UNMAKING WASTE IN PRODUCTION AND CONSUMPTION

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UNMAKING WASTE IN PRODUCTION AND CONSUMPTION: TOWARDS THE CIRCULAR ECONOMY

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Preface

Unmaking Waste in Production and Consumption: Towards the Circular Economy

Li'an Hou

The annual *Living Planet Report* released by the World Wide Fund for Nature (WWF) and the International Non-Governmental Organisation (INGO) Global Footprint Network revealed that 'Earth Overshoot Day', the day on which humanity starts using more ecological services and resources than the earth can generate, is again ahead of schedule.[1] The 2017 Earth Overshoot Day was August 2, 28 days earlier than 10 years ago, and 67 days earlier than 20 years ago. Facing our current situation of resource shortages and environmental pollution, the linear economic road of 'make-use-waste' has been difficult to maintain, and the circular economy of 'make-use-renew' has become an inevitable choice, to promote the recycling of limited resources, so as to make human society sustainable.

The circular economy requires a fundamental change to the traditional economic model of mass production, increasing consumption and ever larger amounts of waste. From the technical perspective of resource utilisation, the circular economy is to be realised mainly through three means: the efficient utilisation of resources, the recycling of resources through the economy and harmless production. The circular economy is based on resource reuse to achieve sustainable economic growth, which is obviously better than the traditional linear economy, which has relied on the destruction of the natural environment in exchange for short-term economic growth. The development of the circular economy thus not only reduces the waste of resources, but also represents a significant new development model.

In recent years, the economic and environmental costs of traditional ways of developing resources have steadily increased. Some countries have begun to mine deep-sea resources, searching for these deep below the surface of the earth and ocean, and even trying to discover resources in outer space. However, finding these increasingly distant resources, or other alternatives, is not the only way to solve our resource crisis. The circular economy advocates the recycling of raw materials, rather than the continuing pursuit of new resources, as a way of meeting the larger needs of social development.

If the search for new resources involves a kind of 'addition' to economic activity, but one dependent on consuming more resources, then the circular economy involves a 'multiplication' of this activity, but one requiring less resources, and

thus less environmental impact. The development of the circular economy is thus the only way to achieve social and economic development before sufficient alternative resources can be found. After years of practice, it has been shown that the production and development model of the circular economy is of great significance to business, environment and society. Facing increasingly tighter resource constraints, 'Unmaking Waste in Production and Consumption: Towards the Circular Economy' becomes an important pathway to implementing the circular economy for the new era.

This book is based on research from both developing and developed countries. Through interdisciplinary exchanges, discussions and studies, it analyses the concept of the circular economy, emphasizing the different contexts in which the circulation of materials through the economy takes place. It presents some unique views on the theory and practice of the circular economy, and embodies some remarkable achievements in the study of its application.

The first half of the book mainly interprets the past and present of the circular economy, at a more theoretical and policy level. This part, starting with the flow of raw materials and the efficiency of resources, explores the internal law and operating mechanism of the circular economy in the light of the consumption of goods and services. The second half focusses on the impact of the circular economy concept on technology and design, from the perspective of enterprise, environment and society and suggests ways in which the circular economy can be applied in new and traditional industries, from the macro level.

The book's authors include dozens of scholars from around the world who have collaborated to develop new insights into the circular economy and its application. In this book, you can find both scientific and reliable firsthand survey data, but also find profound theoretical analysis and research on this developing model for a sustainable future. It can be used as a reference for both researchers and decision-makers, as well as for ordinary readers concerned about how the problems of resource overconsumption and environmental damage might best be solved through the implementation of the circular economy. This book is timely, a valuable contribution to academic and scientific work on this vital topic.

(Translated from Chinese by Dr. Na Ji.)

Note

1. Initially started on December 31 in 1986, Earth Overshoot Day has been moving forward ever since. See: https://www.overshootday.org.

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Introduction

Robert Crocker, Christopher P. Saint, Guanyi Chen and Yindong Tong

> A circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times (Webster, 2015)

While there are many definitions of the circular economy currently in use, the one most often cited in English is that from the British charity, the Ellen MacArthur Foundation, given above. Like most others, this starts from the assumption that the earth's 'natural capital', the resources which we depend on, are 'stocks' that need to be conserved, kept in use for as long as possible and reused, rather than being used up as needed and then discarded. This is necessary because the global market at present does not properly account for or price the environmental costs of the extraction of resources, their manufacture into goods, or for the environmental impact these goods have in use or after their eventual disposal.

