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Sustainability guide for Bioenergy

A scoping study

A report for the RIRDC/L&WA/FWPRDC/MDBC Joint Venture Agroforestry Program

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Foreword

Interest in biomass based energy production (bioenergy) is increasing in Australia. This is being driven by a mix of commercial forces, government support through a range of programs, and policies and environmental imperatives that have stimulated the search for economic returns from perennial vegetation in our broad scale dry land cropping zones. While there are potential benefits in terms of security of energy supplies, reduced greenhouse gas emissions, improved air quality, management of dryland salinity and economic opportunities for rural and regional Australia, there are also potential disbenefits with respect to soil and water management, vegetation clearing and biodiversity loss, and waste management. Despite the level of interest in bioenergy in Australia, there has been no comprehensive and systematic study of the sustainability implications of broad scale development of a bioenergy industry.

The range of production systems for a source of biomass, and the various technologies to convert the biomass to energy differ greatly in efficiencies, scales and environmental impacts. The sustainability (or not) of a project is very specific, and it is therefore neither appropriate nor possible to develop a fully quantitative recipe approach to cover the broad range of potential projects that can be considered under the banner of bioenergy. A process-based approach which can be adapted to a wide range of applications has therefore been developed. This Bioenergy Sustainability Guide puts forward a process for developing projects or industries based on sustainable bioenergy, including a review and assessment of all the related and collateral issues that need to be considered, managed or mitigated to ensure sustainability first as a land use issue and then from the perspective of the efficiency of the biomass to bioenergy conversion and consumption process.

We hope that various sectors of the bioenergy industry will attempt to apply the framework proposed in this scoping study, and that constructive discussion and comment will ensue as we move towards developing a truly sustainable industry.

This project was funded by the Joint Venture Agroforestry Program (JVAP), which is supported by three R&D Corporations — Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia, and Forest and Wood Products Research and Development Corporation (FWPRDC), together with the Murray-Darling Basin Commission (MDBC). The R&D Corporations are funded principally by the Australian Government. State and Australian Governments contribute funds to the MDBC.

This report, a new addition to RIRDC's diverse range of over 1500 research publications, forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems.

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Contents

Executive summary

Energy produced from biomass (bioenergy) is the subject of scientific, industrial and political interest in Australia and elsewhere in the world. The drivers for this interest are numerous and complex. These include:

- environmental considerations, principally involving greenhouse gas emissions and air quality issues, but also often touching on sustainable land management
- economic considerations, generally associated with the levels of government support needed to enable bioenergy sources compete with fossil fuel sources
- social considerations, often around the viability of rural regions and industries whose traditional income sources from agricultural commodities has declined.

Proponents of bioenergy development generally only focus on the positive aspects of an energy source that is at least superficially "renewable". Yet there are also potential negative consequences for the environment associated with bioenergy development that need to be openly acknowledged, examined and avoided in project development. This study has been motivated by the premise that the <u>bioenergy business</u> is essentially part of the <u>sustainability business</u>. To achieve the support from community and government needed to enable bioenergy projects to achieve financial and political feasibility, the sustainability credentials of the proposal have to be fully explored and communicated. Such a process has to be more than a public relations exercise.

The range of production systems for a source of biomass and the various technologies to convert the biomass to energy differ greatly in efficiencies, scales and environmental impacts. The sustainability (or not) of a project is very specific, and it is therefore neither appropriate nor possible to develop a fully quantitative 'recipe' approach to cover the broad range of potential projects that can be considered under the banner of bioenergy.

This Bioenergy Sustainability Guide puts forward a process for developing projects or industries that address sustainability goals in substantive ways.

The substantive content of the Guide starts (Chapter 2) with brief consideration of bioenergy and sustainability in general. Common benefits and disbenefits of bioenergy developments are discussed.

Approaches to sustainability assessment are considered in Chapter 3. Sustainability criteria and indicators have been a common approach of describing key characteristics of sustainability in different sectors and examples are given for such approaches in agriculture and forestry. Environmental (and social) impact assessment (EIA) has been the standard approach to evaluating impacts of particular project proposals. EIA will continue to play a key role in project assessment and regulatory approval. However the authors of this report see it as only part of a broader approach to the development of bioenergy projects that truly deliver on sustainability goals. The "systems view" is often constrained in EIA to the localised impacts of the project and broader sustainability assessment and wider systems interactions are not addressed. In this Guide, our focus is as much on the "how" as the "what" of sustainability, i.e., how can a dialogue be established around the technical assessment activity that in the end, develops understanding and confidence in the community around the project or industry's overall sustainability? It is this second focus that has shaped our thinking in the preparation of this guide. The overall objective is for the bioenergy industry and individual bioenergy projects to develop (where warranted) a "licence to operate" from the wider community. Environmental Impact Assessments will be part of this process but need to be set in a wider dialogue around overall sustainability.

The concept of "community licence to operate" is discussed in Chapter 4 together with consideration of the likely difference in level of assessment with different scales and complexities of bioenergy development.

The core of the Guide is contained in Chapter 5, where we suggest a stepwise sustainability evaluation guide. Key steps are:

1. Define systems boundaries, including production area for biomass and offsite impacts of production system and conversion process.
2. Define biomass feedstock characteristics
3. Assess condition and impact of current land management regime
4. Benchmark current land condition and impact against an appropriate reference point – to set a biophysical "sustainable reference point"
5. Profile proposed new land use or management regime (skip if no change in land use)
6. Compare new or modified land use against current and "sustainable reference point" (skip if no change in land use)
7. Develop and describe the optimum bioenergy conversion pathway
8. Evaluate and develop control methods for environmental impacts
9. Evaluate and develop management strategies (where appropriate) social and economic impacts
10. Synthesis of all steps for an overall sustainability assessment.

It is important to note that these steps are meant to help guide the development process and sustainability assessment via a series of iterations – with more detailed data gathering and analysis taking place in later iterations as key issues for project sustainability emerge. It also is important to note appropriate community consultation mechanisms need to be in place throughout.

Key questions or "hurdles" that need to be asked and answered at different points in this assessment cycle include:

- Is energy recovery the highest order use for this biomass? If not, is it truly sustainable to use the biomass for a lower order application?
- Is land use for bioenergy maintaining or improving upon current land quality and current off-site impacts of land use on the wider environment?
- Is the proposed land use really sustainable in the long term – one can think of situations where a land use change for bioenergy leads to reduced off-site environmental impacts but the land use is still ultimately unsustainable because of wider regional influences (such as landscape scale salinisation)
- Ultimately, have the full range of systems impacts been explored in such a way that there is a broadly based "licence to operate" developed within the communit?

Chapter 6 provides a checklist whereby these ten steps are further elaborated. The aim is to stretch the thinking of the project proponents to ensure broadly based sustainability thinking and assessment shapes project development.

1. About this report

1.1 Report objectives

A set of complex environmental, economic and political influences exist in Australia to create a high level of interest in the prospects for bioenergy. Foran and Mardon (1999) provide a good overview of the potential significance of bioenergy development on the Australian economy over the medium to long-term. While there are potential benefits in terms of security of energy supplies, reduced greenhouse gas emissions, improved air quality, management of dryland salinity and economic opportunities for rural and regional Australia, there are also potential disbenefits with respect to soil and water management, vegetation clearing and biodiversity loss, and waste management. There is also debate within the scientific, industrial and general communities on the energy and greenhouse gas benefits of bioenergy development.

Despite the high level of interest in bioenergy in Australia, there has been no comprehensive and systematic study of the sustainability implications of a broadscale development of a bioenergy industry. This project began in 2002 as a scoping study to develop a conceptual framework for consideration of the sustainability outcomes of bioenergy development in Australia. A workshop and three subsequent presentations and discussions were held with Bioenergy Australia members. The authors attempted to take the diverse views expressed this group during these discussions into account.

This Bioenergy Sustainability Guide has been developed to support the bioenergy sector's thinking and planning around sustainability. The guide starts with no preconceptions on the sustainability credentials of any particular bioenergy activity. Instead, the aim is provide a roadmap for the bioenergy sector to deploy in their efforts to develop a "licence to operate" from the broader community.

The range of production systems for a source of biomass and the various technologies to convert the biomass to energy differ greatly in efficiencies, scales and environmental impacts. The sustainability (or not) of a project is very specific, and it is therefore neither appropriate nor possible to develop a fully quantitative 'recipe' approach to cover the broad range of potential projects that can be considered under the banner of bioenergy.

This Bioenergy Sustainability Guide puts forward a process for developing projects or industries based on sustainable bioenergy, including a review and assessment of all the related and collateral issues that need to be considered, managed or mitigated to ensure sustainability first as a land use issue and then as a specific yield and efficient conversion pathway proposition.

There are two other reports, which are related to this one:

- The Waste Management Association of Australia (WMAA) (2004a) Sustainability Guide to Energy from Waste was under development when work on this Sustainability Guide began. Although 'Energy from Waste' is a single sector of the bioenergy industry, the strength of the approach led to collaboration between Mark Glover (WMAA) and CSIRO Sustainable Ecosystems researchers to develop a process-based approach to encompass the broader extent of bioenergy projects.

- The NSW Bioenergy Handbook (DEUS 2004) commenced a little after this project and the Handbook has recently been released. The authors of this Bioenergy Sustainability Guide collaborated with those of the NSW Bioenergy Handbook, and the two publications are intended to be complementary. The Handbook gives a much more detailed introduction to bioenergy, including production systems for the types of feedstocks for electricity, heat generation and transport. It also covers processes for conversion of biomass feedstock into energy. The sustainability issues associated with each of the feedstock production systems and conversion technologies are discussed in the NSW Bioenergy Handbook, but it is not designed to provide a process for answering the question ‘Is this project sustainable?’ This Sustainability Guide is aimed at addressing this question at a project-specific level. The overall project development framework put forward by DEUS (2004) is adapted here (Figure 1 – Steps in Developing a Bioenergy Project DEUS 2004). The steps which are elaborated upon in this Sustainability Guideline are highlighted.

