2xEP – The Next Wave

A Project to Unlock Energy Productivity Innovation

1. Purpose of Next Wave Project

A2EP – the Australian Alliance for Energy Productivity (which recently changed its name from A2SE) has been working for 3 years to progress an agenda for doubling Australia's energy productivity by 2030 (from 2010 base). In recent times it has been developing roadmaps for doubling productivity in each end use sector of the Australian economy. Please see the 2xEP.org.au website for more information.

Energy productivity (EP) refers to the value created from using a unit of energy. Our target can be achieved either by doubling the value created from using the existing amount of energy or halving the energy use – or more likely some intermediate position of greater value and lower energy use. It is important to understand that EP innovation also has these two aspects – we are looking at technologies that facilitate both improved value adding as well as reducing energy use – and ideally both.

The 2xEP program is now looking to develop a strong understanding of the opportunities for emerging technologies and new business models they facilitate, to substantially improve energy productivity beyond the impact of current best practices that have been implemented in Australia. This may include measures that are commercial, but have very low market penetration at present. Activities that may be considered part of 'incremental change', are already achieving significant increases in adoption (and are covered by sector EP 'roadmaps'), or are likely to be pursued for reasons other than energy productivity improvement will be noted, but will not be pursued.

The innovation project is seeking to understand and catalyse technology/business model innovation to drive a doubling or better of EP by 2030 by:

a. Building an EP innovation inventory. This will involve a scan of literature and research to identify relevant opportunities. Those meeting the above criteria will be documented, and relevant information sources will be referenced. This phase of the project is funded by three State governments.

b. Modeling the evolution of the economics of game-changing EP innovations as they evolve technically, capture economies of scale, and their value proposition becomes attractive relative to the incumbent technologies and models. The aim of this work is to define the likely penetration and their expected impact on EP of the emerging models by 2030. We are yet to secure funding for this stage of the work and beyond.

c. Determining how we could accelerate Australian EP innovation by addressing barriers and managing risks to their implementation, and by capitalising on opportunities in niche markets. We plan to recommend policy initiatives and conduct pilot activities to accelerate uptake of energy productive technology and business models in Australia to ensure achievement of 2xEP or better by 2030. This work is also subject to securing funding.

2. Why the Next Wave is needed now

The work done on our sectoral 2xEP roadmaps has identified likely gaps between the expected improvements in energy productivity and the 2xEP target by 2030. There is every expectation that these will be covered by new technology development and deployment. So this work on the innovation roadmap is critical to provide clarity about the key new technology opportunities for energy productivity improvement by 2030.

There are additional reasons why this work is critical at this juncture:

- Address uncertainty in government about planning issues and risks involved with technological transformation. There is still poor understanding of the likely impact of these new technologies, including the commercial impact on government owned assets (such as electricity infrastructure) as well as on planning.
- The Commonwealth's 2017 climate policy review will need to come to an understanding of technologies that could improve EP and cut emissions to 2030, and how to accelerate their deployment.
- The Prime Minister's Innovation Statement speaks to economic opportunities from innovation, and it needs to include an understanding of the opportunities for EP innovation and funding requirements. The PM's 'Mission Innovation' commitment to doubling clean energy R&D investment will need to be supported by information on EP innovation, as will the government's commitment to the expansion of ARENA's mandate to include energy efficiency/productivity, providing it receives funding support from the Commonwealth.
- The Paris accord outcome will unleash a wave of innovation in EP/low carbon technologies at rate and scale never seen before. And it is important for Australia to capture its share of these opportunities.

3. Scope

The Next Wave project scope will examine:

- Improved technologies and processes to do current tasks/deliver services, with higher EP. This includes accelerated transfer of existing international best practices, not utilised in Australia.
- Systems optimisation including supply chain optimisation.
- Big data and the "internet of things" - innovations in ICT to better measure, control/ automate and optimise energy use.
- Game changing combinations of new technologies (1-3 above) and new business models that deliver required end use services in a different way, with a step change improvement in EP.

