EERC RESPONSE TO TECHNICAL REVIEWERS' COMMENTS
R011-C

Trace Element Measurements During Biomass Gasification

Energy & Environmental Research Center
Principal Investigator: Nicholas Lentz
Request for $250,000; Total Project Costs $500,000

1. The objectives or goals of the proposed project with respect to clarity and consistency with North Dakota Industrial Commission/Renewable Energy Council:

Reviewer 3A (Rating: 3)
The overall goal of this proposal is to characterize (detect) trace elements in the biomass derived syngas. The objectives, however, are loosely put together and not well associated with the goal. The tasks do not reflect the objectives with integrity. Tasks 2 and 3 (which correspond to 2nd and 3rd objectives) are basically the same, even the language used is almost identical, except the feedstocks from which the syngas is generated are different. However, the significance of separating these two is not justified.

From reading the rest of the proposal, this reviewer understands that one aspect of the project is to evaluate the self-developed trace element testing ME-ST method and to compare with the reference EPA M29 method. The ME-ST method is being developed and claimed efficient and cost-effective, and promising in replace of the EPA M29 method. If so, it is a sound and valid objective for such a project. Otherwise, the proposed work as stated by the objectives would be considered an analytical routine for prestigious research institution like EERC in biomass gasification projects, not as an independent research project.

The proposed work is in support of biomass gasification projects and consistent with the ND Industrial Commission/Renewable Energy Council goals.

Reviewer 3B (Rating: 3)
The goal is to refine trace element analysis for gasification streams. Conventional methods are not well adapted to the reducing atmospheres of syngas. Trace element analysis is not as pressing a problem in bioenergy as it is in coal utilization. Thus, I scored this criterion lower for not being fully "consistent" with the NDIC/REC goals as I interpreted them.

Reviewer 3C (Rating:4)
The objectives were clear and trace elemental analysis is something that needs to be studied on the biomass gasification. It will provide a great technological contribution if an alternative method can be develop that is less expensive and reduces solvent use.

Response: *The EERC appreciates the opportunity to respond to the reviewers' comments. We agree in general with Reviewer 3B's assessment that current trace metal measurements in gasification systems are not as consistent as is needed for regulatory purposes and DSC feedback systems.*

For about two decades, the EERC has been conducting research into trace metals in gasification and combustion systems, as well as for other industries, with a particular emphasis on mercury. Much of this work has been conducted through the Center for Air Toxic Metals® (CATM®). In order to focus precious research funds on the most pressing needs, CATM has a Research Advisory Council (RAC) that provides feedback regarding the most urgent needs.

At conferences and workshops internationally, respondents consistently express the need for a reliable measurement method that overcomes the difficulties of a wet-chemistry method yet provides valid and reliable data. The Boiler MACT rule that was recently released by the U.S. Environmental Protection Agency (EPA) has indirect limits on trace metals by using particulate matter (PM) as a surrogate. Additionally, it is expected that the Utility MACT to be released March 15th will also require the reduction of trace element emissions.

Trace metal measurement in gasification systems has been very problematic and, as CO_2 control regulations are more likely and more distributive energy is being developed, the CATM RAC has given this area higher priority. Among the reasons noted for this need, respondents indicate that small gasification systems are more likely to use "opportunity" fuels and that variability in fuel quality is likely to cause greater problems at the small scale than in larger units. Fuel cell suppliers and microturbine manufacturers consistently caution that trace metals are problematic.

The multielement sorbent trap (ME-ST) method under development is useful for several trace metals, as well as for other elements, and has shown initial success in combustion systems, but gasification systems present a challenge as many unknowns still exist. Although the EERC is known for developing trace metal analytical methods, few understand the long, systematic process that is needed in development. As reviewers pointed out, combustion environments are not the same as those of gasification.

2. With the approach suggested and time and budget available, the objectives are: 1 – not achievable; 2 – possibly achievable; 3 – likely achievable; 4 – most likely achievable; or 5 – certainly achievable.