IDENTIFY RESOURCE	▪ **How much is there, and for how long? Is it seasonal?** ▪ **Harvesting, collection, processing, transport** ▪ **Is energy the best use of the resource?**
SITE SELECTION	▪ **Proximity to the grid, water supplies, and roads** ▪ **Potential to use heat or electricity locally? Think co-generation** ▪ What are the characteristics of the demand profile?
OUTLINE PROJECT FEASIBILITY	▪ Fuel security (10 – 15 year contract) ▪ Identify all potential markets ▪ Eligibility for government incentive schemes ▪ Grid connection cost ▪ Technology selection ▪ Economic feasibility ▪ **Identification of special environmental or social concerns**
START COMMUNITY CONSULTATION (and continue from here on)	▪ **Engage the community** ▪ **Discuss concerns** ▪ **Identify benefits and any options for involvement** ▪ **Identify process for ongoing consultation**
DETAILED ASSESSMENT	▪ Supply chain: reliability, contracts, processing, storage ▪ Selling the energy: licensing, eligibility for renewable energy credits, power purchase agreements, customers ▪ **Technology assessment** ▪ Economic feasibility ▪ Risk assessment ▪ **Environmental impact statement (>30MW)** ▪ **Statement of environmental effects (<30MW) DEC licensing requirements** ▪ **Stakeholder and further community consultation**
DEVELOPMENT APPLICATION	▪ To local council or to DIPNR ▪ Licence application to DEC follows DA, unless project is ‘integrated development’ (DEC and DA simultaneously)
CONSTRUCTION	▪ Follow DEC requirements to minimise pollution, noise, dust
OPERATION	▪ Maintaining fuel security ▪ Records and reporting for DEC (generator >200kW) ▪ Emissions control and reporting to DEC ▪ Reporting for RECs ▪ Fuel auditing
DECOMMISSIONING	

The highlighted sections show points of connection between this Guide and the overall approach outlined in the NSW Bioenergy Handbook.

Figure 1 – Steps in developing a Bioenergy project (adapted from DEUS 2004, *Figure 24*, p121)

1.2 How the Report is structured

This report is structured around chapters that define the scope and explore pertinent bioenergy and sustainability concepts, chapters that establish the context and need for a bioenergy specific evaluation framework and chapters that document the framework and detail steps in project assessment.

Chapter 2 (Sustainability of Bioenergy) defines sustainability, bioenergy, and takes an introductory look at bioenergy through a sustainability lens, by identifying typical benefits and disbenefits associated with bioenergy development.

Chapter 3 (Assessing Sustainability) reviews the diverse range of approaches employed to assess sustainability and identifies the niche for the sustainability guide in the context of well established procedures such as environmental impact assessment (EIA).

Chapter 4 (Bioenergy Sustainability Guide) explores the intended users and applications for this guide and the likely levels of assessment for different types of bioenergy projects.

Chapter 5 (The Sustainability Evaluation Framework) introduces the sustainability framework developed by this project. This is a 10-step guide which aims to help deliver the "licence to operate" for bioenergy projects from the wider community.

Chapter 6 (Project Assessment Matrix) contains the Project Assessment Matrix and provides accompanying notes to assist in detailed project assessment.

Chapter 7 (Concluding Comments) examines the future pathways for the development of this scoping study, identifies the process for both refinement of the study and bringing together sustainability planning resources in an easily accessible form.

2. Sustainability of Bioenergy

2.1 What is sustainability?

There are many definitions of sustainability. The Brundtlandt Report clearly stated the concept of sustainable development as:

> "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987).

This report led to the United Nations Conference on Environment and Development, known as the Rio Earth Summit in 1989. The Summit adopted Agenda 21 which proposed a program of sustainable development at a global level. Ecologically Sustainable Development (ESD) is enshrined in legislation in Australia. A typical sustainability requirement for a new bioenergy project is as follows:

> "Proponents will be required to demonstrate that the production and use of the fuel is consistent with the principles of ecologically sustainable development (ESD)" (Australian Greenhouse Office – Guidelines for Certification of Additional Fuels).

ESD is defined in the National Strategy on Ecologically Sustainable Development (NSESD, 1993) as:

> "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased".

Section 3A of the Environmental protection and Biodiversity Conservation Act (EPBC 1999) also sets out five principles of ESD that should be considered in planning for ESD reporting. These are that:

a) "decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations
b) if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
c) the principle of inter-generational equity—that the present generation should ensure the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations
d) the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making, and
e) improved valuation, pricing and incentive mechanisms should be promoted."

While the general principles of ESD are clear, it is not always clear how to translate some of these to practical outcomes. Issues of measurement, monitoring and integration are an active area of research for many applications.

2.2 What is bioenergy?

Bioenergy is energy from biomass, which in turn uses solar energy to synthesize atmospheric CO_2 and water into carbon based plant material (with the addition of mineral nutrients from the soil substrate). The short cycle nature of the biomass based fuels means they are, in principle, renewable – CO_2 absorbed in the growth of the biomass is released upon fuel combustion.

Fossil fuels also represent biomass based fuels that have been stored or sequestered over the millennia. However, the balances in the biosphere cannot absorb the current level of re-release of carbon from fossil fuel and such “non-renewable” fuels are believed to be the primary driver of the rapid increase in atmospheric CO_2 levels observed over the last 50 - 100 years and a major factor in implicated in greenhouse induced climate change (IPCC, 2001).

Bioenergy fuels present as considerably more sustainable than fossil fuels in that they are renewable while their released carbon can be reabsorbed by the remaining photosynthesizing biota. However, in sustainability terms, bioenergy products retain two important qualities:

- **They are high carbon fuels** – higher than many fossil fuels (Table 2.1) and so should be adopted only where there is a clear and obvious pathway for the CO2 re-absorption within a short time frame, i.e., whereby CO2 release via fuel combustion is balanced by CO2 absorption in biomass production producing from a greenhouse gas neutral effect (from a fuel consumption point of view – the full life cycle of the biofuel will invariably involve a range of greenhouse emissions and the net result on a life cycle basis may be greenhouse gas reducing, neutral or increasing)

Table 2.1 Carbon content of various fuel types (Tibbs 1993)

Fuel Type	Carbon Content
Fuel wood / biomass	85-91%
Coal	Average 50%
Oil	30-35%
Natural gas	Average 20%

- **Biomass represents much more than just its simple energy value**. Biomass may have a number of resource values, be they food, fibre, industrial or manufacturing values. The basic energy value of biomass will quite likely be one of the lowest order values of the biomass. A sustainable bioenergy paradigm would suggest we pursue the highest order value of the biomass that has been developed from solar energy and photosynthesis. For example, there is a higher order value of timber in a tree, or primary food and/or fibre yield from a crop which should be considered before recovering energy from residuals. The provision of ecosystem services may also be considered as a higher order output from a biomass source before considering simple energy recovery (heat/power) from crop residuals. Even a dedicated “energy crop” of short rotation, coppiced willow or longer rotation woody plantation may fulfil functions of soil remediation, erosion control, water management, biota support, sequestered carbon, fibre recovery, oils, sugar, saps, fruits, flowers etc. before conversion to simple energy products from the residuals. Embedded energy values can also reflect the direct management inputs of ground preparation, planting, husbandry, harvesting and subsequent conversion. For this reason we consider bioenergy as a by-product of a resource grown for another primary purpose rather than itself a primary product – although we acknowledge that there may be some circumstances where a dedicated energy crop may be desirable.

2.3 Bioenergy viewed through a sustainability lens

Bioenergy is often promoted on its environmental benefits but a blanket endorsement of the sustainability credentials of bioenergy is not possible. A comprehensive assessment of the sustainability of bioenergy development requires a balancing of benefits and disbenefits of specific instances (Table 2.2).

Reductions in greenhouse gas emissions through displacement of fossil fuels are one generally acknowledged benefit. However greenhouse gas emissions over the biomass production, processing and energy product distribution and utilization lifecycle need to be accounted for, and under some circumstances the net reductions in emissions may be substantially less than the potential associated with fossil fuel displacement. Another key potential environmental benefit of interest in Australia is the role perennial vegetation can play in limiting leakage of water and salts from our agricultural catchments at risk from dryland salinity. Increasing the proportion of woody perennials in agricultural landscapes may have implications for biodiversity values in these lands. The key social benefits arising from bioenergy development relate to rural incomes and employment associated with new rural industries.

On the other side of the ledger, bioenergy projects which are improperly conceived or implemented to compete with other lands uses and/or the natural environment for scarce water resources, to degrade water quality though loss of sediments, nutrients or agrochemicals, to reduce the social amenity of rural landscapes, to give rise to social disruption and/or damage to infrastructure through transport operations. In extreme cases, bioenergy may actually result in increased greenhouse gas emissions over the full fuel production and consumption life cycle. The long-term productivity of biomass production needs also to be considered if management practices are likely to lead to soil deterioration through compaction, erosion, acidification or nutrient depletion. The implications on the utilization of biomass materials from native forests have already become a contentious issue in industry, community and political circles.