The focus will be on technologies that can have an impact by 2030, with an emphasis on commercialisation and technology transfer.

What's out of scope?

- Utility energy supply. On-site renewables and other energy generation is in scope
- Energy savings using current commercial technology and practices unless there is less than 10% penetration in the Australian market in this specific application, and a slow rate of market uptake.
- There may be some examination of technology at the early research stage, limited to technologies with substantial opportunity for EP improvement, which utilise Australian IP and are applied in industries where Australia has a competitive advantage.

4. Methodology proposed - Basic principles

We reviewed a range of approaches to identify the key energy productivity opportunities in the economy: a sectoral approach; a review by process; and a value chain approach. We have decided on a combined approach, based on analysis of value chains.

The reason for basing this work on value chains EP benefits can be maximised by starting with an examination of the end service required, and working back through the chain to the sources of raw inputs. This approach can provide an overview of the energy and material flows throughout the process of delivery of the end service, which offers insights into ways to optimise these flows, as well as new business models that may fundamentally alter the way the end service is achieved and the relationships between the elements of the value chain.

Steps in our methodology

1. Examine the overall value chain, starting from the user end.
    a. Determine which steps in the value chain have the greatest energy usage, losses and EP opportunities;
    b. Examine opportunities to optimise the service delivery chain by integrating across the chain, focusing on common processes and end needs that touch on multiple steps of the chain, e.g. refrigeration/food preservation, cooking, dewatering/weight reduction in the food supply chain; and
    c. Examine new business models that could disrupt the existing supply chain and deliver major EP benefits.
2. Study in detail each of the large energy using blocks in the chain, and scan for innovative technologies. This includes process changes, energy savings technologies, and innovative investments designed to improve overall productivity through an energy focus.

Most innovation will be achieved by integrating combinations of technologies - for example ICT/sensors and smart controls with a reluctance motor/drive (or induction motor and VSD) driving a high efficiency pump or fan with low pressure drop filters and pipes/ducts. Integration can also occur through combining low cost and reliable sensors and controls with cloud based computing, facilitating improved fault identification and preventive maintenance, monitoring and process optimisation. ICT also can facilitate optimisation along a supply chain and via the 'sharing economy'. Another example is integration of technologies like on-site renewables, energy efficiency, demand management, batteries and thermal storage to capture synergies. There can be real innovation in these integrations, and they can deliver major savings. There are also a myriad of smaller step innovations in existing technologies that will make incremental savings over time. We are not going to explore these, but will note them.

5. **Value chains selected**

The project will focus on two ‘value chains’ that are significant within the Australian economy. These include many activities that are relevant to other sectors of the economy.

In this paper we use the term ‘value chain’ in broad terms to include the supply chain and key elements of a lifecycle model. Our approach is not comprehensive, as that would be an enormous task. The approach is intended to focus attention on major areas of activity, and to support consideration of energy productivity measures that may cross sectoral boundaries, involve shifting activity from one sector or activity to another, integration of several EP measures, or other forms of innovation.

The two value chains are:

