

COOPERATIVE RESEARCH CENTRE FOR COAL IN SUSTAINABLE DEVELOPMENT (CRCCSD)
PROGRAM P1.2: SUSTAINABILITY DIMENSIONS AND IMPACTS

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SUSTAINABLE DEVELOPMENT: UNDERSTANDING & ISSUES FOR INDUSTRY
An occasional series of brief papers designed to explain key ideas and provoke dialogue.

Paper (I): INTRODUCING THREE BASIC CONCEPTS:
SYSTEM EFFICIENCY, RESILIENCY, ADAPTABILITY - their natures and roles.

Australian coal-use industries are living in a highly competitive environment generating many short term disturbances (e.g. price fluctuations) and facing significant technologically and environmentally induced long term changes over the next 20-50 years. This situation is not unique to the coal sector, or even to human commerce, for these three factors (competition, short and long term changes) are faced in varying measures by all systems, be they industries, organisms (including humans), ecologies, public institutions, etc. So understanding how systems cope with them is of inherent interest.

It is of special interest to CRCCSD because preserving or improving the capacity to survive and thrive under competition and short and long term changes lies at the heart of sustainability for both ecological and economic systems. The P1.2 programme aims to introduce this concept of sustainability for CRCCSD use internally. And externally it is the key to how coal-use industries may understand and improve their sustainability performance, and think through their future industrial opportunities.

The purpose of this paper is to explain briefly the three key ideas used in this approach to sustainability. Judge us on what is here, but feel free to tell us what else you would like to see discussed. Feedback of all kinds is welcomed. Industry dialogue will later be explicitly sought. Further discussion papers are planned developing the concept and use of sustainability in the context of the Australian coal chain.

I. Explaining the ideas.

Efficiency is acting effectively with a minimum of waste or unnecessary effort and expense, and hence exhibiting a high ratio of output to input - for example, [organism] swimming so as to obtain maximal glide distance and speed per stroke; [rainforest ecosystem] biodiversity of plants, leaf-eaters etc. that interacts to optimally recycle nutrients; [industry] producing a product for the least possible expenditure.

Resilience is the capacity to recover from a temporary disturbance and resume normal functioning - for example, [organism] rolling with a punch to regain balance, the healing process that repairs damaged tissue; [ecosystem] a species breeding back up from sudden deaths (e.g. in a fire); [industry] organising alternative resource suppliers to replace a temporary supplier failure, spreading investment risk to ride out share price fluctuations.

Adaptability is the capacity to maintain core functions under a long term change that does not permit wholly returning to erstwhile normal functioning - for example, [organism] changing food sources to suit an environmental change or changing behaviour to protect permanently damaged tissue, [dryland ecosystem] functionally equivalent species that can breed up to replace one another as climate conditions change (e.g. drought) and so restore ecosystem function, [industry] changing basic technologies (e.g. from lathes to lasers) and/or functional organisation (e.g. introducing computerised communication and

decision making) to increase competitiveness and/or take advantage of new possibilities.

A simple industrial illustration. In April 2002 the sole Australian supplier of automobile mufflers to the major Australian automobile manufacturers was temporarily shut down by an employee strike. The shutdown of the major automobile assembly lines followed over the next weeks, with each company claiming losses of several millions of dollars a day and potentially threatening lucrative export markets.

The parts supply chain for automobile manufacture is evidently organised on a just-in-time [JIT] logistical basis. JIT design is aimed at providing a required input when, but only when, it is needed, in the quantity, but no more, that is needed. In this way production costs deriving from parts inputs are minimised (no stock-pile costs, minimal supply-sale times). In short, JIT logistics is aimed at maximally *efficient* production. This situation is shown in Figure 1A.