Table 2.2 Balancing benefits and disbenefits of bioenergy

Biomass production / recovery for Bioenergy can:-	**Which can present as a benefit…**	**Or as a disbenefit…**
i) Provide a level of security of supply from the sun rather than fossil sources that are finite	If generated and recovered sustainably	If too much fertile land is quarantined or degraded in the process
ii) Provide more localised supply of heat and power	By reducing transport (fuel) and transmission (power) costs and impacts	Where smaller plant is less efficient in the conversion of the biomass – lack of efficiency equals waste of initial resource value
iii) Deliver substantial greenhouse benefits with short cycle carbon release and sequestration	Because fossil carbon is contained or not released	When direct solar absorption is cost effective and sustainable
iv) Improve overall air quality	By provision of ecosystem services when growing and, if converted via sensitively designed and operated plant, when harvested as compared with traditional fossil fuel conversion	If the conversion pathway is inefficient, such inefficiency can squander much of the potential net benefit
v) Provide economic opportunities for rural and regional Australia	Where biomass energy sources provide a major new product range from the traditional food and fibre sectors or the stimulus for land remediation programs	Where the biomass is harvested unsustainably, the land has a finite capacity to sustain yields for offsite application and biomass harvesting could exacerbate soil degradation if conducted insensitively

Biomass production / recovery for Bioenergy can:-	**Which can present as a benefit…**	**Or as a disbenefit…**
vi) Impact soil quality, fertility, erosion and production	If the activity is conducted to improve soil quality, fertility, retention and production	If the activity is conducted so as to deliver negative soil impacts (over harvesting, insensitive monocultures etc.)
vii) Facilitate the remediation of degraded lands	Where the production of biomass yields is from land quite unsuitable for food production	If conducted inappropriately
viii) Provide local, catchment and global water cycle and management outcomes	If conducted sensitively and with due regard to the prevailing water cycle issues	Where inappropriate planting and over harvesting etc. deliver any or all of the outcomes as disbenefits
ix) Deliver net biodiversity outcomes in the soil and above ground	Where such issues are duly considered in the selection of plantings and the conduct of the specific management plan relevant for each locale	Where insensitive planting (mono cultures) and harvesting deliver negative biodiversity outcomes
x) Provide an intensive bioremediation opportunity for certain urban and industrial waste materials	Where the plantings and nutrient cycles are managed proactively	Where inappropriate wastes are put to land and managed inappropriately
xi) Deliver social / aesthetic outcomes / impacts	Over and above the economic benefits (v)	If inappropriate methodologies or management practices are adopted

3. Assessing sustainability

3.1 Measuring and monitoring sustainability

While the debate on the principles underpinning sustainability is mature and complex, these principles require translation into practical and meaningful methods for measuring and monitoring sustainability. There are multiple approaches and methods being developed and applied. The most appropriate method depends on the level and detail of assessment required for a particular project or purpose.

Approaches include:

- **Adherence to prescribed approaches** (eg Best Management Practice) (eg British Biogen 2003; Oil Mallee Association of WA Inc. 2003; WMAA 2004b)
- **Multiple qualitative and quantitative criteria** and indicators to meet a diverse set of goals where no single indicator exists (eg Anon 1995; Commonwealth of Australia 1998; Smith and McDonald 1998; SCARM 1998; ANZECC 2000)
- **Time trends in a system state** – assessments are made in terms of direction and degree of measurable changes in system properties (eg Eigenraam et al. 2000; Smith and McDonald 1998)
- **Resilience and sensitivity of a system** to maintain productivity when subjected to a stress (Berkes and Folke 1998)
- **System simulation** – eg examine relationship between production and environmental degradation (eg Eigenraam et al. 2000; Smith and McDonald 1998)
- **Life cycle analysis** – environmental impact of options for making products or performing tasks over the complete lifecycle (Evans and Ross 1998; Keoleian and Menerey 1994)
- **Ecological footprint analysis** – estimate resource consumption and waste assimilation requirements of a defined human population or economy in terms of a corresponding productive land area (Wackernagel 1996, Krotscheck and Narodoslawsky 1996; Krotschek et al. 2000)
- **Threat Identification Model (TIM)** – spatially explicit links between defined hazards and the environment, and land practice options that can address these hazards for specific land units (Smith and McDonald 2000).

The literature covered here represents a broad range of approaches, scales, and levels of detail (and therefore effort, time and expense) in measuring, monitoring and assessing sustainability. Some approaches are relevant for national level reporting of trends (eg Montreal Process criteria and indicators - Anon 1995; Commonwealth of Australia 1998). Other approaches may be relevant to the development of a specific sector of an emerging bioenergy industry – for example, the Oil Mallee Association of WA Inc. (2003) Code of Conduct sets out Best Practice Guidelines for a specific industry sector in a specific region. This is supported by a suite of ongoing research into the hydrological implications of the biomass production systems (eg Wildy 2003) and the nutrient cycling aspects (Tim Grove, CSIRO FFP, pers. comm.).

More intensive integrative approaches (eg Eigenraam et al. 2000; Krotschek et al. 2000) may be appropriate for large scale, high impact or contentious projects or industry sectors. Each of them may be relevant in the assessment of an individual bioenergy project – but the choice depends greatly on the nature and scale of individual projects. This Sustainability Guide – as a scoping study - does not advise or prescribe on the most appropriate approach, although this may be a very useful next step.

3.2 The Australian context: existing forms of assessment

Australia has developed many processes at various scales or levels for dealing with issues of sustainability. These include sustainability criteria and indicators for agriculture and forestry, as well as mature processes for Environmental Impact assessment and Social Impact Assessment for specific projects. Any new evaluation framework or guidelines must take account of existing processes.

3.2.1 Australian Agriculture

The response to ESD in agriculture at the national level in Australia has been to develop a criteria and indicator approach. The Standing Committee on Agriculture and Resource Management (SCARM 1998) describes agricultural sustainability as having the following components:

- Farm productivity is sustained and enhanced over the long term
- Adverse impacts on the natural resource base and associated ecosystems are ameliorated, minimised or avoided
- Residues resulting from the use of chemicals in agriculture are minimised
- The net social benefits from agriculture is maximised
- Farming systems are sufficiently flexible to manage risks associated with the vagaries of climate and markets

3.2.2 Australian Forestry

The international approach to measuring and monitoring sustainability in forestry was developed through the Montreal Process (Anon 1995). The definitions of sustainability are based on a criteria and indicator framework for land-use planning. These were adapted for Australia (Commonwealth of Australia 1998), and underpinned by Comprehensive Regional Assessment of forest values and uses for a region. There are 5 to 8 criteria (or values), and 25 to 75 indicators of progress towards these criteria. These include:

- biological diversity
- productive capacity
- ecosystem health and vitality
- soil and water resources
- global carbon cycles
- socio-economic benefits, and
- an effective legal / institutional framework.

The use of forest production as a source of biomass for bioenergy has received substantial attention internationally (eg Richardson et al. 2002), and the Australian context has been strongly debated (Raison 2002).

3.2.3 Greenpower accreditation schemes

"Greenpower" schemes have had to address the issue of sustainability in their accreditation procedures. The Greenpower Accreditation Scheme (http://www.greenpower.com.au) launched in NSW in 1997 and now recognised nationally.

The accreditation guidelines for Greenpower state that:

> *"whilst concerns may be raised over the long-term sustainability of some biomass resource industries, as long as the biomass is sustainably harvested, results in greenhouse gas reduction, and demonstrates a net environmental benefit, it may be eligible for use under Green Power."*

All submissions seeking Green Power approval for generators must include a Statement of Environmental Effects, to the satisfaction of the Project Manager.

Green Power approved projects must also be consistent with other federal and state government sustainability and environmental objectives, including but not limited to:

- the National Strategy for Ecologically Sustainable Development
- State and Local Government waste management policies
- National Waste Minimisation and Recycling Strategy
- water management objectives and use of tertiary treated waste water
- management of soil contamination issues.

3.2.4 ISO 14001 Environmental Management Systems

The ISO 14000 standards series provide global environmental management exemplars for environmental auditing, environmental performance evaluation and product service planning and development (eg lifecycle analysis) (Joint Technical Committee 1996). ISO 14001 relates to Environmental Management Systems (see http://www.affa.gov.au/content/output.cfm?objectid=595f2527-986c-4259-96b1b593e7977b15). They offer frameworks to manage existing and potential impacts on the environment.

The series engenders a 'plan, act, monitor, review' cycle of adaptive management and can be tailored to:

- define environmental risks
- evaluate the effectiveness of the system to deal with the risks
- develop strategies to improve performance
- establish the framework for ongoing assessment and improvement.

3.2.5 Environmental and Social Impact Assessment

As an example, Victoria's Environmental Effects Act (1978) requires Environmental Effects Statements (EES) that include:

- a description of the proposal and relevant alternatives
- an outline of the various approvals required for the project to proceed
- an outline of public consultation undertaken and issues raised
- a description of the existing environment where it is relevant to the assessment of impacts
- predictions of significant environmental impacts of the proposal and relevant alternatives and their consequences (direct and indirect, short and long term and cumulative, with an estimation of the amount of uncertainly involved)
- where a preferred alternative is nominated, and an outline of the reasons for the choice of that alternative
- a program for minimising, managing and monitoring impacts.

In New South Wales, the Department of Infrastructure, Planning and Natural resources (DIPNR) specifies a number of steps for the proponent to comply with and the State agency to assess.

Typically each institution or jurisdiction customises their environmental impact assessment process to match their particular planning circumstances. However they all relate back to the ESD principles articulated in the national strategy (NSESD 1993). Other examples of guidelines for environmental impacts assessment include:

Roads and Traffic Authority, NSW:
http://www.rta.nsw.gov.au/environment/environmentalplanningmgt/enviroplanning_eia.html

Sydney Water:
http://www.sydneywater.com.au/Publications/PlansStrategies/EnvironmentPlan/EnvironmentPlanSummary.cfm

Queensland Environmental Protection Agency:
http://www.epa.qld.gov.au/environmental_management/planning_and_guidelines/impact_assessment/

Western Australia Environmental Protection Authority:
http://www.epa.wa.gov.au/template.asp?ID=3&area= The National Strategy for Ecologically Sustainable Development (NSESD, 1993) contains two objectives for Environmental Impact Assessment (EIA), they are:

- *to ensure the guiding principles of ESD are incorporated into EIA, with emphasis on clarity of application and process, community access and post approval accountability; and to increase the level of consistency and certainty, and avoid unnecessary duplication, of the EIA process across the nation; and,*

- *to increase the sensitivity of the EIA process, its planning and policy context and consequent decision making, to cumulative and regional impacts.*

This Bioenergy Sustainability Guide provides a framework within which existing processes and methodologies of Environmental Impact Assessment (EIA) and Social Impact Assessment (Taylor et al. 1995; Becker and Vanclay 2003) can be deployed. There are a diverse set of statutory requirements specific to each new project, with specific guidelines to proponents.

