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Towards a Circular Economy: Converting Waste and Biomass to Energy Products

https://publications.csiro.au/publications/#publication/PIcsiro:EP198379

Roberts, Daniel. Towards a Circular Economy: Converting Waste and Biomass to Energy Products. In: The Fibre Value Chain Annual Conference; 10-12 December 2019; Melbourne, Australia. Appita; 2019.

Abstract

As circular economy principles become embedded worldwide, recovery of energy and materials from waste streams is seen as a critical component of sustainable waste management. Traditional combustion-based pathways for energy-from-waste have played an important role in the past; however, as the expectation of a greater recovery of energy and materials grows, new technologies are likely to be needed--and we are seeing impacts of this already across Europe. This keynote presentation discusses some of the alternative waste treatment technologies that, in addition to energy recovery, provide pathways to integrate waste management with the production of fuels, chemicals, and other products.

http://hdl.handle.net/102.100.100/299296?index=1

Access: Public

Record Identifier: csiro:EP198379

- 2019-12-12
- Conference Material
- DOI:

Waste Innovation for a Circular Economy - A summary report for the CSIRO Cutting Edge Science and Engineering Symposium

https://publications.csiro.au/publications/#publication/PIcsiro:EP195506

Boxall, Naomi; King, Sarah; Kaksonen, Anna; Bruckard, Warren; Roberts, Daniel. Waste Innovation for a Circular Economy - A summary report for the CSIRO Cutting Edge Science and Engineering Symposium. Australia: CSIRO; 2019.

https://doi.org/10.25919/5d72acc85c7f2

Abstract

The Circular Economy is a regenerative system in which primary material inputs and wastes, emissions and energy leakage are minimised by slowing, closing and narrowing material and energy loops. Sustainable materials management, achieved at all stages of a value chain, increases value adding to materials and resources. In addition to environmental benefits, the Circular Economy represents a significant business opportunity for Australia. The Circular Economy will be worth $4.5 trillion worldwide and it is estimated that a 5% improvement in material efficiency could represent a $24 billion increase to Australia's economy. To support the drive towards a Circular Economy in Australia, CSIRO convened a Cutting Edge Science and Engineering Symposium titled "Waste Innovation for a

Circular Economy" in Melbourne Victoria on May 27-29, to discuss the opportunities, barriers and strategy for transitioning Australia to a Circular Economy. There were 90 delegates, including international and Australian researchers, State, Local and Regional government, agencies and regulatory bodies, industry, community members and educators. This report provides a summary of the symposium, including a full list of delegates, summary of technical presentations and outcomes of workshopping. The report also provides recommendations for actions that are required to support the development of a Circular Economy in Australia, noting that Australia is in a strong economic and political position to embrace the Circular Economy opportunity. Australia's innovation system and the innovation capacity of Australian businesses will enable the delivery of a Circular Economy for Australia.

Access: Public

Record Identifier: csiro:EP195506

- 2019-08
- Report
- DOI: https://doi.org/10.25919/5d72acc85c7f2

Addressing Technical Barriers to Urban Waste-to-Energy in Australia

https://publications.csiro.au/publications/#publication/PIcsiro:EP183961

Roberts, Daniel; Hla, San; Ilyushechkin, Alex; Harris, David. Addressing Technical Barriers to Urban Waste-to-Energy in Australia. In: The 9th International Freiberg Conference on IGCC & XtL Technologies; 3-8 June, 2018; Berlin, Germany. TU Bergakademie Freiberg; 2018. 1.

http://hdl.handle.net/102.100.100/86930?index=1

Abstract

There is growing interest in establishing industrial-scale waste-to-energy projects in Australia. Many of those in the planning stage are targeting combustion or gasification of MSW, and there is also a growing problem of biosolids management particularly associated with costs related to transporting biosolids to agricultural lands which usually locate far away from waste water plant. Understanding these waste streams and how their properties impact technology choice and performance is an important aspect of derisking industrial scale projects. MSW is highly heterogeneous, and contracts are usually made on tonnages (and not important criteria such as energy content). Biosolids are far more homogeneous, but contain high moisture and potentially troublesome mineral matter species. As part of a wider study into the thermochemical behaviour of urban waste streams, conversion characteristics of MSW and biosolids have been studied at the laboratory scale. MSW samples were classified into their key components, and detailed analyses of these undertaken in terms of composition and energy content. Pyrolysis behaviour of biosolids was tested over the temperature range 250–1000°C, and chars of MSW components and biosolids were characterised on the basis of their conversion reactivities. Compositional changes in mineral matter produced from different char samples were analysed using X-ray diffraction analysis (XRD). This work has highlighted components of MSW that are particularly important in controlling the calorific value of MSW streams, and provides insights into how regional and climatic variations may have an impact. This work also shows how the feedstock composition changes during conversion due to the different behaviour of MSW components. We also show how particular inorganic species can become significant for specific feedstocks. The relatively high amount of Fe/P compounds found in biosolids char, for example, reduces significantly during gasification, and almost all sulfur and zinc along with some additional phosphorus is lost during mineral matter transformations at high temperatures (>760°C). Minerals content in dried biosolids can be high and can have an active role in gasification reactions. Understanding mineral matter transformation processes is therefore important to the selection of suitable technologies and managing the properties of, and potential utilisation opportunities for, by-products (e.g. the utilisation of biosolids' ashes as fertilisers).