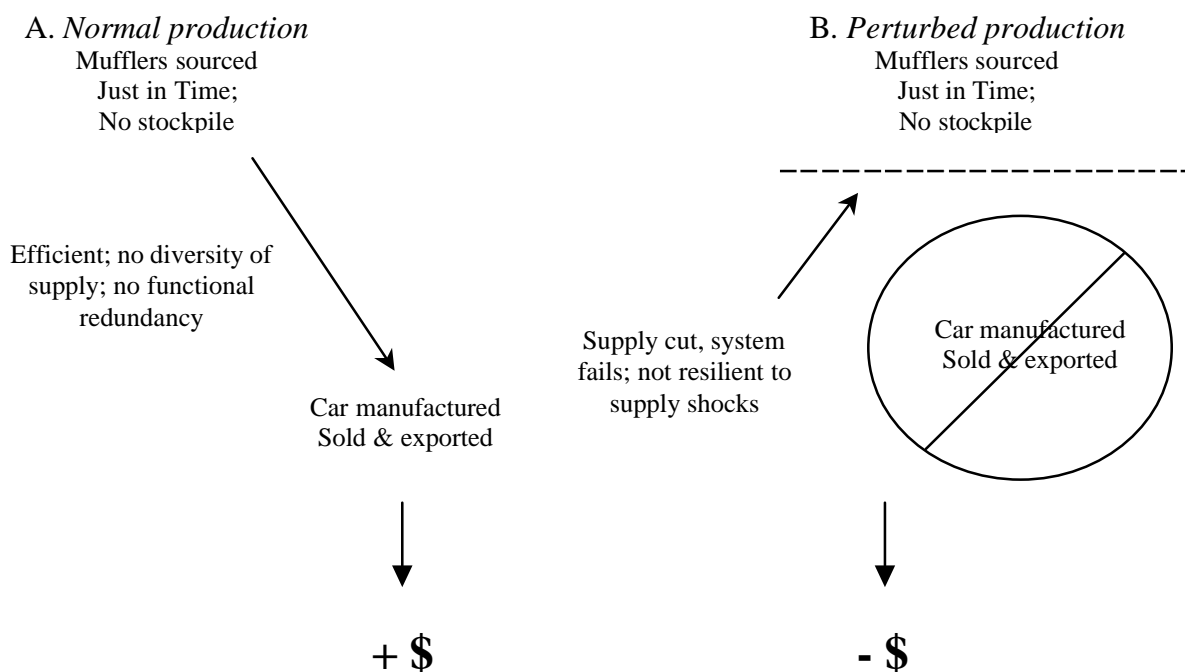


Figure 1 Current Situation (non-resilient)

But JIT efficiency also made the production chain very sensitive to disruption (Figure 1B): a temporary production disruption of modest size and cost (mufflers) at an early location in the chain was quickly amplified into a longer and very expensive downstream interruption to production (cars). The overall production line had no effective way of responding to the temporary disruption of supply so as to eliminate or ameliorate its impact. In short, it was not *resilient* to disturbances of this kind. And this lack of resiliency proved rather expensive. For good or ill, it also provides labour with a powerful bargaining lever. Options for resiliency are illustrated in Figure 2 (below).

Stockpiles of mufflers, as in pre-JIT logistic schemes, would have solved the problem; the stockpiles could have been used while waiting for the muffler maker to come on stream again. (Clearly, they would have to be large enough to outlast the strike.) Put more abstractly, storage capacitance can be used to smooth out disturbances, so that downstream functions continue uninterrupted. (This applies anywhere, e.g. to coal stocks smoothing out temporary disruptions in mine supplies, but equally to wetlands storage smoothing out temporary flooding and drought, electrical capacitance smoothing out voltage fluctuations, and supply teachers or secretarial agencies smoothing out temporary absences and ‘one-off’ demands.) Coincidentally, upstream disturbance leverage is reduced.