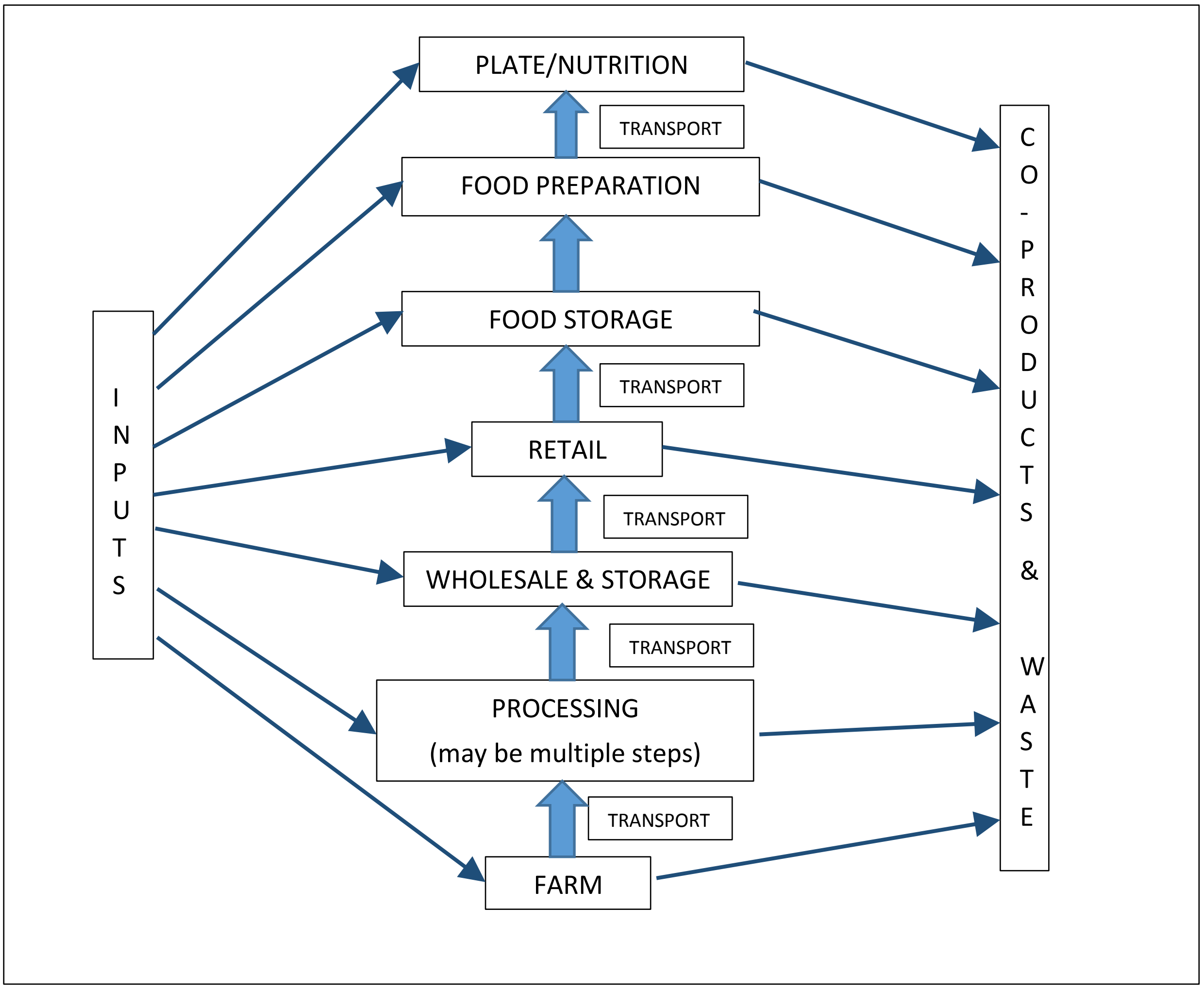
- Farm to plate/nutrition: this considers core activities involved in food production, processing and other activities up to the point of eating.
- Construction materials - from production of raw materials to operation of buildings.

Flow charts for the value chains are being refined, but preliminary versions are including in this report.

Farm to plate (food supply) value chain

This value chain, shown in Figure 1, includes the major activities involved in the production and transformation raw food into provision of edible food consumed by people.