EIA&Cat=Referral+of+Proposals

Northern Territory: http://www.lpe.nt.gov.au/enviro/EIAinNT.htm

DEH – EPBC Act: http://www.deh.gov.au/epbc/assessmentsapprovals/assessments/byeis.html

Australian Antarctic Division: http://www.aad.gov.au/default.asp?casid=212

Although the process of Environmental Impact Assessment (EIA) requires the proponent to address some aspects of sustainability, it is associated more with impacts and does not encompass a total systems view – for example, it would not be able to discern the difference between a proposal for a bioenergy conversion facility relying on biomass feedstock from a new sustainable land use from that of one based on an existing unsustainable one.

Similarly, the Social Assessment Process (SIA) offers some valuable approaches and tools but does not encompass the range of aspects required by a full evaluation of sustainability. This Bioenergy Sustainability Guide is very consistent with the framework and methods described by Taylor et al. (1995) – as described in Table 3.2.

Table 3.2 A social assessment process (as proposed by Taylor et al. 1995, table 4.2 p77)

Scoping	Identification of issues, variables to be described/measured, links between biophysical and social variables, likely areas of impact, and study boundaries
Profiling	Overview and analysis of current social context and historical trends
Formulation of alternatives	Examination and comparison of current social context and historical trends
Projection and estimation of effects	Detailed examination of impacts of one or more options against decision criteria
Monitoring, mitigation and management	Collection of information about actual effects, and the application of this information by the different participants in the process to mitigate negative effects and manage change in general
Evaluation	Systematic, retrospective review of the social effects of the change being assessed including the social assessment process that was employed

3.3 What issues does this new framework address, not dealt with by existing impact assessment?

As the above brief review demonstrates, sustainability assessment is a crowded field – but the different approaches have evolved for different purposes and there remains value in thinking through an approach that is useful for the circumstances that bioenergy faces at the present time.

Two different philosophical foundations emerge from this examination of sustainability assessment. On one hand, characterised by EIA-style approaches, the focus is on evaluating the impacts of a particular project proposal – often with a strong bio-physical focus although increasingly recognising social and economic impacts. The "systems view" is often constrained to the localised impacts of the project and broader sustainability assessment and wider systems interactions are not addressed. On the other hand, a broader approach to sustainability assessment can be taken, in which the focus is not only on the 'what' of sustainability but also on the 'how', i.e., how can a dialogue be established around the technical assessment activity that in the end, develops understanding and confidence in the community around the project or industry's overall sustainability? It is this second focus that has shaped our thinking in the preparation of this guide. The overall objective is for the bioenergy industry and individual bioenergy projects to develop (where warranted) a 'licence to operate' from the wider community. Environmental Impact Assessments will be part of this process but need to be set in a wider dialogue around overall sustainability.

4. Bioenergy sustainability guide

4.1 Users and applications for the bioenergy sustainability guide

The evaluation framework presented in this Bioenergy Sustainability Guide has been developed as scoping study, and we see it as one small step in coming to grips with the complex issues that are arise when one views bioenergy development through a sustainability lens. It fits within an overall bioenergy project development framework, such as that developed in the NSW Bioenergy handbook (eg DEUS 2004, Figure 1). The NSW Bioenergy Handbook (DEUS 2004) provided broad discussions of sustainability issues associated with each type of biomass feedstock – and provided ‘statement’ boxes for stakeholders who have diametrically opposed views on the sustainability of particular biomass production systems. The dialogue can be generic to particular categories of biomass source (eg wood from native forests), or very specific to the project. This Sustainability Guide is aimed at assisting planning, consultation and decision making processes and has a strong focus on dialogue between proponents and stakeholders from project inception. The Sustainability Guide is aimed to assist:

- the current land manager (owner / occupier / lessee / custodian etc)
    - at the time that a bioenergy proposal is contemplated
    - to satisfy the legitimate needs, interests and obligations of the consenting community as represented by
        - Local, State and National Government agencies
        - prevailing consent / approval / licensing authorities
        - neighbours (catchment scale)
        - impacted communities
        - relevant NGOs

This notion of ‘consenting community’ encompasses not only the respective interests and concerns of the current generation, but also those of future generations. This collective ‘consideration’ of a proposal is reflected in the term community consent or licence to operate. This ‘Licence to Operate’ is adopted as the goal for any proposal to change current land use.

4.2 Level of assessment of bioenergy proposals

Many decisions will need to be made about the operation that will have an effect on the community and are therefore notifiable and require consent (through the EIA and SIA processes). The granting of a community licence to operate will take a range of forms depending on the size, impact and sensitivity of any particular proposal. For example, a paddock scale land use change may only require notification to a relevant government authority or just avoiding complaints from neighbours or affected parties in the catchment. Farm or landscape land use changes require formal consents and approvals from the relevant authorities (and neighbours etc.). Macro scale land use changes may be initiated by government in pursuit of some new or existing policy objective. In such a situation this guide would provide a reference or dialogue support system. As such, the evaluation framework is designed to be relevant and applicable in the assessment of specific proposals. It could also inform and be adaptable to medium to long term strategic and policy development – so that a coordinated and holistic approach can be achieved.

The sustainability decisions fall into two groups:

- Changes to land use (or management regime) to supply biomass feedstock
- Operation process and pathway for the conversion of the available biomass to energy

Table 4.1 indicates the level of assessment applicable.

Table 4.1 Preliminary Assessment Matrix to determine level of rigour necessary for any particular proposal

	Grade A Significant Land Use Change – detailed response with full scientific rigour	Grade B Notifiable Land Use Change – detailed response with scientific rigour for key factors	Grade C Prudent Site Management / Planning – be able to demonstrate the appropriate level of review has been applied
Small Scale (property / plot / paddock) ▪ Standard management regime			
▪ Incremental departure from existing land use or management regime			
▪ Significant change of land use			
Medium Scale (local catchment) ▪ Standard management regime			
▪ Incremental departure from existing land use or management regime			
▪ Significant change of land use			
Large Scale (regional / catchment) ▪ Standard management regime			
▪ Incremental departure from existing land use or management regime			
▪ Significant change of land use			

4.3 The "community" as the ultimate arbiter?

The "community" can be represented by any or all of the following, depending on the scale and sensitivity of each particular bioenergy project.

i) Local, State and National Governments
At this level, the socio-political impacts of a project can be assessed against clearly articulated policy positions. In the case of National Government, projects could be assessed against international treaty obligations and standards. Overall, economic impacts of a prospective bioenergy project will be of relevance at this government level.

ii) Prevailing consent / approval / licensing authorities
In addition to the socio-political assessment of projects, local, state and national governments will be responsible for the various formal project assessment processes enshrined in legislation and regulation and by laws. Government departments may also administer specialist departments (Departments of Agriculture or Conservation and Land Management etc.) that not only regulate, but also provide advice and extension services to assist broader policy implementation.

iii) Impacted communities
This group may not be in the immediate catchment or air shed but will feel the social and economic impacts (benefits and disbenefits) and be concerned with aesthetic, recreational values in addition to the amenity issues that might flow from a particular proposal.

iv) Neighbours
Any potential bioenergy activity will have neighbours for the production system, biomass harvesting activity, through to the conversion process and perhaps even in the energy reticulation and utilization phases. Such neighbours may be specifically adjoining land holders (paddock scale) or regional at a catchment scale. Neighbours are likely to be the manifestation of "community" most directly affected by such impacts as land, water and air considerations and noise.

v) Relevant NGOs
Environmental, conservation or local business development groups etc may all have specialist agendas that intersect with a proposed land use change to yield biomass and its subsequent conversion to energy for direct use or reticulation.

vi) Future generations
The concept of sustainability requires that current resource use practices consider the interests of future generations. This concept will influence the relationship between all the manifestations of 'community' and many sectors of the community will have special or vested interests when reviewing bioenergy proposals. The principles of sustainability have been adopted as the common currency for determining the ultimate value of particular proposals and balancing self interest if and when it seeks to influence decision making.

To achieve a community licence to operate, a structured program of dialogue and consultation will need to be implemented at all the key stages in a project's development. The approach of consulting 'early and often' throughout a proposal development process can validate the eventual licence to operate to the benefit of both the proponent and the community.

The final form of a Community Licence to Operate may be the statutory consents, approvals and/or licences as issued by the community as (ii) the prevailing / consent / approval / licensing authorities. However, the formal processes should reflect the more general interaction and consultation with the community in all its other guises before such formal approvals are granted. If the statutory authorities issue formal consents that are not acceptable to the local community, the socio-political processes are capable of reversing or amending such formal decisions. Hence, the formal approvals should reflect a genuine granting of a Community Licence to Operate by the affected community in all its forms.

4.4 Outcomes required of a comprehensive project assessment process

This Sustainability Guide for Bioenergy projects should be utilised by:

- the current land manager and those stakeholders with a legitimate interest in land use decisions
- the project proponent or developer for the conversion pathway decisions and those stakeholders with a legitimate interest in such systems and infrastructure proposals.

Optimising bioenergy requires projects to be developed at a very wide range of sizes and intensities. As discussed in section 4.2, assessable projects might range from some minor agro-forestry to provide firewood for the homestead through to global scale forestry management. In order to do this for the broad range of projects, we have developed logic and sequence in decision making that reflects those sequences used by land managers and project developers respectively.

The framework is sufficiently flexible to apply both qualitative and quantitative data and information as the individual circumstances required, and sufficiently robust as to accommodate both extremes, including industrial by-product management. For example, the primary land use might be wood harvesting for papermaking or food processing which produces lignocellulosic waste or by-product streams. These streams may be suitable as bioenergy sources, either directly or after higher value applications of the biomass and its constituent nutrients and minerals.

Ultimately, the process needs to acquire or derive data and information and resolve this information into conclusions and decisions that satisfy the requirements of the evaluating parties. The information and results need to be of a sufficient standard for the community to grant a licence to operate in whatever form that may take for the respective projects and proposals. For contentious or large-scale projects, a high level of scientifically valid and provable information may be required. For a paddock scale, crop rotation decision, a qualitative run through the framework sequence may suffice. Thus, the level of detail required may alter with each application on its merits, but the framework should provide a common logic and sequence for all such decisions. The evaluation framework should support dialogue as the various parties and stakeholders express their concerns and ambitions and a sustainable resolution is developed.