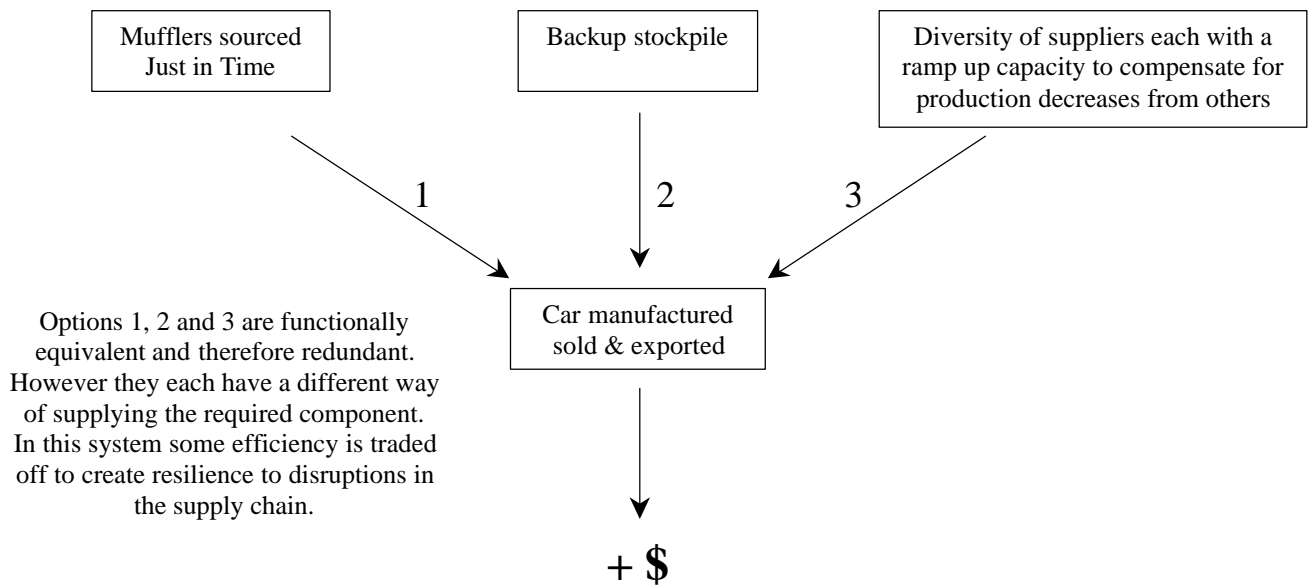


Figure 2 Options, which introduce resiliency

Naturally, the automakers would prefer to function in an environment where such disruptions did not occur, and this latter is what using JIT tacitly assumes. From their point of view a strike is a disruption that has no meaningful role in their business plan. Contrast this to changing model features to meet shifting consumer demand: doing so also requires a temporary disruption to production but one that is integral to pursuit of core business goals. However, should such unwanted strike disturbances occur often enough and be expensive enough, it will be better for a manufacturer to plan to ameliorate or eliminate their effects.

The example of changing model features to meet shifting consumer demand often introduces a different kind of disruption, a longer term change in operating conditions that remains present. If the demand is for small differences in model features, e.g. a rising demand for anti-theft devices, then the production process is relatively cheaply and quickly modifiable to include the demanded changes. If the demand is instead for different models, e.g. a rising demand for 4-wheel drive off-road models instead of small sedans, then the production process can still be modified to suit, but much less easily, quickly or cheaply. In sum, automobile production lines are somewhat *adaptable* to longer term changes in demand, readily adaptable to meet changing demands for minor model features, less adaptable to meet deeper changing design demands. In fact the latter adaptability is often achieved instead by using a number of different manufacturing plants each devoted to its own model and switching production among them as demand changes (contrast the earlier example of functionally equivalent dryland ecology species breeding up in response to climate change).

In our automobile example resiliency was achieved through redundancy, that is, having several alternative sources of muffler supply: the strike-bound maker, a stockpile, several replacement makers (not all on strike together and with enough slack production capacity between them). In fact manufacturers did threaten to diversify their suppliers to include imports if disruptions continued, although this will have other associated costs. In the case of long-term change in operating conditions, similarly, adaptability is also achieved through redundancy, in this case having alternative modifications to the production process available. The redundancy will normally be partly potential (e.g. stored as human knowledge only), but becomes literal when realised, e.g. when the alternative tools, processes and spare parts are actually created to install a feature change in one plant or when different plants are used to produce each model. In all cases the redundancy provides for slack capacity from which a compensating process can be constructed (extract parts from stock piles, replace model features on a production line) that serves to

smooth out threatened disturbances to at least core system functioning.

Of course disturbances of both kinds can also arise internally to the automobile manufacturing system itself. The failure of a fuse on an auto welder, and an ordering error in the marketing department, are both temporary disturbances originating in that system, while the re-tooling of the assembly line for a new model, or the introduction of JIT supply logistics itself, are both longer-term changes arising internally. In sum, we have a first simple four-fold classification of disturbances: temporary or longer-term, internal or external. Each of the resulting four categories will include many sorts of potential disturbances, roughly all those possible disturbances there are to the main ‘factors of production’. For business systems generally, including coal-chain industries, these are disturbances in physical, financial, labour and organisational features, with each category containing many different specific sorts of disturbance.

This extended example illustrates several useful lessons.

- While inefficiency is by definition wasteful, and can prove very expensive in lost competitive edge, lack of resiliency or of adaptability can also prove very expensive, also including lost competitive edge.
- Resiliency and adaptability are achieved through redundancy that provides relevant slack capacity from which compensating processes can be constructed that maintain at least core system functioning.
- Efficiency, resiliency and adaptability have mutually conflicting requirements. Resiliency and adaptability involve having usable slack capacity while efficiency calls for eliminating such redundancies. Resiliency and adaptability involve very different kinds of redundancy since they aim at different outcomes (namely, returning the system to pre-disturbance operation versus changing the system to suit post-disturbance operating conditions).
- Efficiency, resiliency and adaptability are each appropriate responses to different aspects of operating situations: efficiency to basic operating conditions, ignoring disturbances; resiliency to temporary disturbances in conditions; and adaptability to longer-term disturbances in conditions. What mix of these three capacities it is appropriate to have depends on what kind of disturbances and competition a system faces in its operating situation.

Table 1 below summarises the situation.

Table 1

Temporary or short-lived disturbances are called *spikes* and longer-term changes *ramps*, with duration judged in relation to a system’s main operational cycle.