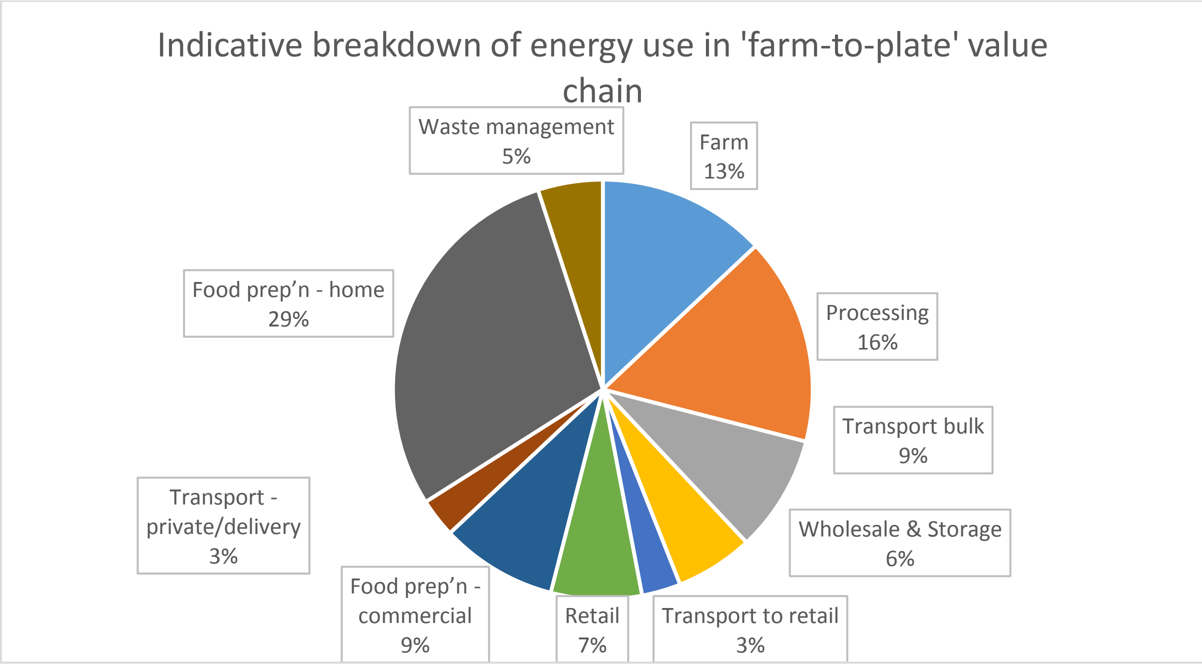
FIGURE 1: Preliminary draft of Farm-to-plate value chain. Inputs may include machinery, equipment, consumables, chemicals, maintenance services. Co-products and waste may include saleable organic materials, chemicals, products created during the core process of food production, or wastes that incur disposal costs and impacts – and which may be convertible into saleable product or service.



Some preliminary analysis has been carried out to establish 'ball park' estimates of the amounts of energy consumed in the stages in this value chain. This assists with identification of potentially significant aspects, on which our literature scan and engagement with specialists can be based.

An analysis of studies from three countries that analyse energy use in the 'farm to nutrition' value chain led to indicative estimates of the contributions of each major sector and some activities to overall energy use. These estimates provide a basis for the pie chart in Figure 2.

Figure 2. Indicative breakdown of energy use in 'farm to nutrition' value chain. Note that this reflects final energy (i.e. energy at the meter), not primary energy ('raw' energy such as fossil fuels used to generate electricity, for which data have not been found). Electricity-intensive activities and sectors (e.g. retail and commercial food preparation and storage) would be much more significant if primary energy data was used.



A brief review of this breakdown highlights the significance of some sectors and activities, as described in Table 1 below. This Table also flags the kinds of activities this project will focus on, and other actions that are potentially important but are outside the scope of this project.

TABLE 1. Major contributors to energy use in 'farm-to-nutrition' value chain, examples of energy productivity improvement opportunities, and classification regarding project scope.

ACTIVITY	SCALE OF ENERGY USE	EGs OF INNOVATIONS WITHIN SCOPE	BEYOND PROJECT SCOPE
Household refrigeration, cooking and private transport	Over 30% of value chain total	Step changes in household appliance efficiency	Incremental household energy efficiency – appliances, behaviour, diet change
Transport	Around 15%, but occurs at several points in value chain	Reduce amounts & distances transported; optimise vehicle efficiency Passenger transport value chain to address travel for shopping	Incremental improvements: A2SE freight transport roadmap will address
Industrial processing, wholesale storage (excludes sugar industry – bagasse)	Around 25%: various scales and locations; process heat, refrigeration	Major process innovations; e.g. heat pumps, high pressure processing, integrated management systems	Incremental improvements: A2SE manufacturing roadmap will address
Retail, commercial food preparation	Around 15% but electricity-intensive:	Process innovation, high efficiency	Incremental improvements, e.g.