Publisher

TU Bergakademie Freiberg

Access: Public

Record Identifier: csiro:EP183961

- 2018-06-05
- Conference Material
- DOI:

Importance of regional compositional changes of municipal solid waste (MSW) on their impact on overall enregy content

https://publications.csiro.au/publications/#publication/PIcsiro:EP177988

Hla, San; Roberts, Daniel. Importance of regional compositional changes of municipal solid waste (MSW) on their impact on overall enregy content. In: Australian Waste-to-Energy Forum; 20-22 February 2018; Ballarat, VIC. AIEN (Australian Industrial Ecology Network); 2018. 10.

http://hdl.handle.net/102.100.100/87212?index=1

Abstract

The variable nature of the characteristics of MSW fuels can cause serious problems with respect to the operation of WtE plants, such as unsystematic waste feeding, unstable combustion/gasification, and poor function of air pollution control devices. International experience tells us that the successful and sustainable operation of WtE plants strongly depends on understanding the characteristics of the waste streams and how they change with geography, seasons, and economic development. It follows that the impact of feedstock variation remains one of the biggest technical risks with any WtE project, regardless of the technology chosen. In Australia, information regarding the detailed thermochemical analyses of urban waste streams and how they might vary is still very limited, despite a number of WtE projects under development. In this study, we analyse physical compositions and chemical characteristics of municipal solid waste (MSW) samples using data from two major cities in Australia. The results show how low energy content portions of MSW and their moisture contents impact on the overall energy content of MSW, and provide some insights into how we can develop tools to model and predict these impacts. We also discuss the importance of pre-treatment and sorting of MSW to managing overall energy contents and ultimately how pre-treatment and pre-sorting can impact on emissions levels of raw flue gas estimating by a mass balance approach assuming possible realistic operating conditions. **This analysis suggests that uncertainties in properties of feed MSW is one of the main risk factors for meeting the regulated emission limits.**

Access: Public

Record Identifier: csiro:EP177988

- 2018-03-02
- Conference Material
- DOI:

Some insights into the thermochemical conversion behaviour of SEQ urban waste streams

https://publications.csiro.au/publications/#publication/PIcsiro:EP176379

Hla, San; Sujarittam, Nuttaphol; Ilyushechkin, Alex; Roberts, Daniel. Some insights into the thermochemical conversion behaviour of SEQ urban waste streams. In: 6th Sino-Australian Symposium on Advanced Coal and Biomass Utilisation Technologies; 4 – 8 December 2017; Perth, Western Australia. Sino-Australian Symposia Series; 2017. 1.

http://hdl.handle.net/102.100.100/87486?index=1

Abstract

There is growing interest in establishing large-scale waste-to-energy projects in Australia. Most of those in the planning stage are targeting combustion or gasification of municipal solid wastes (MSW), and there is a growing problem of biosolids management: for example, in the South East Queensland region, 150,000 wet tonnes of biosolids are generated per year, and transporting these to the approved far-field agricultural lands alone can cost approximately $10 million. Understanding waste streams and how their properties impact technology choice and performance is an important aspect of de-risking waste-to-energy projects. MSW is highly heterogeneous, and contracts are usually made on tonnages (and not based on important criteria such as energy content). Biosolids are far more homogeneous, but contain high moisture and mineral matter, often containing troublesome species. As part of a wider study into the thermochemical behaviour of urban waste streams, thermochemical conversion characteristics of MSW and biosolids have been studied at the laboratory scale. MSW samples were classified into components, and detailed analyses of these undertaken in terms of composition and energy content. Pyrolysis behaviour of biosolids were tested at a range of temperatures from 250–1000°C, and chars of MSW components and biosolids were characterised for their conversion reactivities. Compositional changes in mineral matter produced from different char samples from biosolids were analysed using X-ray diffraction analysis (XRD). Importantly, the moisture variations in food wastes and green garden wastes played a significant role in the energy content of MSW, as did the amount of high energy plastics. While volatile yields of all components were fairly high, there were two orders of magnitude difference in gasification reactivities of different residues. Pyrolysis of biosolids begins around 250°C, with secondary pyrolysis processes starting around 500°C mainly from organic matters. Significant amount of volatilisation from mineral matter occurs at temperatures higher than 800°C, and these transformations are potentially more important to understanding biosolids conversion than the traditional concept of char conversion reactivtiy. The high amount of Fe2P found in pyrolysis char reduces significantly during gasification, and almost all sulfur and zinc, along with some additional phosphorus, is lost during mineral matter transformations at high temperatures (>760°C). Minerals content in dried biosolids high and actively participates during gasification reactions so that understanding of mineral matter transformation assist the selection of the technology in terms of production of by-products (i.e. biosolids' ashes utilisation as fertilizers).