Types of Disturbances & System Responses			
Type of Disturbance	Response aim	Desired response capacity	Kind of redundancy required
No disturbances	Maintain current state	Efficiency	None - redundancies eliminated
Spikes	Restore pre-disturbance functioning	Resiliency	<i>Short-term</i> design modifiability plus parallel input (resource) and output (demand) availability
Ramps	Achieve core post-disturbance functioning (same functionality – not necessarily the same system)	Adaptability	<i>Long-term</i> design modifiability plus parallel input (resource) and output (demand) availability

II. Applying the ideas.

At the outset it was noted that Australian coal-use industries are living in a highly competitive environment generating many short term disturbances (e.g. price fluctuations) and facing significant technologically and environmentally induced long term changes (disturbances) over the next 20-50 years. In short, it would be operationally sensible of them to pay attention to their resiliency and adaptability as well as to being efficient.

Efficiency is always relevant, but there is no use focussing resources on gaining small improvements in efficiency if spikes - e.g. supply or price fluctuations, fuse failures or ordering errors - are going to cripple or eliminate you, or if ramps - e.g. technology or consumer demand changes - are going to do so. Indeed, in the face of such disturbances resiliency and adaptability would be needed precisely to maintain efficient operation (in a more encompassing sense of that term). But how much resources should be devoted to these capacities, and where? That depends on what kinds of spikes and ramps can reasonably be expected and planned for. After all, it is equally no use developing resiliency or adaptability capacity if, long before it is needed, inefficiency sees competition cripple or eliminate you. These lessons apply even without considering sustainability issues (and to all functional systems).

We are currently interested in understanding the efficiency, resiliency, adaptability capacities within single industries, and across interacting networks of industries. For example, BHP's Port Kembla steel works now sells some of its blast furnace slag to a cement producer as a cement replacement. And (see Figure 3) Orica uses spent steel pickle liquor, containing ferrous chloride and some residual hydrochloric acid, as a raw material for ferric chloride production (used for precipitating phosphorus from municipal waste water), while selling its hydrochloric acid by-product back for pickling liquor. In both cases there are economically and environmentally important improvements in efficiency for the system, but also some improvements in resiliency and adaptability, improvements not accessible to the component industries alone.

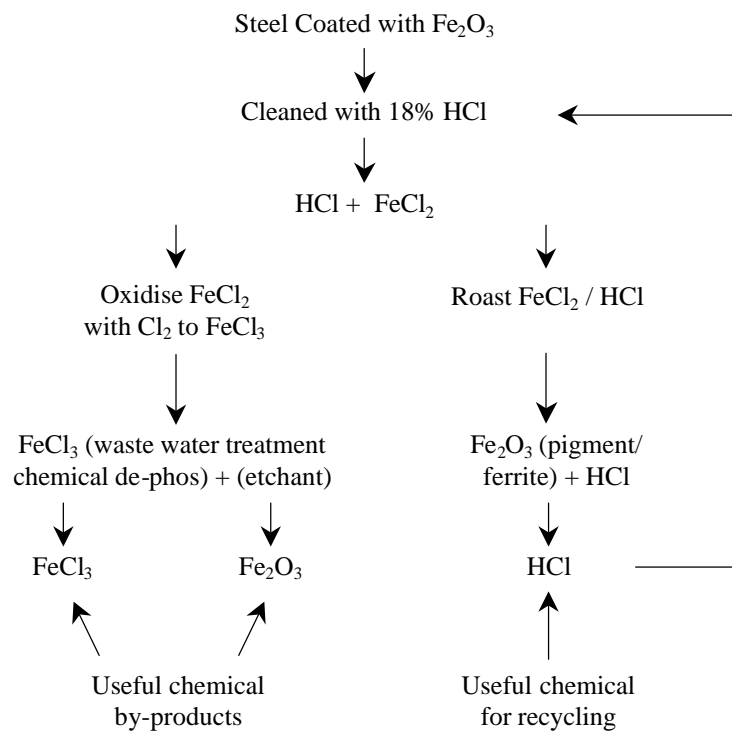


Figure 3 2-industry output recycling system

We will later be approaching our CRC industry partners to discuss these ideas as they apply both internally to their operations and externally with other businesses. We will be looking for case examples of resiliency and adaptability in their industrial functioning, or for its potential even though currently absent.

But beyond that, one of the largest potential ramps facing the coal sector is the impact on its future use deriving from its environmental impacts and the adoption of sustainability development criteria. Consider, for example, the potential impact of a carbon tax. It is precisely here that thinking in terms of resiliency and adaptability as well as efficiency may help to clarify the issues and formulate a strategy for facing the transition to sustainability. After all, in the light of the changes both our ecological and economic systems face, the best way to provide for their future is to sustain their adaptability, and resiliency as needed.

A conception of sustainability focussed on sustaining ecological + economic resiliency and adaptability should also allow us to evaluate the coal chain in our economy for its contributions, positive and negative, to sustainable development. And this in turn should permit formulating a way forward for coal-using industries through the coming transition to sustainability, led by enhancing the coal-chain's distinctive positive attributes while eliminating or sufficiently ameliorating its negative contributions.

These ideas and proposals will form the substance of future papers in this series.

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