	refrigeration, cooking, HVAC, lighting	equipment	improved management, behaviour change
Farming	Up to 15%, mostly diesel for vehicles, irrigation; some electricity (refrigeration, hot water) & process heat	Cut vehicle movement, e.g. use GIS data, drones, 'virtual paddocks' etc.); optimise irrigation; efficient equipment; process innovation	Incremental improvements; broader structural change, e.g. changing crops, integrating tourism
Waste management	Small in terms of direct energy use, but avoiding waste reduces amounts of food produced, processed, transported	New technologies to reprocess, extract valuable elements of waste streams	Waste minimisation throughout value chain, behaviour change, infrastructure provisions. *Note that diverting waste at point of consumption to consumption reduces the need for production upstream*

Common energy using processes that appear across the value chain include:

- Refrigeration, which extends product life, ensures health and product quality, while also allowing some activities to be shifted between stages in the value chain
- Process heating which is often delivered at much higher temperature than required, and includes:
    - Dewatering/drying,
    - Heating for preservation (e.g. pasteurisation, sterilisation) and
    - Cooking;
- Technologies that deliver the required services using alternative mechanisms, such as High Pressure Processing for pasteurisation and micro-filtration; and
- Transport and storage of food from harvesting to plate, as well as wastes and co-products.

There is increasing potential to shift such activities to different points in the value chain: for example, a hot bread shop combines baking and retail, and changes the roles of wholesale and distribution of consumer products. Partial dewatering of milk at the farm reduces transport energy and process energy at the dairy processing plant. The 'value chain' approach also supports consideration of changes that influence upstream and/or downstream effects of changes. For example, reducing waste reduces the amount of food that must be produced, transported and processed upstream of the point where the waste reduction occurs.

Construction materials (provision of shelter) value chain

In this section, a similar approach to the example for 'Farm to Plate (nutrition)' is taken. A 'value chain' diagram is presented, followed by some data on the contributions of the major elements in the chain to energy productivity and a table outlining potentially significant areas within and beyond the scope of this project.

Attempts to estimate the contributions of the elements in the construction materials/shelter value chain in the limited time available at this stage of the project are constrained by a number of factors including:

- The lack of detailed data on energy use in specific parts of the industrial and commercial sectors of the economy;
- Limited data on the proportions of output from various industries used in construction
- Difficulty in separating use of materials between building construction and infrastructure construction; and
- Significant amounts of export and import of materials and products.

Nevertheless, there are good reasons to explore potential to improve energy productivity in this value chain, not just operating energy, which include:

- Many of the processes involved are energy-intensive. Also, improvements will benefit other sectors that use the outputs of the associated industries, and innovations in this sector's processes may be applied to other areas;
- Improving business competitiveness within this value chain will help them remain in Australia, and maintain the diversity and resilience of our economy;
- Some activities have significant environmental impacts, such as quarrying, mining, some forms of forestry, processes with industrial process greenhouse gas emissions, etc. Improving energy productivity can help to reduce those impacts;
- As we improve the energy efficiency of buildings and the equipment used in them, the importance of the energy use and impacts of the construction supply chain increases in relative terms; and
- Large numbers of people are employed in the construction industry, as well as other elements of this value chain, so improving energy productivity can help to maintain or expand employment in this sector.