Publisher
Sino-Australian Symposia Series

Access: Public

Record Identifier: csiro:EP176379

- 2017-12-08
- Conference Material
- DOI:

Characterising municipal solid waste and biosolids for waste-to-energy applications: Insights into effects of compositional variations and inorganic species

https://publications.csiro.au/publications/#publication/PIcsiro:EP178458

Hla, San; Sujarittam, Nuttaphol; Ilyushechkin, Alex; Roberts, Daniel. Characterising municipal solid waste and biosolids for waste-to-energy applications: Insights into effects of compositional variations and inorganic species. In: Bioenergy Australia Conference 2017; 20-23 November 2017; Sydney, NSW. Bioenergy Australia; 2017. 1.

http://hdl.handle.net/102.100.100/87657?index=1

Abstract
Deployment of WtE technologies in Australia is overdue compared to other developed countries in Europe and Asia. It is clear that there are a range of established, safe, viable WtE technologies, many of which may be suitable in the Australian context. It is also clear that from a technical perspective**, one of the largest technical risks of any WtE project are related to feedstock**: securing supply, and ensuring that its composition and properties are suitable for effective operation for the life of the

project. As part of a wider program of work characterising different waste streams for their use in a range of thermochemical conversion technologies, here we analyse physical compositions and chemical characteristics of municipal solid waste (MSW) samples using data from two major cities in Australia. The results show how different domestic waste collection and management systems impact on the overall energy content of MSW those end up in landfill sites. We also discuss the importance of sorting of MSW to managing overall energy contents and ultimately on emissions levels of raw flue gas. This work has also studied thermochemical conversion characteristics of biosolids collected from a waste water treatment plant in Brisbane. Here we have characterised the biosolids in terms of moisture contents, their energy contents, their behaviour under different pyrolysis temperatures, the conversion reactivities of biosolid chars, and mineral matter transformations under different operation conditions. These transformations were shown to be important, as the mineral matter (ash) content in dried biosolids is high and actively participates during the gasification reactions.

Publisher
Bioenergy Australia

Access: Public

Record Identifier: csiro:EP178458

- 2017-11-20
- Conference Material
- DOI:

R& D Addressing Technical Barriers to Gasification-based Waste to Energy

https://publications.csiro.au/publications/#publication/PIcsiro:EP17794

Roberts, Daniel; Hla, San; Harris, David; Ilyushechkin, Alex. R&D Addressing Technical Barriers to Gasification-based Waste to Energy. In: The 42nd International Technical Conference on Clean Energy (Clearwater); June 11-15, 2017; Clearwater, Florida USA. Clearwater Clean Energy Conference; 2017. 1.

http://hdl.handle.net/102.100.100/88478?index=1

Abstract
Gasification-based systems play an important role in the wider waste-to-energy (WtE) spectrum, due to their flexibility in terms of scale and product. While there are many waste-gasification-based projects around the world in the operational and planning stage, there remains a high level of perceived technical risk (associated with feedstock and gasification technology) and, perhaps consequentially, a poor view of project economics, which present as the most common barriers to more widespread investment. Due to the unique chemistry of gasification-based systems, gasification projects must be approached with a different philosophy to those based on more traditional combustion boilers. Furthermore, managing issues of scale-up and feedstock variability requires an excellent understanding of the process fundamentals—there is international experience to demonstrate the importance of these considerations to project success. This presentation will give an overview of the role of gasification in a successful energy-from-waste industry. It will also discuss some recent work studying feedstock variability, gasifier performance, and syngas quality, and how some targeted research early in a project can provide important insights into getting this combination right.

Publisher
Clearwater Clean Energy Conference

Access: Public

Record Identifier: csiro:EP17794

- 2017-06-13

- Conference Material
- DOI:

Nimble, Net-Negative-CO2 Electricity from Biomass

https://publications.csiro.au/publications/#publication/PIcsiro:EP175264

Ilyushechkin, Alex; Wibberley, Louis; Roberts, Daniel. Nimble, Net-Negative-CO2 Electricity from Biomass. In: 42nd International Conference on Clean Energy (Clearwater); 12-15 June 2017; Clearwater, Florida. Clearwater Clean Energy Conference; 2017. 9.

http://hdl.handle.net/102.100.100/88484?index=1

Access: Public

Record Identifier: csiro:EP175264

- 2017-06-13
- Conference Material
- DOI:

The CO2 Gasification Reactivity of Chars produced from Australian Municipal Solid Waste

https://publications.csiro.au/publications/#publication/PIcsiro:EP162019

Hla, San; Lopes, Romain; Roberts, Daniel. The CO2 Gasification Reactivity of Chars produced from Australian Municipal Solid Waste. Fuel. 2016; 185:847-854.

https://doi.org/10.1016/j.fuel.2016.08.039

Abstract
Technical risk and unfavourable project economics are often touted as barriers to successful waste-to-energy systems. Understanding feedstock behaviour, and how this impacts technology selection and operation, is a key aspect to addressing the technical risk component. In gasification systems, feedstock reactivity to CO2 is one of the factors that are known to contribute significantly to feedstock behaviour. In this work, the reactivities of char samples from components of municipal solid waste (MSW) to CO2 were characterised as part of a wider study into gasification behaviour of waste streams. As expected, gasification rates of wood waste and garden waste chars are comparable to those from other biomass fuels. The least reactive chars were found to be those produced from textiles and printing papers. There were two orders of magnitude differences in the rates of the least reactive and most reactive components, which has significance for our understanding of how the composition of the material in a waste gasifier changes with time. Furthermore, we demonstrated a good closure between calculated rates (based on properties of individual components) and rates measured for the entire MSW sample. This shows that this study has a broader applicability, and could be extended to estimate the gasification behaviour of MSW streams of different compositions in a range of gasification technologies.