Reviewer 3A (Rating: 4)
The proposal does not set any measurable objectives other than to "characterize the trace element emissions", therefore, it is most likely achievable.

Reviewer 3B (Rating: 4)
The investigators apparently are proposing to continue development of an analytical method originally devised for analysis of trace elements released during coal gasification and apply it to biomass gasification. Although ASTM M29 has been established for measuring trace elements in combustion (oxidizing) environments, the reducing environment of syngas rapidly deplete the oxidizing solvents used to capture trace elements, reducing the effectiveness of this method for gasification environments. The investigators are exploring a non-solvent sorbent to overcome this difficult. It is hard to determine from the proposal how far along this method has previously been developed as no preliminary data is provided. Otherwise, I do not identify anything that would prevent the objects from being reached.

Reviewer 3C (Rating: 4)
The ME-ST method is already developed. Facility is capable to gasify biomass.

Response: *Currently, most of the data that have been obtained are from combustion environments. The EERC has a very small data set from gasification, which is being used for comparative purposes with the combustion data. The EERC will provide a more complete set of objectives and an initial scope of work at the review meeting on March 24 to demonstrate that we have carefully considered the test matrix needed to extend development to gasification regimes.*

3. The quality of the methodology displayed in the proposal is: 1 – well below average; 2 – below average; 3 – average; 4 – above average; or 5 – well above average.

Reviewer 3A (Rating: 3)
It is lack of details on methodology and no experimental plan in place. There are long paragraphs on the overall research and analytical capabilities at EERC, but not a detail on how the trace elements are to be characterized and by what means. It is even unclear what types trace elements are expected to be characterized in the project have they affect the characterization. There are not any preliminary data or literature analysis on how the trace elements would affect the emissions and/or syngas quality.

Reviewer 3B (Rating: 3)
The methodology section consisted of a workplan, which was sparse on details, making it difficult to judge whether the methodologies were adequate in terms of hypotheses to be evaluated and statistical methods to be applied.

Reviewer 3C (Rating: 3)
The methodology of the proposed project is adequate. Not a lot of detail on gasification conditions for the comparative study.

Response: *Because of both the length of the proposal and the proprietary nature of the proposed sampling method, the EERC did not provide greater detail on the application of the method and data that have already been obtained.*

Of the 14 gasifiers that exist at the EERC, the high-pressure fluidized-bed gasifier (HPFBG) has been chosen as the system on which the proposed tests will be conducted; this system is among those most often used in distributive energy environments and responds well to biomass, which is not the case for all gasifiers. The table below provides more details on the work plan and test conditions. While the focus of this project is on testing trace metals to replace EPA Method 29, we will also evaluate this method for measurement of potassium, as this alkali presents one of the most problematic issues with components.

Overall, the EERC expects to demonstrate that the ME-ST method can reliably measure the low concentrations of trace metals and will also evaluate its potential to measure potassium. This

method will be easy to use for both large-scale utilities and small-scale biomass gasifiers. The economy of this method relative to existing EPA methods is very important to this sector of biomass users, allowing them to buy or lease relatively inexpensive equipment; traps can be sent to an appropriate lab for analysis, without dealing with hazardous and problematic chemicals. The method is inherently flexible for various concentrations: sampling times are easily adjusted according to the expected concentrations.

The trace metals to be analyzed for include potassium, antimony, arsenic, beryllium, cadmium, chromium, cobalt, lead, manganese, mercury, nickel, and selenium. The elements will be collected on the ME-ST during the sampling process and recovered/analyzed in EERC laboratory using a proprietary process.

The HPFBG gasifier will be operated in a configuration that employs a filter vessel and quench pots. Typical syngas ranges for the HPFBG are included in Table 1. These ranges are anticipated for both switchgrass and wood fuels.