A number of consequences flow from this commitment to treat resources as both valuable but limited stocks. Firstly, the circular economy includes the idea that all resources, from water and steel to various foods and rare minerals, must be priced and valued according to their costs to the environment, over a full lifetime, through extraction, production, use and discard. Secondly, the circular economy includes the idea that these stocks should be used and reused for as long as possible, whether in their present form or in another – to 'save the earth', but also to retain and, if possible, increase the value embedded in them.

Since how this is to be achieved now depends on a particular resource's market value, the circular economy adds to these fundamental ideas a third one, that the activities dedicated to maximizing a resource's utility, such as reusing a particular material or resource, or extending that product's lifetime in use, can also generate or recover value. By avoiding all losses represented by wasting, and environmental losses incurred through extracting and making something from new and possibly scarce resources, money is also saved. More radically, the circular economy concept adds to this an understanding that this avoidance of waste and return of lost resources into the flow of resources through the economy will of itself stimulate further economic activity, in this way generating employment (Stahel,

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2010). Thus, circular economic activity both avoids losses – in materials, labour, utility and money – that premature wasting necessarily involves, but also generates a range of new economic activities from the processes of recovery and reuse that seemed unworthy of consideration before, in the so-called 'linear economy'.

This last point links us back to the possibility that not only are resources in use now routinely undervalued – in part because their lifetime in use has been artificially shortened and their potentially valuable components and materials wasted – but that innovative ways of using and reusing resources can retain and even increase their market value, and thus greatly benefit the producer as a result (Stahel, 2010). One consequence of this, now widely recognised in China as well as in the EU, is that generating new economic activities through reuse, recycling and remanufacturing, can not only reduce the environmental impacts of industry, but also create new jobs, and indeed, whole new industrial sectors (Stahel & Reday, 1976).

Eager to discover new business opportunities, many large enterprises have become interested in the circular economy concept, at least in part because of the potential added value engaging in circular economic activities promises. In effect, this profitable reuse, broadly defined to include many different kinds of process and material, and many possible industrial actors, recasts the older ideas of environmental sustainability and product stewardship into a form more amenable to calculable economic benefit. For the circular economy concept makes it quite clear that all stocks are inherently valuable, whether this is accurately reflected in their pricing in the 'real' market at a particular moment or not. As the Ellen MacArthur Foundation's website and many reports make clear, it is the hope of discovering some yet-to-be-identified value hidden in their present 'linear' production and its technical processes or supply chains, as well as the desire to improve their environmental performance, that has driven some very large global companies to now embrace and try to implement the circular economy concept (Lacy & Rutqvist, 2015).

As this suggests, the premature wastage of resources represents both a market failure and a loss of value, not only for the companies involved, but also for the societies in which they operate, and that resource flows can be more efficiently and cleverly managed in a systematic way to regain value, whether this is simply reusing, recycling or remanufacturing components and products, or entirely reforming materials into new ones (Stahel, 2010). Not only resources are saved in this shift to the circular economy, but the energy and contributing resources such as water required to make things from scratch are also greatly reduced. Since it is the extraction of resources, and production of new things, their subsequent short-term use and then premature discard, that are now most obviously implicated in the growth of global emissions, the circular economy concept is thus clearly good news for both business and the environment (Lacy & Rutqvist, 2015).

From a slightly different perspective, governments are also becoming more interested in the circular economy, since for policy makers and political leaders resource loss and waste, along with the pollution and environmental damage mining and manufacturing can generate, represent increasingly heavy costs that they, along with the peoples they represent, must absorb and pay for. It is also

increasingly apparent to these leaders that while the linear economy, or 'business as usual', might at first create employment and generate wealth, its larger and longer term environmental and social costs can become unsustainable, and ultimately destructive to the same communities they might at first benefit. For example, the global manufacture of plastics now vastly exceeds in volume the capacity of standard methods of disposal or recycling to absorb at their end of life, and so the stock of waste plastics is steadily increasing, along with its long-term, and extremely negative, impacts on the environment (New Plastics Economy, 2017). Most governments realise that this whole industrial move towards the circular economy will require more than some voluntary agreement between the larger manufacturers, but an informed shift in policy, along with appropriate financial and regulatory instruments, to encourage a transformation of each industry.