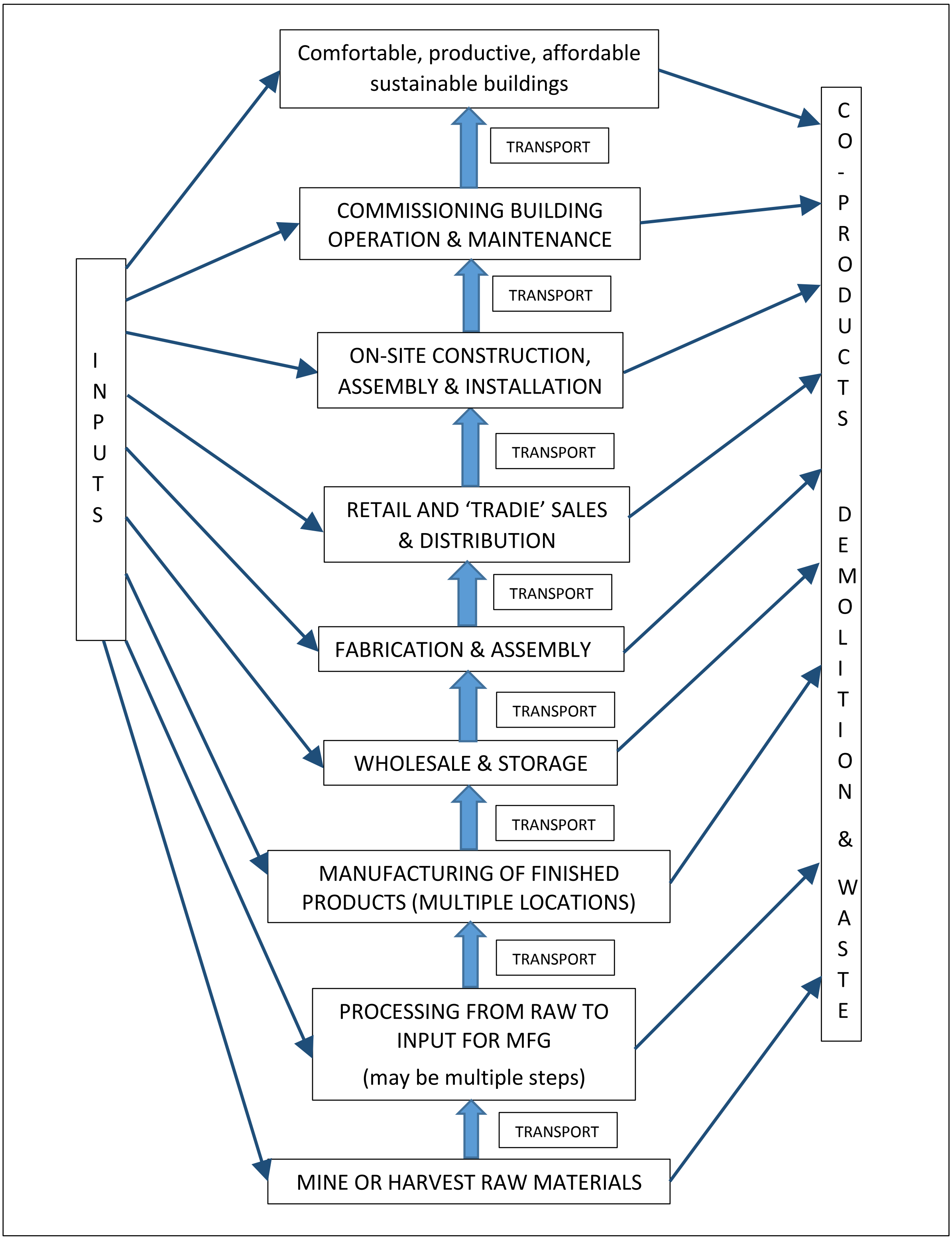
Overall, the elements of this value chain upstream of building operation are widely considered to be responsible for energy use of up to 20% of that from operating energy use within buildings. However, recent studies reported by ClimateWorks in their ASBEC study (*Energy Consult, 2015; Pitt&Sherry, 2012)* point out that heating and cooling energy comprises only 40% of residential energy and 43% of commercial sector energy. So the gap between the main aspect of building energy use affected by this value chain and energy use upstream of operation is much smaller than usually suggested, and the gap is closing.

A lifecycle analysis of inputs to households by Sydney University's Institute for Sustainability Assessment estimated annualised emissions from residential construction and renovation at 11.8% compared with 20% for all household electricity and gas use: if this is correct, upstream construction material emissions may exceed residential space conditioning emissions.

Therefore there is a strong case for this project to explore energy productivity improvement potential in this value chain.