Table 1. Typical HPFBG Syngas Composition

Sample Location	H_2, mol%	CO, mol%	CO_2, mol%	N_2, mol%	CH_4, mol%	H_2S, mol%
Quench pot outlet	20–30	10–15	40–50	1–10	1–5	0.05–0.3

The test plan for Tasks 2 (with switchgrass) and 3 (with wood fuel) are similar and are summarized in Table 2. For each fuel, testing will consist of 6 sample sets to obtain sufficient data to average. It is important for the HPFBG to maintain stable operational conditions throughout the test plan so that the ME-ST data from each sampling period can be averaged and compared to the M29 data. All operational data such as temperatures and feed rate will be logged by the data acquisition system.

Table 2. Test Plan

Test Condition	Sample	Duration, hr	Sampling Location	Additional Syngas Sampling
Baseline		6		GC, LGA
Dual ME-ST, M29	1	1–2	Quench Pot Outlet	GC, LGA
Baseline		1		GC, LGA
Dual ME-ST, M29	2	1–2	Quench Pot Outlet	GC, LGA
Baseline		1		GC, LGA
Dual ME-ST, M29	3	1–2	Quench Pot Outlet	GC, LGA
Baseline		1		GC, LGA
Dual ME-ST, M29	4	1–2	Quench Pot Outlet	GC, LGA
Baseline		1		GC, LGA
Dual ME-ST, M29	5	1–2	Quench Pot Outlet	GC, LGA
Baseline		1		GC, LGA
Dual ME-ST, M29	6	1-2	Quench Pot Outlet	GC, LGA

4. **The scientific and/or technical contribution of the proposed work to specifically address North Dakota Industrial Commission/Renewable Energy Council goals** will likely be: 1 – extremely small; 2 – small; 3 – significant; 4 – very significant; or 5 – extremely significant.

Reviewer 3A (Rating: 4)
Trace element characterization and detection are important to biomass gasification for syngas and are in support of high quality syngas production. If the ME-ST method is successfully implemented in gasification system to approve its efficiency and cost-saving benefit as claimed by the proposal, it would be a great contribution to the biomass gasification industry. It would be a greater contribution to the advancement of instrumentation in trace element measurements.

Reviewer 3B (Rating: 2)
I thought it was telling that the investigators did not tabulate the expected concentrations of trace elements in biomass compared to coal and estimate the syngas concentration. This would reveal that the concentrations for biomass were very small, which means they are both difficult to detect and, more importantly, there is little reason to try to detect them. The investigators ignore potassium, the most problematic trace element in biomass, responsible for ash fouling and corrosion in gasifier systems and downstream components.

Reviewer 3C (Rating: 3)
The analytical method development will be a significant technological contribution to standard setting organizations (EPA, ASTM, etc.) and researchers as an alternative method that is less expensive.

Response: *We agree with Reviewers 3A and 3C that trace metal emissions in the gasification environment are challenging and create a need for a reliable and economical measurement technology. Reviewer 3B is correct in saying that trace metal contents in biomass are small and that they are, therefore, even more challenging to accurately detect/quantify. But we disagree with Reviewer 3B's comments that there is little reason to measure them. Syngas quality for fuel cells, microturbines, hydrogen separation membranes, and other downstream power or combined heat and power (CHP) systems has repeatedly been mentioned by manufacturers, emphasizing the need to have an extremely clean fuel gas in order to avoid damage to power/CHP units. This is even more important in systems that have downstream catalysts, as these are very sensitive to trace metals and alkali, and are extremely expensive to replace.*

The guidelines for the proposal define a strict page limit, which precluded us from a lengthy discussion of the analytical ranges of various biomass materials. It should be noted that there are very few reliable databases that show biomass analytical concentrations. The European Union has two of the best-developed databases that contain analytical results for biomass: Phyllis (accessed at www.phyllis.nl) and BioDat (accessed at www.biodat.eu/pages/Home.aspx). However, even in these databases, while there is a wide variation of the biomass materials analyzed, data sets are very small for similar categories of biomass. Because of the small amount of data available, despite the EU's heavy dependence on biomass, the Phydad project was initiated to try to standardize measurement and analytical techniques and to provide training across European nations to disseminate this knowledge. Clearly, significant data gaps exist when it comes to biomass.