5. The sustainability evaluation framework

The sustainability evaluation framework put forward in this document is a subset of the overall project development framework put forward in the NSW Bioenergy Handbook (DEUS 2004). We propose a ten step process - six steps to confirm that a biomass feedstock is available and sustainably produced, and a further four steps to address the sustainability issues for the conversion of the available biomass and its subsequent utilization as an energy source. These sequential steps are shown in Figure 5.1 and are described in greater detail below.

The evaluation framework should be used in an iterative way. We suggest that a 'first pass' evaluation be undertaken using 'back of the envelope' numbers to get a broad understanding for the scale and magnitude of the production system and impact of any changes, and thus guide the user into selecting a level of assessment which is appropriate for the particular project. The second and subsequent iterations must become more detailed and quantitative – to the level required in the final assessment.

As described in Section 4.1, this evaluation is undertaken in the context of gaining a 'licence to operate' – from both the statutory and community perspectives. The level of detail in the assessment will be determined by what it takes to gain this licence to operate – larger or more contentious projects will require a greater level of detail and accuracy than simple ones. The framework explicitly acknowledges the role of the formal Environmental Impact Assessment or Social Impact Assessment processes – but attempts to put these in the broader context with respect to:

- a systems view of a specific project (on-site and off-site, biomass production system and conversion pathways)
- regional planning perspective for an emerging bioenergy industry
- indication of the sustainability of a production system rather than the impacts – to enable assessment of sustainability of existing land uses for biomass supply (as well as changed land use).

Step 1: Define system boundaries, including production area for biomass, and offsite impacts of production system and conversion processes

This Sustainability Guideline is based on taking a 'systems view' of bioenergy production. The first step in eliciting a view of the system is to define the boundaries of the production system, taking into account the land on which the biomass is growing, as well as the boundaries of where the impacts of the production system may be expressed. For example, the on-site boundary for a production system of sugar cane would comprise the area of land on which it grows, while the off-site boundary might include rivers, estuaries or offshore reefs which are impacted by sediment or other pollutants which run off the production site. Likewise the systems boundaries for a grain based biofuel operation would include the processing facility (e.g. ethanol factory), the grain farms producing the biomass feedstock and potentially the rivers and floodplains receiving salt or nutrient loads, or reduced water flows as a result of the grain-based farming activity.

It is very important to understand key processes which drive (and in turn are driven by) the production system. These should be clearly defined, and the boundaries for each delimited in this step.

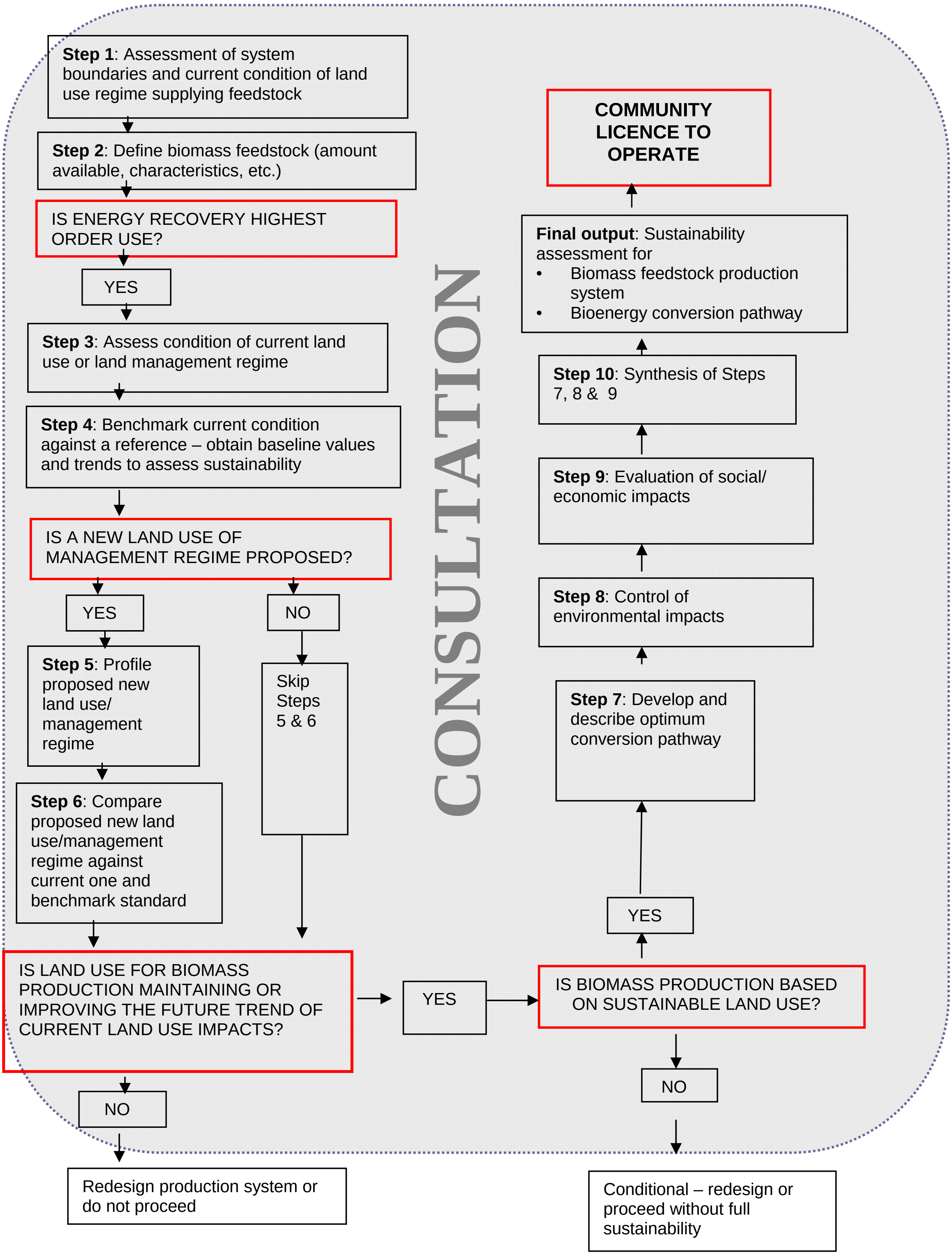


Figure 5.1 Proposed sustainable land use with bioenergy recovery protocol

Step 2: Define the biomass feedstock – amount available, characteristics etc

This step will be a critical early step in developing a bioenergy proposal – it is listed as the first step in the DEUS (2004) project development framework. The step will require a general description of biomass available, the rate of availability by volume by season or special event, and the initial form of the available biomass, i.e:

- particle size
- density
- moisture content
- ash content
- CV (wet and/or bone dry)
- volatile matter
- fixed Carbon
- potential metals or critical contaminants

In addition, the prevailing circumstances such as:

- existing facilities, infrastructure or locally relevant specialisation
- local / regional needs for heat / power
- other apparently available local opportunities / needs

will need to be assessed.

Decision Point: Is energy recovery the highest order use for the biomass which is proposed for feedstock?

This evaluation framework considers bioenergy as a by-product from some other process for which the biomass has a higher order value. The assessment at this decision point will become more detailed with successive iterations. For example, it may not be possible to determine in the first iteration whether the value of retaining the biomass in situ to fulfil ecosystem functions (eg carbon sequestration, nutrient recycling or habitat provision in the case of wood from forests) until Steps 3–6 are completed with some robustness.

If, in the final iterations, the energy value is a lower order value than some other use – or leaving/ returning it in situ - then the bioenergy development cannot be portrayed as a positive development in terms of sustainability. Otherwise proceed to Step 3.

Step 3: Assess current condition of land use regime supplying the biomass feedstock

The current condition of the land used for, or impacted on by the production system must then be characterised at an appropriate scale and level of detail, depending on the level of assessment to be undertaken. (see Appendix A – Indicative Data Collection Summary). Where a block of land (or landscape) is or has been significantly altered or managed for unsustainable levels of yield or productivity, the values assessed will identify the effects of the imposed management regime and in particular identify processes out of balance with the whole or characteristics / values that might be critically close to the system resilience thresholds.

Appropriate methods for detailed assessment may include those taken by 'Landmark' (Eigenraam 2000) or Landscape Function Analysis (Tongway and Hindley 1995, Tongway and Hindley 2003). For example in the case of a bioenergy proposal based on sugar production, this step may consist of using measurement and modelling approaches to check nutrient and/or sediment balances, while in mallee farming the emphasis may be on modelling the water balance to predict the impacts of continuing this land use on deep drainage and salinity. In bioenergy proposals based on forestry operations, the current land use investigations may focus on water and sediment yields from the forested landscape and the impact of the forest management regime on biodiversity values.

The basic information to underpin this step will be used in combination with Steps 4 – 6 to obtain the community licence to proceed. In final iterations, the quality of the data needs to be sufficiently robust to convince the relevant third party, or peer review group of the validity of the sustainability assessment.

Step 4: Benchmark current condition against a reference - obtain baseline values and trends to assess sustainability

The status of a particular land resource needs to be benchmarked or compared against some point of reference, which will differ according to the circumstances. The methods selected to benchmark will depend on the production system, scale, and the level of assessment required. For instance, a wheatbelt farm may be draining water and salts at a certain rate in response to current management practice. The significance of this rate of drainage can only be assessed relative to the reference point of the long-term equilibrium rates of water and salt drainage under natural vegetation. If wheat farming has shifted this water balance relative to what existed under natural conditions, then the likelihood is rising water tables and dryland salinisation will result at some point in time and space.

This comparison of existing conditions against benchmark conditions should provide the basis to identify factors or processes which may be bringing ecosystem functions (on-site or off-site) close to threshold changes which may cause ecosystem functions to collapse, and may be irreversible.

The 'current condition' of the land use or management regime determined in the previous step must be used in this step to predict the future trend of continued application of the land use regime over the life of the bioenergy project. So, for example, in the case of standard crop rotations in the wheatbelt, some assessment must be made of the future impact on water tables, salinity, soil acidity and health if the land were to be managed in the same way, say for the next 50 - 100 years. Particular attention must be paid to the future trend of those processes which would bring the production system close to threshold changes – for example in the above example, if the production system was located on a low lying, flat landscape where there was uniform rise of saline groundwater, there would be a sudden threshold change across the whole area when the groundwater reached 2 m of the land-surface.