The added risks now associated with climate change, with rising seas, extreme weather events, environmental degradation and species extinction, have necessarily increased, and made unavoidable, the social and economic costs now associated with the linear economy. Consciousness of these climbing risks, and the increasingly high costs of inaction, are driving the cycle of intergovernmental reports, meetings and commitments that have marked our era. Consequently, governments across Europe and Asia, and especially those within the EU and in China, are in the process of shaping policies, financial instruments and regulations to stimulate and help implement the circular economy. This is in part driven by the urgency of the global environmental crisis, but also by the logic of the circular economy concept itself. Reusing materials and shifting to renewable energy, to conserving resources and reducing wastes, makes more and more sense, and is also more cost effective in the long-term. A number of larger cities and state governments around the world have also begun to embrace the circular economy concept, recognizing the potential benefits of this model for their own environmental, social and economic programs, including increasing employment and 'green growth'. In China, for example, a small city like Jieshou in Anhui province (Jieshou, 2017), is now totally dedicated to benefitting from China's increasing commitment to the circular economy, employing some 40,000 people in circular economic businesses. To take another example, in South Australia, in May 2017, with limited fanfare, the state government announced it would commit itself to creating a circular economy over the next two decades, a commitment that will impact businesses of all sizes operating in the state, and soon lead to a reshaping of enabling legislation and regulation (GISA).

While there is little that is entirely new about the concept of the circular economy, and its origins can be traced back to ideas in currency in the 1960s and 1970s (see Crocker, Chapter 1), its broader implementation is necessarily challenging, requiring a gradual transformation of many economic, technical and material settings, from regulation and taxation through to supply chain management and product design, and this will need to occur in every domain. It will also require a much richer understanding and more detailed knowledge of resources, and of what is now considered 'waste'. What exactly is being wasted, and in what volumes, why this is wasted and how this can be recovered and made use of again, all become important topics for more intensive research and experimentation.

Design, and the application of technology to this end, also become vital components of the implementation of the circular economy. Beyond all rhetorical and marketing flourishes about the economic potential of the circular economy, is the hard work of many researchers re-examining current practices and processes to both transform wastes of all kinds into viable, and safe, resources, for a second, or third, life in use.

This book has been titled *Unmaking Waste* because this phrase accurately sums up what the circular economy must involve, in terms of both future research and industrial practice. While wasting materials, products and components might presently be justified in the linear economy, because through more rapidly wasting what we make and use we make room for the new, and thus can sell more, and keep the wheels of commerce spinning, this is clearly short-sighted and ultimately self-destructive. In contrast, the circular economy allows us to reconceptualise most waste as having some inherent value, and to recognise that waste is typically the final consequence of some decision (whether conscious or not), that can be reconsidered, and in many cases reversed and undone or 'unmade'. Thus, the circular economy is about systematically reducing the speed and extent of the ever expanding and accelerating cycle of extraction, production, use and discard that marks today's present linear economy. This 'unmaking of waste' must be considered not only in terms of the end of the cycle of production, use and discard, as it is presently considered through current practices of recycling (MacBride, 2011), but in terms of design, of reshaping the beginning of this cycle to suit this more circular pattern of material flows, which is the goal of the circular economy itself.

The aim of this book is to bring together examples of recent research exploring some of the consequences of this central idea of 'unmaking waste' to further the implementation of the circular economy in a selection of different contexts. Since the circular economy as a concept requires the radical realignment of many of our cherished ways of designing and making things, using and disposing of them, this book cannot hope to be comprehensive, but rather seeks to cover a broad sweep of exemplary themes with a specific link to the central idea of the circular economy. This is done here through the lenses of many disciplines, including history, economics, consumption, design, material science, marketing, construction and systems innovation. Seeking to stimulate its readers to consider the circular economy's concept and its potential implementation in more depth, it does not seek to 'sell' the concept as a necessary, and marketable, 'solution' to our environmental problems (there are others doing this), but rather to promote more research on the concept and its implementation, as a potential vehicle for the changes required by our growing, and ever more serious environmental crisis.