Of the trace metals in biomass, mercury is usually of most concern, but selenium, chromium, and arsenic are gaining visibility. We appreciate the chance to further clarify that mercury concentrations, as measured in biomass, are highly variable and tend to be a factor of ~10 to 100 lower than mercury-in-coal values, making accurate measurement even more difficult. However, some biomass feedstocks can have concentrations similar to low-mercury coals. Mercury data from various sources ranged from <0.001 to 0.04 ppmw (dry) (see references 1–6 below). Table 2 summarizes the mercury concentrations for different biomass feedstocks. Mentz et al. found that the bark from stemwood trees exhibited a significantly higher mercury concentration than the woody part of the tree (4). Mentz found that the stemwood mercury concentrations had a range of 0.001 to 0.004 ppmw, while the bark ranged from 0.001 to 0.037 ppmw, with the average values represented in Table 2.

Table 2. Biomass Feedstock Mercury Concentrations

Feedstock	*Hg, ppmw (dry)*	*Reference*
Alfalfa	*<0.07*	*1*
Rice Straw	*0.02*	*2*
Wheat Straw	*0.028*	*2*
Wood Chips	*0.032*	*2*
Wood Chips, high bark	*0.011*	*2*
Rice Straw	*0.019*	*2*
Rice Straw	*0.017*	*3*
Stemwood	*0.0023*	*4*
Bark	*0.0125*	*4*
Spruce	*<0.002*	*5*
Beech	*<0.002*	*5*
Oak	*<0.001*	*5*
Spruce Bark	*<0.001*	*5*
Beech Bark	*<0.001*	*5*
Oak Bark	*<0.001*	*5*
Willow Bark, twigs	*0.03*	*6*
Willow Bark, branches	*0.03*	*6*
Willow Wood, twigs	*0.04*	*6*
Willow Wood, branches	*0.03*	*6*

1. *Salo, K.; Mojtahedi, W. Fate of Alkali and Trace Metals in Biomass Gasification. Biomass Bioenergy* ***1998****, 15, 263–267.*

2. *Thy, P.; Jenkins, B.M. Mercury in Biomass Feedstock and Combustion Residuals. Water Air Soil Pollut.* ***2010****, 209, 429–437.*

3. *Meister, B.C.; Williams, R.B.; Jenkins, B.M. Utilization of Waste Renewable Fuels in Boilers with Minimization of Pollutant Emissions. Laboratory-Scale Gasification Screening Experiments. PIER Final Report CEC-500-2005-134. California Energy Commission, Sacremento, California,* ***2005****.*

4. *Mentz, K.; Pinkerton, J.; Louch, J. Potential Mercury and Hydrochloric Acid Emissions from Wood Fuels. Forest Products Journal* ***2005****, 55, 46–50.*

5. *Demirbaş, A. Biomass Co-Firing for Boilers Associated with Environmental Impacts. Energy Sources* ***2005****, 27, 1385–1396.*

6. *Adler, A.; Verwijst, T.; Aronsson, P. Estimation and Relevance of Bark Proportion in a Willow Stand. Biomass Bioenergy* ***2005****, 29, 102–113.*

The data set shows a significant amount of variability, even within similar feedstock types. This indicates that geography (where the feedstock is grown) is a significant factor in the mercury concentration, along with other factors such as tree type, growth rate, age, etc. The underlying geology of the soils will also affect other trace metals.

CATM studies have also shown tremendous variability within the same categories of biomass. For example, cattails (a good potential source because of their multiple benefits to the environment) have tremendous variability at different growth phases and CATM's studies show that, depending upon the time of the year, the leaves can contain 700% of the concentration of mercury that is present in the soil. Cattails have frequently been proposed as a viable means of biaccumulating trace metals, while providing biomass materials and wildlife habitat in North Dakota and the upper Great Plains.