Publisher
Elsevier

Access: Public

Record Identifier: csiro:EP162019

- 2016-12-01
- Journal Article
- DOI: https://doi.org/10.1016/j.fuel.2016.08.039

Addressing the technical barriers to gasification based Waste-to-Energy systems

https://publications.csiro.au/publications/#publication/PIcsiro:EP166698

Roberts, Daniel; Hla, San. Addressing the technical barriers to gasification based Waste-to-Energy systems. In: The 1st Australia-Japan Symposium on Carbon Resource Utilisation; 27-30 November, 2016; Melbourne, Australia. CSIRO; 2016. ..

http://hdl.handle.net/102.100.100/89330?index=1

Abstract
A range of technologies is required for effectively harnessing the renewable energy embodied in our agricultural, industrial, and urban waste streams. Gasification-based systems offer flexibility in terms of scale and product, and will play an important role in a viable energy-from-waste industry in Australia. However, the variety of technological options available, and the challenges associated with selecting the right technology for a specific feedstock, lead to considerable uncertainty which increases the perceived risk (and cost), and which presents a barrier to widespread demonstration and deployment. In Australia, there is a growing interest in gasification-based approaches for waste-to-energy as part of urban waste management systems and forestry or agricultural operations. However, there is very little technical data and information regarding the thermochemical characteristics and gasification behaviour of the waste streams—in particular the highly heterogeneous and variable urban wastes. Such data are required to ensure appropriate feedstock–technology–product matches, and to support project design and delivery to reduce the chances of failure. To fill these requirements and to support the development and deployment of alternative urban waste management, we are investigating the gasification behaviour of a range of urban and agricultural waste streams. This presentation will give an overview of the role of gasification in a successful WtE industry and, as well as some results from recent and ongoing studies on the investigation of thermochemical conversion behaviours of Australian urban wastes. These include characterisation in terms of thermo-physical properties, pyrolysis and gasification fundamentals of municipal solid waste, green waste and biosolids.

Publisher
CSIRO

Access: Public

Record Identifier: csiro: EP166698

- 2016-11-29
- Conference Material
- DOI:

Addressing the barriers to greater penetration of gasification-based bioenergy

https://publications.csiro.au/publications/#publication/PIcsiro:EP164421

Hla, San; Roberts, Daniel. Addressing the barriers to greater penetration of gasification-based bioenergy. In: Bioenergy Australia Conference 2016; 14 - 16 November 2016; Brisbane, Queensland. Committee of BioEnergy Australia Conference 2016; 2016. 1.

http://hdl.handle.net/102.100.100/89383?index=1

Abstract
Since the energy crisis of the 1970s research, development, and deployment of gasification technologies has increased, primarily due to its flexibility in terms of feedstocks, products, and applications. We have seen how gasification has allowed coal to be used as a feedstock for low emissions, high efficiency power as well as the production of chemicals, fuels, SNG, fertilisers, plastics, etc.: there are more than 140 large-scale commercial gasification plants, with many more under construction, mainly in China. Development of biomass gasification technologies began in earnest in the US in the late 1980s, followed by Western European countries then later in 2000s by Japan and

China. While there are thousands of small scale gasifiers in use in Asia, unlike coal gasification, widespread deployment of biomass gasification at significant commercial scale is limited. The main barriers to commercialisation of biomass-gasification-based technologies are high initial investment cost (especially for first-of-a-kind plant), complexities in pretreatment systems, problems associated with low energy density and seasonal availability, and tar production and its implications on gas cleaning. Nevertheless, biomass gasification has been successfully deployed in some specific markets and industries (e.g. where government subsidies and favorable policies align, such as some European countries with good biomass availability and strong governmental support for renewables and the Japanese Government's policy on strict landfill regulation). It is clear that gasification has potential to offer a scalable, flexible means for increasing the penetration of bioenergy into Australia's energy systems, operating in spaces where other approaches (such as digestion or combustion) are less practicable. In this review, insights into the development of biomass gasification technologies for both small and medium scales, their advantages and drawbacks, driving forces and essential R&D required for penetrating into local bioenergy markets are discussed.