This book had its origins in the first 'Unmaking Waste' conference held in Adelaide, South Australia, in May, 2015 (UnmakingWaste), with 13 of the essays originally presented as papers to this conference. These essays, now expanded and rewritten, were then augmented over the intervening two years with some additional invited essays, with two originally presented as papers to a related seminar held under the auspices of our China Australia Centre for Sustainable Urban Development (CACSUD) on 'The Futures of Waste' at the University of South Australia in September, 2016. The remaining chapters, mainly focussed

on the Chinese experience, were then added to complete the collection of nineteen essays presented here. As editors, we are very grateful to the eminent Academician, China Academy of Engineering, Professor Li'an Hou, for contributing his thoughtful Preface, and to Mr Vaughan Levitzke, Chief Executive of Green Industries SA, whose lifetime of dedication to waste reduction in Australia and our region has been widely recognised, for his kind Afterword to this collection.

The book is divided into four parts, representing four broadly loosely defined themes. The first, *History, Theory and Experience,* is mainly concerned with the larger picture of the history, economics and policy initiatives required to implement the circular economy. It begins with Robert Crocker's essay on the longer history of the 'circular' concept in sixties environmentalism, and how this has shaped environmental agendas ever since, including that embraced in the circular economy. It emphasises the power of design to generate overconsumption and waste, or, potentially, to cure the larger problem this overconsumption has created. This is followed by Martin Shanahan's discussion of the potential role economics could play in further developing and contributing to the circular economy concept, providing an overview of some of the most important of the missing voices. These economists now have an increasing relevance to today's efforts to implement the circular economy. This is followed by Xu Zhao's valuable round-up of the history, development and implementation of the circular economy in China, perhaps the world's first nation to most fully embrace the concept, from the top down, as a means for gradually putting into practice that government's grander goal of creating an 'ecological civilisation', an ideal that the rest of the world could do well to emulate. The final essay, by Norman Goh, Christopher Saint and colleagues, on the potential use and policy implications of the use of biosolids, suggests what the circular economy concept might mean in one presently undervalued resource, water, and the human and industrial wastes it typically gathers as it is makes its way through our linear economy. This last essay begins to reveal to the reader the greater scientific, technical and policy distances still to be covered if the circular economy is ever to be implemented. It also signals or announces the themes taken up especially in the last two parts of the book.

This first part is followed, in the second *Consumption, Design and Behaviour,* by five essays on the implications of the concept of the circular economy on consumption, consumer behaviour and those areas of repair and reuse that are more directly accessible to consumers. In many respects this part picks up on Robert Crocker's initial argument (Chapter 1) that the circular economy needs to be considered also in terms of consumption, and specifically, design for consumption. The first essay in this part, by Hélène Cherrier and colleagues, repositions the consumer's relationship with the consumer product of the linear economy towards one of care and relationship. For as they argue, the object once possessed effectively 'talks back' to its owner, requiring time, place, maintenance and attention: this is a material, psychological and social relationship, and not just a momentary transaction. The consumer's potential custodianship of objects becomes an important topic of research in itself, once one considers consumption and possession as more than just going shopping to stimulate economic growth (see Miller, 2009). This more interactive view of the things we possess and use is

followed by an essay on potential ways of approaching the problem of 'fast fashion' by Jen Ballie and Mel Woods. This explores a collaborative project involving textile designers and manufacturers in Scotland attempting to use design to shift fast fashion towards more sustainable outcomes. The process outlined emphasises the importance of design informed by the whole lifecycle of the intended product, and the role of co-creation in the new economy of end-of-life value creation, or recreation (Sanders & Stappers, 2008).

Taking up both themes explored by the first two essays in this part, that of the consumer's ongoing relationship with their possessions, and that of co-creation in linking production to consumption, the next essay summarises a fascinating design-led experiment conducted by Kirsty Máté, where passing shoppers were encouraged to stop and engage with a range of second-hand or donated objects in more direct, interactive, typically non-transactional ways. This essay, along with the two preceding ones, reminds the reader of how consumers are now 'trained' by advertising, marketing, and peer example, to adopt a linear perspective of the products they buy, as short-lived, packaged products and only of real value when they are brand new, or nearly so, a perspective that is neither natural or unchangeable, but one that can be altered, under the kinds of circumstances Máté manages to briefly create.