This information will provide the basis for the 'maintain or improve future trend' criterion required for a proposal to proceed through this framework.

This step will also identify any remedial activities or proactive programs that may be necessary to support the assumption that 'maintain or improve' outcomes will be sufficient to diagnose systems failure. The difference between the prevailing values for certain critical sustainability criteria and the benchmarked values does not necessarily provide a simple or directly actionable result. Natural systems, such as the complex and dynamic processes in soil or in the vegetative cover above or in the landscape or catchment depend on an amount of change or disruption to be able to evolve properties of persistence, adaptiveness and variability.

The change from original, undisturbed conditions is not in itself 'unsustainable' and can actually stimulate valuable evolution processes. However land managers in Australia over the last 200 years have not fully understood the natural system dynamics that they were changing. They have often presumed a level of ecological resilience that was not available. This has often led to demands being placed on the natural systems and cycles that cannot be supported and resulted in significant trends towards system degradation and decline. This evaluation framework strives to ensure that these factors are better understood.

Decision point: Is a new land use or management regime proposed?

Some bioenergy proposals will be based on existing land uses and management regimes (eg co-firing bagasse in the sugar production system), while others will be based on new land uses (eg mallee belt-farming, or plantation block-planting in wheatbelt areas) or management regimes (eg removing thinnings or dead wood from a forest). If significant changes to the land use or management regime are proposed, Steps 5 and 6 must be followed. If the proposed land use is based on an existing one, without significant changes to the management regime, then Steps 5 and 6 should be skipped.

Step 5: Profile proposed new land use or management regime

Land use changes have in the past usually been proposed and sanctioned based on intuition, prevailing market forces or a desire to try something new and see how it turns out. Seldom have such changes been accompanied by objective information or good science. This is especially true of the smaller or incremental changes. Apparently minor changes can be quite sustainable and even stimulating of ecological resilience and evolutionary development. They can also generate dramatic or depletionary effects in aggregate when many such choices are made simultaneously.

This step requires the current land manager to demonstrate a comprehensive understanding of both the direct and offsite effects of the proposed change. A proposed change in land use or management regime will lead to different physical, chemical and biological cycles and impacts – which may be beneficial, neutral or degrading. Similar methods to those used in Step 3 (Assessing condition of land use regime supplying the biomass feedstock) must be applied in this step.

These investigations must extend to the full systems boundaries, as defined under Step 1. In some cases the implications of a land use or management change will be far reaching and challenging to track throughout the system (in space and time). Take for instance the introduction of bioenergy project based on forestry operations to what was previously pasture land:

- The additional water use of these trees may reduce salinisation in some parts of the downstream catchment,
- but also reduce freshwater flows in the river systems.
- These reduced freshwater flows may damage floodplain vegetation and interfere with the breeding activity of threatened bird species.
- The higher salt loads in the urban water supplies lead to the need for investment in desalinisation plants, based on fossil fuels.
- The additional fossil fuels generate more greenhouse emissions than were saved by the bioenergy project in the first place.

An analysis that stopped at the boundary of the bioenergy factory and the land used for the forestry operation (such as might be typical in an EIS) would miss the real impact of this proposal on the wider environment.

Step 6: Compare proposed new land use or management regime against current one and benchmark standard

As for Step 4, this step aims to identify the following with respect to the proposed change in land use or management regime.

Some priority might be given to any critical values or issues that were identified in Step 3 (eg. salinity, erosion / run off, biodiversity) which may need direct and immediate attention - rather than the incremental effects that might be planned to occur over a medium to longer term time frame. Certain tradeoffs or balancing of benefits and disbenefits may be required to fully satisfy this step, which will be acceptable as long as no individual value threatens to fall below a critical resilience value either individually or as an accumulated effect (ie in aggregate).

This step presents an important milestone for an evaluation of the 'maintain or improve future trend'' criterion. After the effects of the proposed new land use have been evaluated and the primary yields or deliverables accounted for in terms of system sustainability, the decision to yield additional biomass for energy recovery rather than reapplied as sequestered Carbon will be a crucial determinant of whether to proceed or not.

The new proposed land use must be placed in a broader planning context – for example, the first hectare of 100 000 of native vegetation has a different value to the last remaining hectare.

This step may never be an exact science or absolute process or methodology for establishing determined values, but the concept of this Sustainability Guide and the broader land use evaluation framework seeks to place the responsibility for assessing these issues on the party currently advocating a significant change.

Decision point: Is land use for biomass production maintaining or improving future trend of current land use or management regime?

The synthesis of Steps 3 &4 to assess current land use / regime against benchmark standard (or Steps 5 and 6 to assess impact of a new land use or management regime) will show whether the proposal is able to meet the MINIMUM standard of this Guideline – which is to maintain or improve the future trend of existing land use impacts. If this criterion is not met, the production system must be redesigned in order to meet it – if not, then it is not valid to claim that the project will make a contribution to sustainability.

Decision point: Is biomass production based on sustainable land use or management regime?

A biomass production system can meet the minimum criterion of maintaining or improving the future trend of current land use impacts, without actually being sustainable. For example, it may be that strip planting oil mallees in a current wheatbelt farming situation in south-west WA may change the terms of the water balance sufficiently to improve the predicted trajectory of water table rise / salinity, which would occur without introduction of deep-rooted perennials. However, it may still not be sufficient to arrest the further development of salinity and therefore does not fully meet the sustainability criterion. In some cases – such as the mallee example where off-site impacts constitute a major part of the overall sustainability - there will be a strong link between the scale of a land use regime and the overall sustainability. In other words, planting oil mallee in wheat fields on one farm in the WA wheat belt might meet the criterion "maintaining or improving the future trend of current land use impacts", but fail the wider sustainability assessment because of landscape scale changes in water tables.

If the proposal is able to meet the previous Decision Point criterion ('maintain or improve the future trend' of current land use / management regime), but does not meet full sustainability criteria, then the options are to:

- redesign the production system to improve sustainability credentials
- proceed with Conditions attached (provided in consultation through License to Operate).

The second part of the Sustainability Evaluation framework (Steps 7 – 10) deals with the conversion pathways from biomass to energy and the overall social / economic impacts of the development. In many ways this is a simpler process, because the system boundaries are easier to determine and (unlike the biomass production systems) control at the point of operation.

It is important to note that the systems boundaries in this section of the framework will generally include both the bioenergy conversion process (i.e. the conversion from biomass to some transformed energy source such as ethanol, renewable electricity etc) and the bioenergy utilization process (i.e., the combustion of biofuels in motor vehicles or the distribution and use of renewable electricity in the grid). The full circumstances associated with bioenergy utilization need to be considered in the analysis of sustainability impacts. Life Cycle Analysis is the standard approach to this type of assessment problem and well established protocols are in place for definition of systems boundaries.

Step 7: Develop and describe the optimum conversion pathway

This step assumes that the available biomass has been produced as a sustainable yield from the land, and has been accurately defined. The development of the optimum conversion process may first involve identifying other potential sources of biomass (which should also be confirmed as sustainable yields and be accurately described through Steps 1 – 6). The evaluation of other sources will inform the potential scale of the emerging project and describe the logistical challenges in aggregating the most cost effective volume of biomass for conversion.

Aggregation of biomass to a central point (perhaps adjacent to a use for the primary or secondary heat evolved) will also scope and define the transmission costs and issues in the event that power is to be generated that could be surplus to a defined local end use.

The rate of availability of the biomass source, (and seasonal factors) when matched to the potential heat and power application, will identify and scope the need and quantum for any supplementary fuel source to underpin the viability of the emerging project.

With the potential biomass identified by type, volume, rate of availability and the alternative fuel source selected, the conversion technology can be selected to meet the established challenge. This may be a stand alone facility or an alternative or co-firing application to an existing facility, or it may be a new conversion plant or capability. Co-firing applications can provide a cost effective response to the alternative or standby fuel source issues, but this may be offset by conversion inefficiencies or geographical compromises in systems development.

The selection of a proposed conversion technology will inform and scope the resultant issues of ash management, materials handling systems, water issues, cooling systems and greenhouse gas emissions for more detailed analysis in Step 8.

Key issues to be considered in this step will generally revolve around full life cycle impacts on greenhouse gas emissions and atmospheric emissions (air pollution). In some cases important land and water contamination issues will need to be examined.

Step 8: Evaluation and control of environmental impacts

This step aims to relate the anticipated environmental impacts of a proposal to the acceptable values in any particular locale and demonstrate that, if approved, the levels of assurance required can be delivered with confidence for the life of the project.

Environmental impacts of a proposed change in land use in general and the recovery of bioenergy in particular can include such issues as:

- pollution to land, air and water (including greenhouse gases, particulate matter and other contaminants)
- noise
- loss of amenity.

These effects can be generated by harvesting processes, traffic, plant and machinery including emissions to land, air and water and utilization of the heat and/or power generated. Each locale will have and express a tolerance of such environmental impacts by:

- reference to the values contained in any prevailing legislating, regulation or by-law
- the informed but subjective values allocated to such environmental impacts by the local community.

This latter category will be significantly informed by such issues as consideration of loss of amenity or aesthetics or employment and commercial outcomes. Since the ultimate goal of this bioenergy project sustainability assessment tool is to acquire a ”community licence to operate”, the resolution of these issues is crucial. The defined EIA and SIA processes relevant to the locality will be used (see section 3.2.5).

Step 9: Evaluation of social / economic impacts

The objective of this step (9) is to demonstrate that the social and economic impacts:

- have been adequately described and quantified
- are acceptable to the community
- can be controlled or delivered in substantially the form described for the life of the project.

The establishment of a bioenergy project in any particular locality will have a range of social/ economic impacts. Such impacts can be both positive and negative and could be manifested in assessed values for:

- employment / training issues
- OH&S issues
- local amenity and aesthetics
- commercial effects, locally, regionally, globally
- delivery of genuinely sustainable outcomes
- environmental impacts (see Step 8)
- offsets and balances or provision of community infrastructure.