Publisher
Committee of BioEnergy Australia Conference 2016

Access: Public

Record Identifier: csiro:EP164421

- 2016-11-14
- Conference Material
- DOI:

Reducing the technical risk in gasification-based EfW: Feedstock, gasifier, and syngas science

https://publications.csiro.au/publications/#publication/PIcsiro:EP166697

Roberts, Daniel; Hla, San; Harris, David. Reducing the technical risk in gasification-based EfW: Feedstock, gasifier, and syngas science. In: National Energy from Waste Conference 2016; 25-27 October 2016; Sydney, NSW. Waste Management Association of Australia; 2016. ..

http://hdl.handle.net/102.100.100/89478?index=1

Abstract
Gasification-based systems fill an important role in the wider EfW spectrum, in particular in Australia, as flexibility is being sought after in terms of scale and product: the EfW technology mix needs to be able to support more than large-scale boilers for steam and electricity. **Contrary to many opinions,** gasification does work; however, by approaching gasification projects with the same philosophy as those used in traditional boiler-based systems (or other technology suites) the technical risk is increased, and the chances of failure are high. The unique chemistry of gasification-based systems, combined with the wide range of technology options from which to choose and the impact these have on feedstock behaviour means that a gasification project needs a strong technical foundation. This ensures that feedstocks and gasifiers are appropriately matched, that this combination produces a syngas that is suitable for the application, that feedstock preparation requirements are addressed, and that the scale of the gasifier and downstream plant are appropriate for the feedstock being used. This presentation will give an overview of the role of gasification in a successful energy-from-waste industry. It will also discuss in detail the impacts of feedstock and gasifier variability on gasifier performance and syngas quality, and how some targeted research early in a project can provide important insights into getting this combination right.

Publisher
Waste Management Association of Australia

Access: Public

Record Identifier: csiro:EP166697

- 2016-10-27
- Conference Material
- DOI:

A Characterisation of the Ash Formed from Gasification of Biomass Waste

https://publications.csiro.au/publications/#publication/PIcsiro:EP161439

Ilyushechkin, Alex; Hla, San; Roberts, Daniel; Harris, David. A Characterisation of the Ash Formed from Gasification of Biomass Waste. In: 8th International Freiberg Conference on IGCC&Xtl Technologies; 12-16 June; Freiberg, Germany. TU Bergakademie Freiberg; 2016. 10.

http://hdl.handle.net/102.100.100/90310?index=1

Abstract
Gasification of biomass waste streams (e.g. timber mill residue, urban green waste) is an attractive option to both address emerging waste management issues and utilise a largely-untapped renewable energy resource. Gasification-based systems offer flexibility in scale, feedstock, and especially in varieties of end applications. As with any gasification system, a good understanding of the mineral matter behaviour of different feedstocks under different gasification conditions is an important in order to avoid gasifier operational problems associated with ash or slag produced. **The nature of the residue is also important, as some trace species commonly found in urban waste streams can be problematic to the beneficial use of ash or slags.** Two types of biomass waste (wood chips and urban green waste) were recently tested using CSIRO's fixed-bed research biomass gasifier. This paper presents a characterisation of the ashes produced during this gasification over the temperature range 900–1100ºC, and compares these compositions with ashes prepared by low temperature ashing of the feedstock in oxidizing condi-tions. It was found that wood chips have low ash content (~0.6–0.8wt.%) and the ashes contain predominately Ca-rich phases. Urban green wastes have higher ash levels (~6.8–9.5wt.%), which is rich in Si and Ca. The main difference in ash mineralogy is associated with Ca-species which formed different phases under gasification and combustion conditions. The composition of ashes produced at different temperatures and atmospheres were also calculated using thermodynamic modelling tools, and the impact of temperatures and ash chemistry on operational limits are discussed.

Publisher
TU Bergakademie Freiberg

Access: Public

Record Identifier: csiro:EP161439

- 2016-06-15
- Conference Material
- DOI:

Insights into woody biomass gasification using a research gasifier

https://publications.csiro.au/publications/#publication/PIcsiro:EP156589

Hla, San; Roberts, Daniel. Insights into woody biomass gasification using a research gasifier. In: BioEnergy Australia Conference 2015; 30 November- 2 December 2015; Launceston, Tasmania. BioEnergy Australia; 2015. 1.

http://hdl.handle.net/102.100.100/91354?index=1

Abstract
Woody waste streams (e.g. timber mill residue, urban green waste) represent a largely-untapped renewable energy resource; those that are utilised are usually combusted for power generation at a

range of scales and efficiencies. Gasification-based systems offer flexibility in scale, feedstock, and application, and can be used to broaden the base of waste utilisation in Australia. Sub-tropical and tropical municipalities in Australia face considerable challenges with the volume of green waste requiring management, with much of it not being reused as compost due to the disparity between supply and demand. Energy contents of green wastes are as high as wood wastes (on a dry basis) as they primarily consist of garden waste mainly prunings, palm fronds, grass clippings and branches. Their use as an energy feedstock, however, remains limited. CSIRO operates a research scale biomass gasifier, designed to convert solid biomass fuels into useful synthesis gas, which can be further integrated in our research gas processing and power generation facilities. This paper presents the results of recent investigations using this gasifier, whereby it was used to gasify woody biomass to investigate the effects of air ratios and staging on gasifier performance. Effects of moisture content on the performance of gasification process were also explored. The results showed that an optimum equivalence ratio was found to be about 0.34 yielding the cold gas efficiencies of biomass gasifier approximately 70%. Under this optimum operating condition, the lower heating value (LHV) of syngas produced was found to be 4.3 MJ/Nm^3 and, the peak temperature of combustion zone was observed as high as 1050°C high enough to crack the tars inside gasifier. These data are important to the assessment of feasibility and economics of different waste-to-energy concepts.