Potassium, as noted, is a great concern. The EERC is well acquainted with the problems that can arise as a result of relatively high amounts of alkali, in particular potassium, which is typical of most biomass materials. In Table 3, below, we have noted analyses from several biomass samples, showing the significant concentrations of potassium.

Table 3. Typical Analyses of Various Biofuels

Biofuel	*Wood Chips with Bark*	*Wood Chips Without Bark*	*Hybrid Poplar*	*Alfalfa*	*Wheat Straw*
Proximate Analysis, wt%, as-received					
Moisture	*4.71*	*4.10*	*5.20*	*7.80*	*9.60*
Ash	*18.4*	*1.07*	*1.13*	*3.93*	*7.62*
Volatile Matter	*60.9*	*78.8*	*78.9*	*82.9*	*74.4*
Fixed Carbon	*16.1*	*16.1*	*14.8*	*5.35*	*8.38*
Ultimate Analysis, wt%, as-received					
Carbon	*37.0*	*45.9*	*45.0*	*41.8*	*38.3*
Hydrogen	*4.97*	*6.17*	*6.13*	*6.11*	*5.91*
Nitrogen	*0.32*	*0.10*	*0.82*	*1.64*	*0.76*
Oxygen	*39.3*	*46.7*	*46.6*	*46.4*	*47.2*
Sulfur	*0.03*	*0.02*	*0.25*	*0.12*	*0.23*
Heating Value, Btu/lb	*6960*	*8095*	*7641*	*7112*	*6462*
Chlorine, ppm	*250*	*47*	*93*	*2340*	*2120*
Ash Chemistry, wt%					
SiO_2	*71.7*	*15.5*	*4.61*	*30.0*	*63.9*
Al_2O_3	*12.1*	*4.50*	*1.52*	*0.51*	*<0.5*
Fe_2O_3	*5.60*	*3.85*	*2.01*	*0.72*	*0.44*
CaO	*2.10*	*45.5*	*49.0*	*25.1*	*3.42*
MgO	*1.50*	*7.25*	*8.51*	*4.31*	*1.73*
Na_2O	*0.73*	*0.85*	*0.42*	*1.53*	*2.71*
K_2O	*3.35*	*14.0*	*24.9*	*27.9*	*22.6*
TiO_2	*0.68*	*0.18*	*0.11*	*0.12*	*0.10*
P_2O_5	*0.56*	*3.56*	*7.82*	*8.72*	*1.33*

5. **The principal investigator's awareness of current research activity and published literature as evidenced by literature referenced and its interpretation and by the reference to unpublished research** related to the proposal is: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 3A (Rating: 4)
Although not documented clearly in the proposal with literature review, it seems the PIs are long time experienced and have had expertise in trace element characterization/ emission analysis. Their awareness on the current development in the topic area is at least above average.

Reviewer 3B (Rating: 3)
Only three references were cited, and none of these are clearly addressing biomass gasification. The investigators appear knowledgeable relevant to trace elements in coal, but show little understanding of biomass inorganic content, which is distinct from that of coal. The investigators seem unaware of the most pressing issues in analysis of biomass gasification streams.

Reviewer 3C (Rating: 4) <No comment>

Response: *The EERC has experience with several gasification systems, including those that use coal, biomass, or blends as feedstocks. As Reviewer 3B points out, biomass' elemental distribution is very different from coal, as was discussed in detail above.*

Proposal length limits precluded a better illustration of EERC/CATM expertise. Below are just a few of the recent biomass gasification citations produced by the EERC.

Hanson, S.K.; Buckley, T.D.; Schmidt, D.D.; Leroux, K.M. *Guide to Commercial Biomass Energy Conversion Systems*; Prepared for North Dakota Forest Service; Energy & Environmental Research Center: Grand Forks, ND, June 2006.