Many of these issues and impacts will be weighted differently in different locations and circumstances and depend on site availability and selection. Different views or perspectives can arise from local, regional and larger scale community interests. For example, a remote rural application may value the employment and commercial benefits more highly but consider impacts of traffic and amenity more negatively. The measurement of net environmental impacts will also be a direct result of considering the totality of the effects within the context of the receiving environment. The objective of this step (8) is to ensure that a bioenergy project can be scoped and delivered such that the social / economic impacts (positive and negative) will remain within the range agreed for the duration of the project.

The establishment of acceptable values and outcomes for the full range of social and economic outcomes will be directly related to the quality and veracity of the community consultation program implemented to satisfy this step (9). The social issues and impacts can be the most subjective or difficult to define or satisfy and yet they may be the very issues that most materially affect the granting of the community licence to operate. For this reason, proactive, informed and sensitive consultation is recommended to ensure the greatest level of common understanding before decisions are made (Taylor et al. 1995).

Step 10: Synthesis of steps 7 to 9

The synthesis of steps 7 to 9 aims to derive a balanced, final analysis of the biomass production systems through the energy conversion pathway which will confirm that it has been optimised, to ensure that:

- the proposed environmental, social and economic impacts and outcomes are acceptable to the fully informed community
- the resultant net energy balance from the project demonstrates a positive net outcome in preference to the default option established at Milestone 1.

The ultimate success criteria adopted for this ten step, two stage sustainability assessment is the achievement of a community licence to operate. In the event that the proposal fails to meet acceptable financial hurdles, the project will need to be modified or withdrawn. But whatever the financial outcomes, the failure to achieve a community licence to operate will prevent the proposal from proceeding.

The delivery on the environmental outcomes (Step 8) and the social / economic impacts (Step 9) will significantly inform the design of the proposed bioenergy conversion pathway (Step 7) and vice versa. Hence the need for an iterative synthesis process. An outcome of this step should be to confirm that the ‘maintain or improve’ sustainability criteria will be achieved.

The key steps that may be revisited in this iterative synthesis step are based first on the results of Steps 1 - 6. This confirmed that a defined yield of biomass was available from a particular biomass production system. The iterations inherent in Steps 8 and 9 should have established the optimum conversion pathway (Step 7) which in turn can then establish the net benefits, disbenefits and necessary compromised to support this step 10 evaluation.

Final proposal evaluation

At this point the net environmental, social and economic impacts can be assessed to determine if a consent to operate might reasonably be provided by the community. Such an evaluation will be able to confirm that:

- the ‘maintain or improve future trend of current land use’ values can be substantiated – on balance
- the exact nature of the balancing issues will have been transparently assessed
- any conditions of such an approval will have been transparently and systematically developed
- a short, medium and long term management plan will have been systematically scoped and developed
- if a formal consent / approval process is required, the preparation involved to this point will provide a solid foundation of research and assessment to support such statutory applications
- the key sustainability topics of land and water use, biodiversity, air quality, social impacts and the greenhouse impacts will be objectively assessable across the range of data and information collected during the preceding 9-step process.

6. Bioenergy project assessment checklist

This section seeks to provide the detailed framework for the completion of each step of the 10-step/2-stage proposal evaluation process. The provision of the assessment sheets, with the set of focus questions, are intended to provide a transparent and consistent pathway through the sustainability assessment process.

6.1 Assessment Matrix

- *A **yes** response would support the continued development of the project to the next step.*
- *A **no** response would suggest that a further review of the proposed assurance mechanisms was required or that the proposal should proceed no further.*
- *A **provisional** response would indicate that positive responses to previous or future criteria would be required to provide the level of confidence necessary in a formal consent or approval process.*

Complete each section and assess answers / review before progressing to the next stage

Table 6.1: Qualitative assessment matrix

	Assessment		
	Yes or not applicable (N/A)	**No**	**Provisional**
	Proceed to next step	Reassess	Reassess
Step 1 – Assessment of systems boundaries for bioenergy project			
Has the boundaries for the biomass production system been adequately described, including off-site impact boundaries?			
Have the boundaries for the biomass to bioenergy conversion system been adequately described?			
Have the systems boundaries to the bioenergy utilization process been appropriately defined?			
	Proceed to next step	Reassess	Reassess
Step 2 – Define biomass feedstock			
Has the potentially available biomass been adequately described?			
Have the prevailing circumstances been adequately described?			

	Assessment		
	Yes or not applicable (N/A)	**No**	**Provisional**
Is energy supply the highest order use for the available biomass?			
	Proceed to next step	Reassess	Reassess
Step 3 – Assess condition of current land use or land management regime			
Have the **fixed conditions** (e.g., Appendix A1.0) been accurately described to establish the boundary limits and site circumstances?			
Have the **variable conditions / factors** been accurately described?			
Have the **interactive and collateral issues** been adequately described?			
Has sufficient information and argument been provided to accurately profile the existing land quality as the basis for determining future plans and actions?			
	Proceed to next step	Reassess	Reassess
Step 4 Benchmark current condition against a point of reference			
Have the original, benchmark conditions been adequately established to indicate trends or the relative sustainability of existing conditions?			
	Proceed to next step	Reassess	Reassess
Step 5 Profile new land use and/or management regime			
Has the proposed new land use been sufficiently defined, evaluated and described as to allow detailed assessment of impacts and a balance of benefits and disbenefits and thus the net sustainability of the proposal?			
Will the proposed new land use (and the full implementation of the integral management plan) address all or any of the critical values identified for attention in Step 3?			
Will the proposed new land use observe the adopted ‘maintain or improve future trend’ criterion?			
	Proceed to next step	Reassess	Reassess

	Assessment		
	Yes or not applicable (N/A)	**No**	**Provisional**
Step 6 Compare proposed land use / management against current and reference			
Is the land use and/or management proposed likely to lead to maintenance or improvement in the environmental impacts arising?			
Has the proposal as presented confirmed that a sustainable yield of biomass is available for consideration for conversion to energy?			
	Proceed to next step	Reassess	Reassess
Step 7 Optimal biomass to bioenergy conversion pathway			
Has the biomass conversion pathway scenario been developed with sufficient vigour and transparency as to give third parties confidence in: The efficiency of the energy recovery? The definition of the resultant impacts as basis for determination of their acceptability and sustainability?			
	Proceed to next step	Reassess	Reassess
Step 8 Evaluation and control of environmental impacts			
Have the projected impacts, such as emissions, residuals management or amenity, been scoped and minimised and evaluated with reference to local standards such that, on balance, they are acceptable in the local, regional or national circumstances?			
Has a sufficient level of control and assurance been demonstrated to ensure that the negotiated values will be the maximum for the duration of the project?			
In light of the quality of the information provided can a position be sustained that control of the potential environmental impacts will be sustained for the duration of the project?			
	Proceed to next step	Reassess	Reassess

	Assessment		
	Yes or not applicable (N/A)	**No**	**Provisional**
Step 9 Evaluation of social and economic impacts			
Have the social and economic benefits and impacts been adequately identified and determined?			
Is there reliable evidence that such benefits and impacts are acceptable to the determining community?			
In light of the quality of the information provided, can a position be sustained that the proposed social and economic factors are acceptable to the local community and can be maintained for the life of the project?			
	Proceed to next step	Reassess	Reassess
Step 10 Synthesis and overall assessment			
Is the project viable as presented without threatening the sustainability values incorporated to define the proposal?			
	Proceed	Reassess	Reassess

At this point a project that has successfully progressed to this stage would be ready to complete a formal EIA / EIS or DA approval process which could be undertaken with some confidence as to the chances of ultimate success.

7. Concluding comments

This Bioenergy Sustainability Guide was written as a scoping study for the Joint Venture Agroforestry Program. Our initial work on methods for a quantitative, integrated 'criteria and indicators' approach was workshopped with Bioenergy Australia in March 2003. This workshop was built around a multi-criteria assessment diagram (Appendix B) that was an attempt to integrate a series of very different sustainability dimensions. A key conclusion from this workshop was that no simple "specification" was going to be possible on what was a sustainable bioenergy activity and what was not. The diversity of activity under the bioenergy banner and the diversity of understanding and values within the audience for this work was too great to establish a foundation for moving forward based on a rigid assessment framework. Hence our approach was to shift the focus to the "journey" rather than focus on the endpoint. Hence this guide is about shaping our thinking in pursuit of sustainability in bioenergy development.

Glover's (2004) Sustainability Guide to Energy from Waste was under development when work on this Sustainability Guide began. The Energy from Waste project was much larger than the current one, and included 25 industry workshops around Australia (with a value of over half a million dollars) to get industry discussion and sign-on. Recovering energy from waste represents a subset of the activities covered in this Bioenergy Sustainability Guideline, and collaboration between the authors enabled a broadening of the approach to cover the full gamut of potential bioenergy projects. This Guideline now requires informed application and constructive discussion of the framework proposed here by members of the Bioenergy industry.

We recommend that Bioenergy Australia provide the forum for further discussion and next steps of development of the Bioenergy Sustainability Guide. However the industry must first have some time to test the ideas put forward here and agree if this is the most appropriate direction and scope of the framework, before further development goes forward.

It may desirable to aim towards a web-based collection of technical 'tools' (approaches, methods, frameworks, expert systems, databases) for use in evaluating sustainability of bioenergy at national, regional and project scales - for example

- Green Chemistry – promotion of innovative chemical technologies that reduce or eliminate the use or generation of hazardous substances in the design, manufacture, and use of chemical products http://www.epa.gov/greenchemistry/
- Design for Environment (DfE) is the systematic integration of environmental considerations into product and process http://dfe-sce.nrc-cnrc.gc.ca/home_e.html

Australia has been forward thinking in establishing the online Bioenergy Atlas (Bugg et al. 2002) (www.brs.gov.au/bioenergy_atlas) and Biomass database. An assessment of the data, systems and tools required to inform and promote better investment decision making for the industry overall is needed. This should feed into a long term work plan that is undertaken collaboratively between all of the potential contributors to share information and provide for more efficient use of the limited resources. This Bioenergy Sustainability Guide could form the basis for such a toolkit.