FIGURE 2. Shares of energy use in the elements of the 'construction materials to shelter' value chain. Inputs may include additional materials, consumables, services and use of premises.

Shelter may be provided for households, businesses and their activities, animals, materials, products and/or recreational activities.



Broad features of energy use in this value chain, based on the limited review of data so far, are:

- Energy use in this value chain upstream of operation is likely to be responsible for around 40 million tonnes of CO2 equivalent annually, almost 10% of Australian energy-related emissions and over 7% of total emissions. Of this, transport is likely to be at least 20%.
- Operational energy use of buildings comprises 773 PJ of final energy, of which 59% is electricity (so electricity is around 80% of primary energy) and 23% of total Australian emissions, of which space conditioning is likely to be over a third (lower than its share of final energy due to the significant roles of gas and wood, which have much lower emission intensity than electricity), and refrigerant leakage (related to refrigeration and HVAC) 7% (ie 1.6% of total Australian emissions).
- For stationary energy use upstream, total final energy use is likely to be over 400PJ. Process heat and electricity dominate, with the industries contributing to this value chain responsible for over half of Australian industrial heat use.
- Steel (much of which seems to be recycled steel from electric arc furnaces) dominates upstream energy impacts, followed by cement products (which also emit process CO2 emissions during cement manufacture) and bricks dominate energy 'embodied' in construction materials. Timber and aluminium are significant contributors.
- Building fit-outs and renovations are likely to be responsible for up to a quarter of energy use associated with building construction in the value chain.
- Use of construction materials for infrastructure is likely to be greater than for buildings, so it may be responsible for an additional 40 MT CO2e annually beyond building construction.
- The construction sector uses around 100 million tonnes of raw material, from which around 25 Mt of useful products and materials are produced.

Table 2 includes a very preliminary indication of the scale of energy use in each element of the value chain, as well as examples of measures that may improve energy productivity.

TABLE 2. Major contributors to final energy use in 'construction materials to shelter' value chain, examples of energy productivity improvement opportunities, and classification regarding project scope. Note that values for energy use are indicative only.

Even though some of these technologies exist, adoption has been limited and partial, and integrated solutions will offer additional large savings.

ACTIVITY	SCALE OF ENERGY USE (excluding building operating energy for upstream activity)	EGs OF INNOVATIONS WITHIN SCOPE	BEYOND PROJECT SCOPE
Mine, quarry or harvest raw materials	Around 25% of total, 10approx. 100 PJ. Mostly diesel for off-road vehicles, power generation	Minimise energy use for moving material, eg replace trucks with mine-floor processing, conveyors; downstream measures cut usage	Optimise operations; minimise material use in value chain; use recovered/recycled materials; shift to other materials
Process to refined material inputs to mfg	35-40% of total. Some processes electricity intensive, some require very high temperature heat	In downstream value chain adopt emerging products, materials, systems, eg factory mfg of buildings; engineered timber or tensile structures	Optimise operations, high strength alloys, help designers to optimise material use