This is then followed by an insightful essay by Ruth Lane and Wayne Gumley on where many everyday items presently end up in the linear economy, in charity shops and recycling centres, and how these institutions rather precariously fit into, or link to, the present consumer retail landscape. This essay is drawn from the larger Australian research initiative, 'Wealth from Waste' (Wealth from Waste, 2017), which both authors have been closely involved with, and brings out the way that reuse is now intentionally marginalised in the linear economy, as of a lesser value, for charities, and volunteers to pick up and somehow deal with. The final essay in this section, by Anne Sharp and Vaughan Levitzke and colleagues, takes up this theme using the forensic lens of marketing to gain a closer view of consumer intentions when confronting their own wastes. The essay revisits the waste hierarchy from a consumer behaviour perspective, focussing attention on its most preferred but often neglected behaviours, including 'avoidance' and 'reuse', and testing consumer attitudes towards these in novel ways, so that waste managers might be better informed about how to implement the circular economy in their domain (see also GISA).

This final essay in the second part of the book links to, and introduces, the third part, *Waste and Resource Recovery*. This begins with an essay by Jacob Fry and colleagues on the problem of measuring 'waste footprints', taking Australia as its central case. This attempts to map waste outputs more accurately across Australia by type and destination, a summary of an important contribution to the growing research on 'waste informatics'. This need to more accurately measure waste, is necessarily a critical component in the implementation of the circular economy. From this more abstract overview, the next essay, by Lionel Taito-Matamua and colleagues, returns us again to the role of design in 'closing the loop' to implement the circular economy, but this time from the perspective of 'local' waste. In a fascinating and ongoing design and educational experiment, the authors seek to

transform the hugely problematic issue of marine plastic wastes into local objects for tourist consumption on Samoa, using simple, off-the-shelf technologies. Ironically, this takes the wastes tourists themselves are in part responsible for, and turns these into a series of crafted reminders of their visit.

The next essay is again design focussed, by Singh Intrachooto, summarizing a study he and some colleagues led on scrap or waste utilisation in Thai factories, mostly SME furniture manufacturers, a study which again highlights the important role of design in implementing more circular processes and outcomes in this, as in many other, industries. While it seems to show the huge gap between ideal and realisation of *unmaking waste* in Thai industries, it shows again most clearly how waste remains neglected and largely unaccounted for, and undervalued, and thus a lost opportunity that the circular economy promises, again with the aid of design, to remedy. This essay is followed by one by Rita Li and a group of colleagues from Hong Kong, China and Australia on the continuing problem of construction and demolition waste. It usefully introduces this subject by overviewing contrasting national or government approaches to the problem, a subject taken up in more technical detail in the final part of the book. Reading this essay, it becomes clear that it is the work of governments particularly to help correct the failures of the present market that the linear economy has for so long exploited, largely unhindered by regulation or market limitation. The last essay in this part, by Wenchao Ma and Guanyi Chen and colleagues, is again a comparative essay on waste, but this time surveying waste composition in different cities, within differing climatic regions, within China, and their potential treatment. This bookends the essay that began this part, by reemphasizing the importance of waste informatics, of more thoroughly understanding the composition of the wastes being generated so that more might be achieved in their transformation in the circular economy. This greater understanding of waste – and not just in numbers – it should be emphasised, is again an essential pathway for future research: we still do not know enough about waste, about its volumes, varieties and potential uses, to be able to more effectively reuse it as resources, and until this can be more accurately mapped, generating more circular economic activities, systems and technologies will remain more difficult to design for, and implement.

This final essay in the third part of the book, usefully opens up the question of the application of innovative technologies to waste streams, which the fourth and final part of the book seeks to address: *Technology and Systems Innovation*. The opening essay in this final section is by Samane Maroufi and colleagues, focussing on the transformation of more 'difficult' wastes into materials of greater value. This more detailed, and scientific, essay, is based upon work that Veena Sahajwalla and her research group has been undertaking for the last decade, and provides an insight into their methods, now made famous by their work on using tyre wastes to make steel, a patented innovation taken up by steel makers across the world. In this essay, they turn their attention to the question of 'end of life' vehicle wastes, and how these polymers might be used in a similar way. This first essay in this section provides a valuable insight into the transformative potential of *remaking* waste into entirely new materials for production.

