes. Near the town of Hollum an aquifer situated on a NAM site -NAM is a 50:50 joint venture between Shell and ExxonMobil - was contaminated with mineral oils. The location lies behind a first set of dunes approximately 2½ km from Hollum and next to an area used as a drinking water source. The site was considered vulnerable and therefore it was decided that containment of the contamination was desirable.

The sole access point to the site by car is via the beach and no electricity or suitable water is available. Remediation of the site was subject to conditions stating that disturbance to the surrounding area must be kept to a minimum (this included noise and visual disturbance). Furthermore the system mustn't be dependent on utilities being supplied from inhabited areas, but should be able to operate independently. "During the remediation study the location specific requirements were taken into account," says Hans Govers who was responsible for remediation of the 'Hollum' site.

The containment system implemented is made up of a small pump and treat unit that is powered by solar energy and fits in a container. It causes very little disturbance and is able to operate independently. Wind energy was also considered as an option, but a windmill would be too visible. Therefore solar energy was chosen as power supply. Six solar panels provide enough energy to operate the groundwater pumps throughout the year. Containment and remediation of the contaminated aquifer is possible using something that is in great supply on the island: the sun. The system was started up in December 2005 and is still running. Concentrations in the influent are diminishing and the contour of the contamination is decreasing.

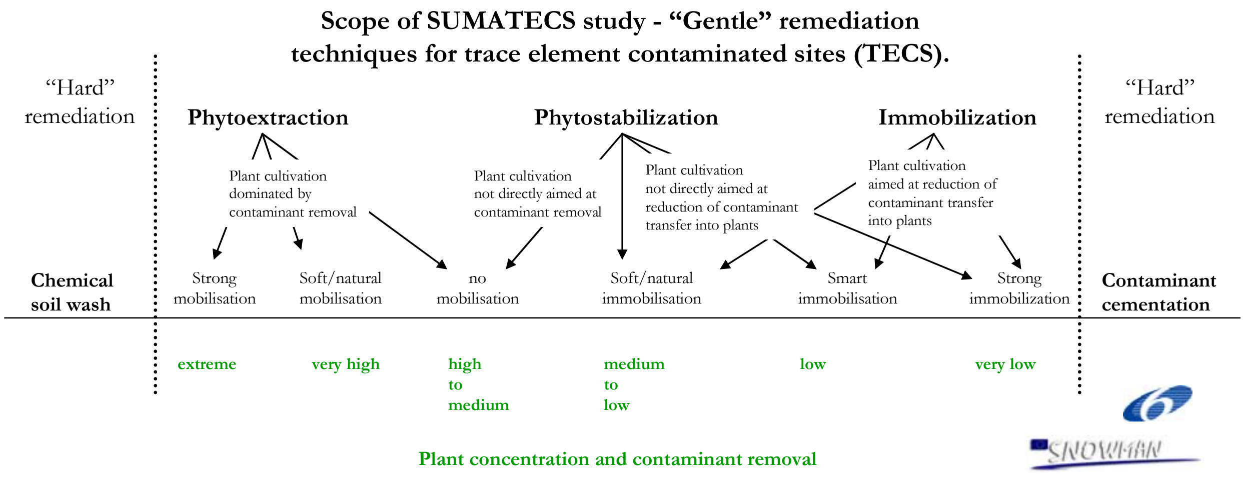
4.3 Selecting gentle remediation approaches, Andy Cundy, UK

The application of "gentle", *in-situ* remediation technologies (specifically, *in-situ* techniques that do not significantly impact soil function or structure, such as phytoremediation, *in-situ* immobilisation, etc., see illustration below) has been the subject of intensive research and development over a number of years. Though a great deal of progress has been achieved at the laboratory or bench scale, and at field demonstration scale, the application of these technologies as practical site solutions is still in its relative infancy. In addition, there are considerable differences between the adoption and promotion of these technologies between different EU member states. A range of factors may be argued to have limited the widespread adoption of these gentle remediation technologies, including those of site heterogeneity and uncertainties in the characterisation of the bio-available or bio-extractable contaminant fraction; the timescales required for remediation; and general uncertainties over the feasibility or reliability of some of these techniques as practical solutions (e.g. phytoextraction). One major issue is that a number of *in-situ* remediation options are available, and thus some form of decision support is required to allow the user to make an informed decision on which is the most suitable technique(s) for the site requiring remediation or management. Site management and/or remediation should also be affordable, feasible, effective & sustainable, factors which also need to be built in to the decision support process.

The need to further develop decision support systems for selecting gentle remediation approaches, and to examine (a) the use of these technologies as more sustainable remediation tools, and (b) the current barriers to their widespread adoption, has been recognised by the development of the SUMATECS project (SUstainable MAnagement of Trace Element Contaminated Soils). This project was launched in October 2007 under the umbrella of SNOWMAN, which is a network of national funding organizations and administrations providing the research funding platform for soil and groundwater, bridging the gap between knowledge demand and supply[1]. Focussing initially on trace element contaminated sites, the SUMATECS project aims to implement a literature and project-based review (including a review of the country-specific state of the art and current procedures) to identify the current status of research and application of “gentle” remediation technologies across Europe, and to:

(i) derive or recommend decision support systems and remediation scenarios (which include verification, and analysis of environmental, economic and social impacts) and
(ii) define further research needs and priorities

for gentle remediation technologies. The study, co-ordinated by the University of Natural Resources and Applied Life Sciences (Austria), and involving research and management organisations from France, Germany, Sweden, Czech Republic, Belgium, Italy and the U.K, covers soils contaminated by trace elements (TECS) (singly or in combination with organics), at brownfield and working industrial sites and their surrounding agricultural or urban areas. Initial findings from this project will be presented in Milan in June 2008.



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1 SNOWMAN is one amongst more than 70 ERA-Nets (European Research Area – Networks) being funded by the European Commission’s 6th Framework programme for Research and Technological Development. Further information is available at http://www.snowman-era.net and http://www.rhizo.at/Sumatecs.

4.4 Renewable Energy on Contaminated Lands. Penelope McDaniel, USEPA.

Currently, energy from renewable sources makes up only a small fraction, approximately 2.5 percent[2,] of the energy consumption in the United States. Energy demand projections indicate an estimated 31% growth in demand over the next 25 years[3]. Further, power generation projections indicate an estimated 45% increase over the next 25 years in renewable energy demand, from 357 to 519 billion kilowatt-hours[4]. A broader renewable energy portfolio is vital reducing upstream and downstream greenhouse gas emissions, it can benefit the economy, and will further national security and energy independence.

However, several renewable energy sources are "land intensive", requiring large surfaces to establish sufficiently large generating capacities to significantly contribute to the nation's energy supply. Examples include wind and photovoltaic energy farms, and energy crops for biofuels. At the same time, millions of acres of land in the United States face use restrictions due to historical contamination problems. Matching renewable energy generating capacity with these lands offers an unique opportunity to add to the renewable energy pool while putting impaired lands back into productive use and preserving the "greenfields" that might otherwise be developed for generating renewable energy.

Penelope McDaniel of the USEPA is leading an effort from the Agency's Headquarters to identify these opportunities and foster their implementation by working in collaboration with multiple interested parties and will share some of nuggets of knowledge acquired to date thru her presentation.

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