Mfg of finished products	Less than 5% of total energy, but some electricity-intensive; often high value adding	Advanced mfg techniques, technologies, eg 3-D printing	Optimise operations; replace old, inefficient equipment, improved product design
Wholesale, Storage, Retail	Less than 5% of total energy, but some electricity-intensive; often high value adding	Online shopping; local 3-D printing	Optimise operations and equipment within buildings, smart storage systems
Fabrication & assembly	Less than 5% of total energy, but some electricity-intensive; often high value adding	Factory construction of modules, buildings; improved product design	As above
Retail and 'Tradie' sales & distribution	Less than 5% of total energy but electricity intensive and influence impacts of trade customers	Improve product energy efficiency	As above, and customer advisory services, skill up and motivate tradespeople
On-site construction activity	Less than 5% of total energy – most for large buildings and infrastructure projects	Efficient equipment, scheduling, factory modular construction; advanced materials and systems	As above; project management
Commission-ing, building operation & mainten-ance	773 PJ (2012-13) of final energy, with electricity 59% (3/4 of commercial final energy and half of residential, and around 80% of primary energy). Approx 125 Mt CO_2e p.a. New buildings much more efficient than stock (but could be better, especially in summer)	High performance building envelopes, appliances and equipment; smart packages that combine monitoring, analysis, feedback, smart control; improved design	As above; training; accountability; budgeting and finance; dwelling size, climate and micro-climate, occupant behaviour, ongoing appliance efficiency improvement,
Demolition & disposal (inc recovery & recycling)	Small energy cost, but avoids substantial energy use by reducing demand for upstream supply chain	Material reprocessing technologies	Design for disassembly, material selection, optimal structural design
Transport	Transport emissions allocated to commercial 26.7 Mt and residential 45.6 (NGGI by economic sector); raw and bulk materials large (100 Mt raw materials, 25 Mt finished materials) but transport impact not yet quantified. Scale varies across and within sectors: bulk, medium (eg containerised), light freight. LCV, tradie travel inefficient, add to congestion and costs.	Minimise need for amount of and movement of materials, goods and people, eg factory building construction, in-situ processing and conveyors replace off-road trucks; online shopping with optimised delivery; electric delivery vehicles	Minimise need for transport, eg: Locate elements of system close to each other, switch modes Optimise vehicle selection, management and use, packing and loading Optimise operations; improved logistics, eg back-loading; vehicle efficiency, mode shifts
Waste manage-ment	Low energy use, dominated by transport and reprocessing	Small scale local recycling technologies with 3-D printing and other local production	Build recycling and reprocessing infrastructure, motivate community and business

Overview of energy productivity issues

Overarching demand for the outputs of this value chain is influenced by several factors, including:

- Floor area, building height, development density and extent of excavation involved, which influence the amount of materials and types required for construction and infrastructure. Virtual solutions can transform energy use. For example, on-line shopping should reduce retail floor area required, while optimised delivery services can use less fuel than private vehicles
- Adaptability and durability of buildings and materials also influence the level of construction activity.
- Urban development trends influence the distance materials must be transported, amount of infrastructure per square metre of buildings, and types of infrastructure (e.g. roads or rail transport)
- Choices about types of materials are influenced by cultural and institutional factors, technological evolution (e.g. engineered timber may challenge concrete and steel construction, high strength), availability of design tools, skills, cost and time involved in accessing materials or virtual alternatives, reliability of quality outcomes, etc.

So there are many opportunities for emerging energy productivity solutions to cross sectoral boundaries, and replace or transform existing activities and processes.

6. A Collaborative Process – how you can contribute

The 2xEP program is open and collaborative. All the papers developed in this process will be shared with the 2xEP sectoral working groups and innovation working group, and placed onto the 2xEP web-site for external input.

We have the opportunity in this process to develop some major insights into how EP can be improved through innovation but this can only be fully exploited with the active input from business and researchers within and external to the 2xEP process.

Sources of information for the technology/business model scan:

- **2xEP innovation working group.** We have assembled about 30 leaders in energy technology in Australia into a working group to support and guide this work and are actively seeking input to this process.

- **2xEP sector working groups.** We have approached 5 of our sectoral working groups on manufacturing, agriculture, freight transport, passenger transport and built environment to provide their input on the innovations that they see impacting their sectors by 2030. Members include innovation organisations in that sector.

- **Direct approach to other innovation organisations in Australia.** (e.g. FIAL, UTS IOT Program)

- **Web literature scan**, which is well underway for the food value chain (see section 8).

- **Emailed survey of research organisations.** This is currently underway.

2xEP has its own website at 2xEP.org.au

The site holds background material, sector overviews and summaries, links for contact. Comments and contributions are welcome.

AUSTRALIAN ALLIANCE FOR ENERGY PRODUCTIVITY

Doing more. Using less.

-
- Australian Alliance for Energy Productivity
  phone: 02 9514 4948. Email: info@a2ep.org.au web: a2ep.org.au
  Level 11, UTS Building 10, 235 Jones Street, Ultimo NSW 2007