We hope that this Guide is tested and used, further enhanced and constructively discussed by the bioenergy industry as we move towards a fully developed sustainable industry.

Appendix A

Note: this Appendix is not a prescriptive method for data collection. As described in the text, the method will vary according to the level and scale of land use change, and therefore the assessment level required and methods applied. Please use only as a broad example of the sorts of data sheets, which may be developed in the early iterations of a bioenergy development proposal.

<table>
<tr><td colspan="4">Step 1 – Define system boundaries, including production area for biomass and offsite impacts of production system</td></tr>
<tr><td colspan="4">Brief description of anticipated land use change to establish rigour and detail required in subsequent responses:</td></tr>
<tr><td>Preliminary Assessment Matrix to determine level of rigour necessary for any particular proposal</td><td>Grade A Significant Land Use Change – detailed response with full scientific rigour</td><td>Grade B Notifiable Land Use Change – detailed response with scientific rigour for key factors</td><td>Grade C Prudent Site Management / Planning – be able to demonstrate the appropriate level of review has been applied to all factors</td></tr>
<tr><td>Small Scale (property / plot / paddock)
▪ Standard management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Incremental departure from existing land use or management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Significant change of land use</td><td></td><td></td><td></td></tr>
<tr><td>Medium Scale (local catchment)
▪ Standard management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Incremental departure from existingland use or management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Significant change of land use</td><td></td><td></td><td></td></tr>
<tr><td>Large Scale (regional / total catchment)
▪ Standard management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Incremental departure from existing land use or management regime</td><td></td><td></td><td></td></tr>
<tr><td>▪ Significant change of land use</td><td></td><td></td><td></td></tr>
</table>

(Indicative) Data Collection Summary
A1.0 Current Land Use or Management Regime Clearly specify land use and management regime
A1.1 Location

A1.1.1 Longitude…………	A1.1.2 Latitude………..	A1.1.3 Altitude………..	A1.1.4 DP……………..
A1.1.5 (shown on map)	A1.1.6 Area…………ha	A1.1.7 Ownership Details………………………….	
A1.1.8 Geology	General for plot with special features		

A1.2 Climate		
A1.2.1 Type	(Cool Temperate)	
A1.2.2 Temp	Max / Min / frost Hrs sunlight / UV index	By month / season
A1.2.3 Rainfall	Max / Min / Av.	By month / season
A1.2.4 Humidity	Wet / dry bulk	By month
A1.2.5 Wind rose	Direction / velocity	By month / season
A1.2.6 Ambient air quality	Dust / smog etc.	By month / season
A1.3 Vegetative cover	Type / description / history / key features	

A2.0 Variable Conditions

Soil Quality	**Assessment/ Test Method**	**Unit of Measure**	**Value**
A2.1 Physical Structure – depth / layers / density / particle distribution			
A2.2 Chemical Profile – pH / NPK-Eutruphication / EC / metals- minerals profile / sodicity / drainage – permeability profile / organic matter – C etc.			
A2.3 Biological Profile – vegetative cover / flora / fauna /microbial profile			

Soil Quality	**Assessment/ Test Method**	**Unit of Measure**	**Value**
A3.0 Interactive Systems or Collateral Issues			

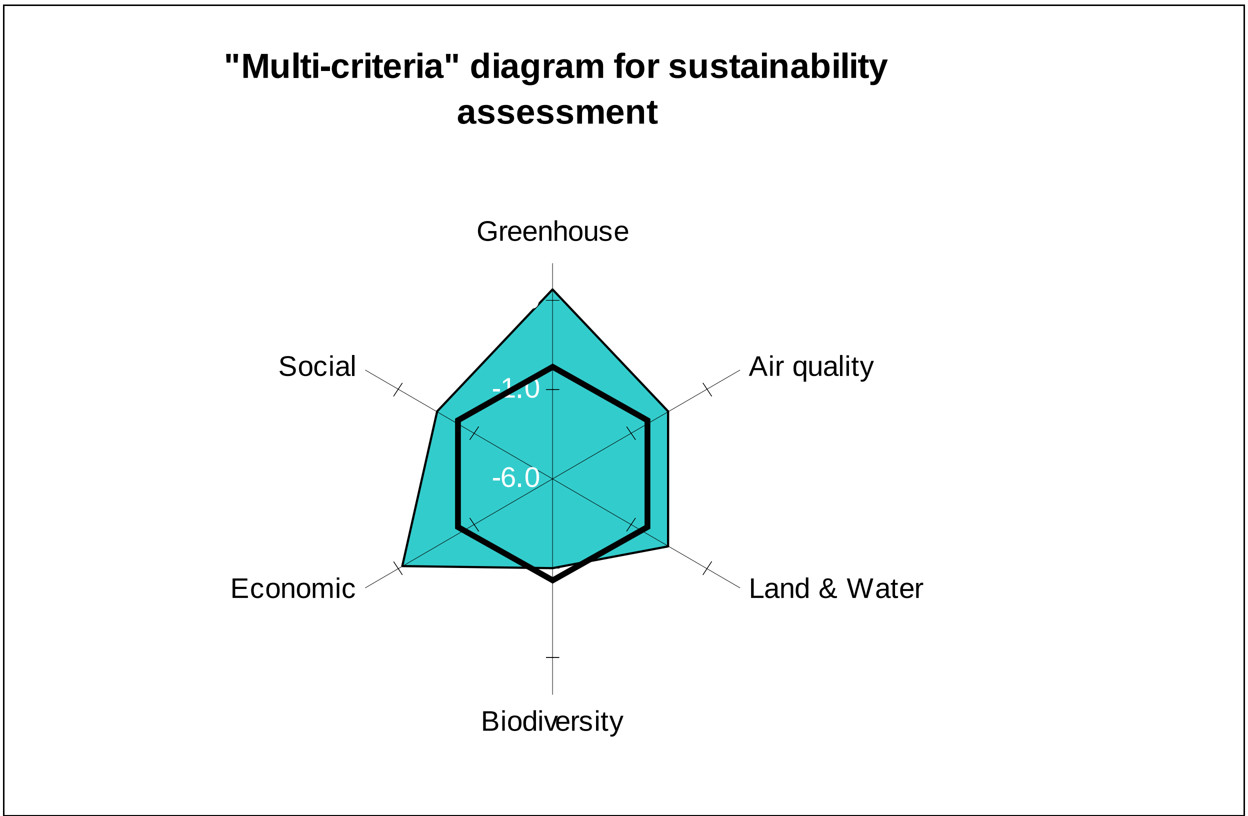
A3.1 Water Cycle Issues
 	
A3.1.1 Quality
- Surface
- Subsoil
- Aquifer
A3.1.2 Flow
- Absorption
- Retention
- Transpiration
- Run off
    - Surfaces
    - Subsoil
    - Aquifer			

A3.2 Mineral and Nutrient Cycles - *NPK* - *Trace minerals / metals* - *Carbon / Humus*			
A3.3 Resource / Mineral / Metals Utilization / Extraction			
A3.4 Top Soil (re)generation			
A3.5 Biodiversity Profile - *Macro* - *Micro*			
A3.6 Pest / Disease Control			
A3.7 Social / Aesthetic Values			
A3.8 Economic Profile - *Income – on site $/ha* - *Yields – off site $/ha* - *Primary – t/ha* - *Embedded – t/ha* - *Biomass yield - $/ha* - *Direct employment* - *Related activity*			
A 4.0 Identify key processes (from A1.0 – A3.8) which support production, or have off-site impact (eg sedimentation, water movement, fauna mobility restrictions) On-site boundary of production processes Off-site boundaries for impact processes	Show areas on maps, within numeric models etc.		

Land managers should feel free to append all the detailed information, data or reasoning that they seek to rely on to support the values they suggest for each box in this format.

Appendix B

B.1. Multi-criteria framework used in early scoping of the bioenergy sustainability framework



Explanation of the diagram:

- each criterion is plotted on a common rating scale on the six axes of the diagram
- heavy solid line represents "baseline" without bioenergy project
- light shaded area represents assessed impact (positive of negative) of bioenergy project on sustainability criteria.

B.2. Explanation of the six sustainability criteria

Criterion 1. Greenhouse gas balance
To what extent are greenhouse gas emissions reduced over the full energy production and consumption lifecycle, relative to a representative mix of current sources of energy? Are there circumstances whereby net greenhouse emissions could actually be increased by the bioenergy activity?

Criterion 2. Air Quality impacts
What impact will the consumption of the bioenergy source have on air quality in towns and cities? Will there be increased or reduced levels of any atmospheric contaminants arising from energy storage, distribution and consumption?

Criterion 3. Land and water impacts
Does the biomass production activity threaten to degrade soil and water resources, impact negatively with water flows for environmental or other production or consumption needs? Are fresh and marine

waters likely to be polluted by nutrients and agro-chemicals employed in the biomass production or waste management activities. Are there any positive land and water implications, such as reduced waterlogging and dryland salinity associated with the biomass production activity?

Criterion 4. Biodiversity impacts

Does the bioenergy activity require new clearing of native vegetation? Are there any negative impacts likely on native fauna and flora associated with biomass harvesting from managed native forests or plantation forests? Are there any biodiversity benefits likely as a result of a reduced threat to native vegetation (e.g. in the case of minimization of dryland salinity) or improved habitat values in agricultural landscapes (e.g. enhanced vegetation structure or connectivity)?

Criterion 5. Economic consequences

Will the bioenergy activity result in a net decrease or increase in rural/region incomes and employment? Will there be large hidden cost implications for regional economies such as degradation of transport infrastructure? Will other industry's economic performance be enhanced or degraded? Will the activity require taxpayer support and what are the net benefits for regional and national economies?

Criterion 6. Social implications

Will landscape amenity values for the local community change? Will quality of life be influenced through changed heavy traffic, noise and dust etc? Will community function be enhanced by new or different employment opportunities? What implications or opportunities are there for indigenous communities?

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