Publisher

BioEnergy Australia

Access: Public

Record Identifier: csiro:EP156589

- 2015-11-30
- Conference Material
- DOI:

Gasification behavior of municipal solid waste (MSW)

https://publications.csiro.au/publications/#publication/PIcsiro:EP156470

Hla, San; Romain, Lopes; Roberts, Daniel. Gasification behavior of municipal solid waste (MSW). In: BioEnergy Australia Conference 2015; 30 Nov- 2 Dec 2015; Launceston, Tasmania. BioEnergy Australia; 2015. 1.

http://hdl.handle.net/102.100.100/91353?index=1

Abstract

Waste-to-energy (WtE) processes are an important aspect of sustainable waste management. All major developed countries in Western Europe and some from Asia (i.e. Japan, Taiwan and Singapore) convert more than 35% of their municipal solid waste (MSW) into useful energy via different WtE processes. Australia is at an early stage of adoption of modern WtE technologies, with three major WtE projects in WA recently receiving approval. To support the development of a broader WtE industry in Australia, CSIRO is undertaking a R&D program addressing aspects of gasification of a wide range of waste streams. Though there are many waste gasification plants operating around the world, detailed studies on gasification behavior of MSW are scarce. This work presents some results from a study of the gasification behavior of the different components of MSW. In this work, samples of the 'combustible' components of MSW were pyrolysed at 900°C and their char gasification reactivities determined for the first time. As expected, gasification rates of wood wastes and garden wastes are comparable to those of other biomass fuels. The least reactive components in MSW were found to be food waste, textiles and printing papers. There were orders of magnitude differences in the rates of the least reactive and most reactive components, which has significance for our understanding of how the composition of the material in a waste gasifier changes with time. To demonstrate this, the gasification rates of each MSW component were used to calculate the conversion rate of the entire MSW sample, taking into account the original composition and physical properties of each component. This result was then compared with measured values and found that they are in good agreement. This closure demonstrates that this

study has a broader applicability, and could be extended to estimate the gasification behavior of MSW streams of different compositions.

Publisher
BioEnergy Australia

Access: Public

Record Identifier: csiro:EP156470

- 2015-11-30
- Conference Material
- DOI:

Mineral matter interactions during co-pyrolysis of coal and biomass and their impact on intrinsic char reactivity

https://publications.csiro.au/publications/#publication/PIcsiro:EP15498

Ellis, Naoko; Masnadi, Mohammad; Roberts, Daniel; Kochanek, Mark; Ilyushechkin, Alex. Mineral matter interactions during co-pyrolysis of coal and biomass and their impact on intrinsic char reactivity. Chemical Engineering Journal. 2015; 279(. .):402-408.

https://doi.org/10.1016/j.cej.2015.05.057

Abstract
Gasification of blends of biomass and coal can offer renewable fuels the scale and extent of deployment usually associated with fossil fuels. For significant penetration of renewables, however, co-utilization of significant quantities of biomass is required, which significantly impacts process performance. At a fundamental level, char reactivity affects many practical aspects of gasifier operation, and is complicated by the influence of blends of coal and biomass and their different behaviour during devolatilization. In this work, intrinsic gasification reaction kinetics of chars from biomass and coal mixtures with different proportions were studied: one set of chars produced separately and mixed prior to gasification; and another with chars produced from co-pyrolysis of biomass–coal blends. Lower specific and intrinsic rates were observed for the samples where the biomass and coal were pyrolyzed together than when they were pyrolyzed separately, suggesting some interaction during devolatilization that affects reactivity behaviour. XRD results showed that the catalytically-active calcium species in the biomass interacted with the aluminosilicate species in the coal mineral matter to form Ca2Al2SiO7 (gehlenite) crystals, which are catalytically inert. The conversion of catalytically-active Ca to catalytically-inactive Ca may have led to lower reactivity of co-pyrolyzed mixtures, highlighting the importance of understanding the type and nature of often catalytically-active species when investigating the gasification behaviour of blends of coal and biomass materials.

Publisher
Elsevier

Access: Public

Record Identifier: csiro:EP15498

- 2015-11-01
- Journal Article
- DOI: https://doi.org/10.1016/j.cej.2015.05.057

Characterisation of Chemical Composition and Energy Content of Green Waste and Municipal Solid Waste from Greater Brisbane, Australia

https://publications.csiro.au/publications/#publication/PIcsiro:EP149913

Hla, San; Roberts, Daniel. Characterisation of Chemical Composition and Energy Content of Green Waste and Municipal Solid Waste from Greater Brisbane, Australia. Waste Management. 2015; 41:12-19.