While this essay highlights the value of material science in transforming waste materials into entirely new ones, the following essay, by Tim McGinley, highlights the value of IT systems in providing more accurate and useful information and access to second-hand or wasted building materials for reuse. Focussed on the potential use of building information modelling (BIM) systems, in combination with online market systems like e-Bay to more creatively reuse building parts and components, this type of innovation is gaining traction across the construction sector because of its enormous cost- and waste-saving potential. Turning back again to the designed 'front end' of construction, this is followed by Philip Crowther's essay on design for disassembly in construction, which highlights the enormous potential in carbon and material savings of this still neglected but widely understood technology in such a strongly conservative industry. The penultimate essay in this part is again design and technology focussed, a fascinating case study by Peng Sen and colleagues from Tianjin on the extensive water engineering design involved in Tianjin University's new 'green' campus. This essay again highlights the importance of *designing* the circular economy, which is such an important and recurrent theme in this book. The final essay in this part, and of the whole book, is by Abbas Elmualim and colleagues, and returns again to the problem of construction waste, focussing on the still underutilised potential of designing smart prefabricated parts and components into buildings. The greater resource efficiencies and carbon reduction generated from this innovation, and the kind of innovations suggested by the previous essays in this part, confirms again the enormous potential of the circular economy to not only reduce waste and pollution, but to create a practical, and achievable, transitional pathway to sustainability.

A number of recurring themes, emphasised above, can thus be seen in this book. Firstly, many of the essays as we have emphasised, address the increasingly important role of *design*, in reforming or reusing materials, objects, systems and environments into more effective, and more valuable forms of reuse. This design focus or intent spans many of the essays here. Indeed, essays in each part of this book reveal how design cannot remain just an 'idea' informing the circular economy, but lies at the centre of this concept, and must be applied to each domain to reverse the present wasteful flows of resources and energy that have given rise to our environmental crisis.

The second theme that stands out on reading these essays is the importance of understanding and enumerating *waste* itself in more depth, with a much greater degree of accuracy, and in some cases reimagining or reconceptualizing waste in entirely new ways. Wastes are, typically, misallocated resources, whether their potential reuse has been understood and recognised, or not. Without accurately understanding waste's composition, elemental qualities, volumes and locations, implementing the circular economy will remain largely impossible. Knowing what is *in* waste itself, or what might be done to reuse wastes, the subject of several of the essays in the last part of this book, becomes an especially important topic, if the circular economy is ever to be implemented.

Thirdly, the essays in this book are also threaded through with the theme of the importance of the application of *science and technology*, and especially of innovations in materials, processes, products and supply chains, with these all,

in their own way, linked back to design. The circular economy's implementation, as many of these essays attest, will require more effective, and innovative ways of applying scientific knowledge and technology, even in relatively familiar contexts.

Another final, but also important theme presented here, is the *interdependence of production and consumption*, which is typically neglected in discussions not only of the circular economy, but in the current discourse on sustainability itself. In the first essay, and in the essays that make up the second part especially, consumption is addressed repeatedly as the shaper and stimulator of our present overconsumption of resources, and of the 'material flows' that make up both the linear, and circular economies. Shaped by design, technological innovation and the pricing of goods, consumption, like design and technology cuts across or influences almost every discussion of wastes, resources, services and their respective values. What consumers want or value shapes their engagement in the economy, and can contribute directly not only to materials chosen for use, but also to what is wasted, and ultimately to the economy's larger environmental impacts.

Involving over 40 researchers from around the world, including many from Australia and China, from both developed and developing nations, this collection of essays is unique in suggesting how the circular economy concept can become a vehicle for transitioning towards a more sustainable society, and how it can also be used as a lens through which more effective responses to now common environmental problems can be designed and developed. From the vantage point of the many disciplines represented here, the circular economy has rapidly become a useful framework for understanding and developing solutions to some of the worst of today's environmental problems.

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