https://doi.org/10.1016/j.wasman.2015.03.039

Abstract
The development and deployment of thermochemical waste-to-energy systems requires an understanding of the fundamental characteristics of waste streams, such as physical composition, chemical analysis, and energy content. Despite Australia's growing interest in gasification of waste streams, no data is available on their thermochemical properties. We present here, for the first time, a characterisation of green waste and municipal solid waste in terms of chemistry and energy content. The study took place in Brisbane, the capital city of Queensland. The moisture content of green waste ranged from 29–46%. This variability – and the tendency for soil material to contaminate the samples – was the main contributor to the samples' energy content, which ranged between 7.8 and 10.7 MJ/kg. The chemical composition of the green waste was consistent with that expected for woody biomass material. The municipal solid waste was hand-sorted and classified into 10 groups, including non-combustibles. The total moisture content of food wastes and garden wastes was as high as 70% and 60%, respectively, while the total moisture content of non-packaging plastics was as low as 2.2%. The chemical properties of the combustible portion of municipal solid waste were measured directly and compared with calculations made based on their weight ratios in the overall municipal solid waste, as well as their particular chemical properties. The results obtained from both methods were in good agreement. The overall energy content (lower heating value on a wet basis, LHVwb) of the municipal solid waste was 7.9 MJ/kg, which is well above **the World Bank-recommended value** for utilisation in thermochemical conversion processes.

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Energy content and chemical composition of municipal solid waste and green waste streams from Brisbane transfer stations

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Hla, San; Roberts, Daniel. ENERGY CONTENT AND CHEMICAL COMPOSITION OF MUNICIPAL SOLID WASTE AND GREEN WASTE STREAMS FROM BRISBANE TRANSFER STATIONS. In: Bioenergy Australia; 1-2 December 2014; Adelaide. Bioenergy Australia; 2014. 38.

http://hdl.handle.net/102.100.100/93537?index=1

Abstract
Urban wastes such as municipal solid waste (MSW) and green waste contain a significant amount of energy. This can be recovered as a source of renewable energy, reducing the amount of material diverted to landfill. Even though regular surveys have been conducted in the major cities of Australia to understand the composition of MSW, these only focus on the quantity and distribution of wastes, and determination of its energy and chemical characteristics have been out of scope. This work, therefore, has developed a systematic method for characterising urban waste streams in order to measure the energy content and chemical compositions. Three green waste samples from three different transfer stations in greater Brisbane were collected. The chemical composition of the green waste samples did

not vary significantly and was consistent with what might be expected for woody biomass material. Lower heating values of the green waste on a wet basis were found in the range 7.8–10.7 MJ/kg. Samples of nine combustible components from the MSW were collected and their chemical properties analysed separately. Total moisture contents of food wastes and garden wastes were found to be as high as 70% and 60% respectively (on a mass basis) while total moisture contents of wood wastes and other plastics were found to be as low as 12% and 2.2% respectively. Volatile matter contents of most components were in the range 70–80% except for plastics which contain more than 90% volatile matter. The major factors contributing to the energy content of MSW could be identified as moisture contents, weight percentage of high energy components (e.g. plastics) and weight percentages of non-combustibles. The net energy content (LHVwb) of the MSW sample used in this study was found to be 7.9 MJ/kg which is above the **World Bank recommended minimum energy for waste**-to-energy applications.

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Gasification for Energy-from-Waste: Technologies, Applications, and R&D Needs

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Roberts, Daniel; Hla, San. Gasification for Energy-from-Waste: Technologies, Applications, and R&D Needs. In: Bioenergy Australia 2014 Conference; 1-2 December 2014; Adelaide. Bioenergy Australia; 2014. ..

http://hdl.handle.net/102.100.100/93547?index=1

Abstract
Current energy from waste systems are usually based on combustion technologies, with high quality emissions control systems leading to routine compliance with strict local environmental laws and regulations. Advanced energy from waste technologies now include gasification-based systems, offering feedstock and product flexibility and efficient operation even at small scales. **A successful energy from waste industry in Australia will need to have both combustion and gasification systems as part of the technology mix; there are some fundamental aspects of gasification**, however, that are poorly understood, and targeted R&D is required to support their widespread deployment in Australia. This paper will give an overview of the gasification process, highlighting some of the aspects of the process that differentiate it from combustion and pyrolysis. These differences will be discussed in the context of EfW policy development, and used to show how gasification-based systems can be particularly suited to the conversion of many urban and agricultural waste streams to energy products. The role of R&D in supporting gasification-based energy from waste is also discussed, with particular emphasis on the importance of understanding feedstock behaviour as well as the selection of the end product (i.e. thermal, electricity, liquid fuels or chemicals) and how these can influence technology choice.

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- DOI:

Waste to Energy: Review of Thermochemical Waste Conversion Technologies

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Hla, San; Cousins, Ashleigh; Roberts, Daniel. Waste to Energy: Review of Thermochemical Waste Conversion Technologies. Brisbane, Australia: CSIRO; 2014.

http://hdl.handle.net/102.100.100/94319?index=1

Abstract
Urban waste streams in Australia are an untapped renewable energy resource. The space available for landfilling of urban wastes is decreasing in our major cities, and the methane produced by landfilled municipal solid waste (MSW), green waste, and biosolids is now recognised as a significant and long-term source of greenhouse gas emissions. Local authorities, state and federal governments, and the waste management industry now recognise the opportunity provided by the conversion of the energy in urban waste streams into renewable power or other energy products. **Whether this is called 'energy-from-waste' (EfW) or 'waste-to-energy' (WtE), there is a clear international precedent that modern plants are clean and efficient**; with appropriate technology choice, it is technically feasible for a waste-to-energy industry to be developed in Australia. There are significant differences between combustion-based processes and those based on gasification, having implications for plant scale, feedstock matching, project economics, public acceptance, and product choice. This report reviews the international state-of-the-art in waste-to-energy technologies, discussing the combustion-based systems common in Europe and the US (where atmospheric emissions are tightly regulated) and the gasification-based systems in Japan (where there are additional requirements on ash melting and utilisation). It also discusses some of the newer, emerging technologies based on gasification (or combinations of pyrolysis and gasification), some integrated with plasma systems for driving the gasification process or for cleaning of the gas produced. Given a good understanding of the properties of the waste stream, the local requirements of scale, and associated issues regarding 'social licence to operate', waste-to-energy in Australia is technically feasible. **There have been failures of local waste-to-energy projects; however these should not sound the death knell for future projects in Australia**. Rather, they should be used to highlight the importance of a detailed understanding of the thermochemical properties of the waste stream(s), the behaviour of these streams under different process conditions, and how this knowledge influences technology choice and operating strategies. **There are aspects of the economics of WtE systems that offer some challenges in the Australian context**. The importance of landfill taxes, levies, or fees in conjunction with legislative requirements on the success of WtE in Europe, the US and Japan is clear. We are now seeing the development of policies and strategies in state governments across Australia, which is providing some direction and guidance for project proponents. There remains a lack of information, however, regarding the economics of some of the more advanced and emerging technologies, in particular those based on gasification. **Without such insights, techno-economic analyses comparing the complete suite of options available for specific applications are not possible**. **This restricts the degree to which project proponents and local authorities can make informed decisions about technology options for Australian WtE projects.** The development of sound, coordinated policy, supported by local research, development and demonstration activities have the potential to overcome these technical and economic challenges and see waste-to-energy realised in Australia.

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Review of Thermochemical Energy-from-Waste Technologies: International Experience and Opportunities for Australia

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Hla, San; Roberts, Daniel. Review of Thermochemical Energy-from-Waste Technologies: International Experience and Opportunities for Australia. In: National Energy from Waste Symposium; 23-24 July 2014; Lorne, Victoria. WMAA; 2014. 14.

http://hdl.handle.net/102.100.100/94480?index=1

Abstract
There is steadily increasing interest in Australia in opportunities to recover the energy contained in urban waste streams. The most prospective technologies in this regard seem to be thermochemical systems, used extensively in Europe and Japan where Government policies have been put in place to minimise the amount of waste ending up as landfill. **Poor economics and failed attempts in the past are often cited as barriers to the successful deployment of such systems in Australia,** yet international examples show that, given an appropriate understanding of the waste streams and the technology of choice, they offer a viable solution to the problems associated with landfilling, whilst increasing the penetration of renewables into the energy sector. This review considers the state-of-the-art in thermochemical conversion technologies most suitable for conversion of urban waste streams, using experience and insights from around the world. A number of technologies from conventional waste-to-energy plants (such as moving grate incineration and fluidised bed combustion) to more advanced novel gasification based systems (e.g. direct melting, twin internally revolving fluidised bed, plasma assisted waste gasification) is assessed in order to provide a better understanding of some of the technical requirements and issues associated with these technologies. This information is required as part of any process to select technically viable options for efficient and effective solid waste conversion in Australia. Some perspectives on previous Australian attempts at waste conversion via gasification are given, suggesting that targeted R&D and the right economic conditions should lead to the realisation of a WtE capability in Australia.

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Removing Barriers to Deployment of Fuels-From-Waste and Low Emissions Coal Technologies in Australia

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Roberts, Daniel. Removing Barriers to Deployment of Fuels-From-Waste and Low Emissions Coal Technologies in Australia. In: 63rd Canadian Chemical Engineering Conference; 20-23 October 2013; Fredericton, New Brunswick, Canada. Canadian Society for Chemical Engineering; 2013. 1 p.

http://hdl.handle.net/102.100.100/96255?index=1

Abstract
Energy supply in a carbon constrained world requires efficient coal-based technologies and consideration of new, renewable sources of energy. High efficiencies, product flexibility, and their amenity to CO2 capture mean that coal-gasification-based systems have a role to play in the future energy mix. The problem of urban waste management coupled with its greenhouse gas liability if left to landfill are motivations for the deployment of technology solutions for the efficient conversion of a range of waste streams to energy products. The individual process steps that make up these solutions have been proven in a range of energy and chemical industries. R&D is required to support the pilot-scale research and subsequent demonstration of these technologies for specific applications, in particular in Australia where there are no large-scale gasification installations. For coal-based systems issues of fuel suitability, gasifier design, syngas processing scale and cost, and product economics are important. To remove barriers to waste gasification for the production of a range of energy products an understanding of the handling, preparation, and gasification behaviour of waste streams is required, as is a sound techno-economic framework for decision making and feedstock-technology-product matching. CSIRO has a strong track record in understanding the gasification behaviour of a range of carbonaceous feedstocks, using these fundamentals as the basis for feedstock-technology matching, fuel selection, and techno-economic assessment of different feedstock-to-product combinations. This presentation gives an overview of CSIRO's research in these areas, giving a perspective of the global scale of some of the challenges, and some insights into the emerging research issues.

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