Hutton, P.N.; Patel, N.; Martin, K.E.; Singh, D. *Development and Testing of a Thermally Integrated SOFC–Gasification System for Biomass Power Generation*; Phase II Interim Report (July 1, 2003 – May 30, 2005) for Xcel Energy, Inc.; Energy & Environmental Research Center: Grand Forks, ND, July 2005.

Hutton, P.N.; Schmidt, D.D.; Martin, K.E.; Patel, N. *Biomass Gasification for Power Plant Fuel Testing*; Final Report (Oct 1, 2005 – June 30, 2006) for Pembina Trail RC&D; EERC Publication 2006-EERC-06-08; Energy & Environmental Research Center: Grand Forks, ND, June 2006

Leroux, K.M.B. *Fuels for Schools – Minot and Dickinson Biomass Feasibility Studies*; Final Report (June 1, 2006 – June 30, 2008) for North Dakota Forest Service and Bottineau Chamber of Commerce; EERC Publication 2008-EERC-05-01; Energy & Environmental Research Center: Grand Forks, ND, June 2008.

Leroux, K.M.B.; Williams, K.D. *Energy Opportunities for Mayville State University*; Final Report (Feb 15 – March 31, 2007) for Energy Services Group; EERC Publication 2007-EERC-03-07; Energy & Environmental Research Center: Grand Forks, ND, April 2007.

Leroux, K.M.; Williams, K.D. *Energy Opportunities for Mayville State University – Phase II*; Final Report (Jan 1 – Feb 29, 2008) for Energy Services Group; EERC Publication 2008-EERC-02-04; Energy & Environmental Research Center: Grand Forks, ND, Feb 2008.

Leroux, K.M.B.; Williams, K.D.; Hanson, S.K.; Zacher, E.J. *The Potential for Biomass District Energy Production in Chugachmiut Communities*; Final Report for Chugachmiut, A Tribal Organization Serving the Chugach Native Peoples of Alaska; EERC Publication 2007-EERC-07-07; Energy & Environmental Research Center: Grand Forks, ND, July 2007.

Schmidt, D.D.; Leroux, K.M.B. *North Dakota Forest Service Fuels for Schools Feasibility Studies;* Final Report (July 1, 2005 – June 30, 2006) for North Dakota Forest Service; EERC Publication 2006-EERC-06-07; Energy & Environmental Research Center: Grand Forks, ND, June 2006.

6. **The background of the investigator(s) as related to the proposed work is**: 1 – very limited; 2 – limited; 3 – adequate; 4 – better than average; or 5 – exceptional.

Reviewer 3A (Rating: 4)
As mentioned above, the PIs seem well qualified and their expertise is above average.

Reviewer 3B (Rating: 5)
Well qualified team.

Reviewer 3C (Rating: 4)

Response: *We thank the reviewers for their confidence in the EERC's abilities and hope we have successfully demonstrated additional expertise and understanding of how this project would provide a much needed method for measurement of trace metals in gasification of biomass.*

7. **The project management plan, including a well-defined milestone chart, schedule, financial plan, and plan for communications among the investigators and subcontractors, if any**, is: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – very good; or 5 – exceptionally good.

Reviewer 3A (Rating: 3)
The research goal is straightforward and the project will be conducted within the EERC. The simple management statement in the proposal is adequate to this reviewer.

Reviewer 3B (Rating: 3)
Adequate.

Reviewer 3C (Rating: 4) <no comment>

Response: *We thank the reviewers for their confidence in the EERC's abilities. Prior to initiating testing, a well-detailed test plan will be developed and approved by sponsors. This will include milestones and deliverables, and quality assurance/quality control measures to be used, and will clearly show the management and testing structure of the EERC project team.*

8. **The proposed purchase of equipment** is: 1 – extremely poorly justified; 2 – poorly justified; 3 – justified; 4 – well justified; or 5 – extremely well justified. (Circle 5 if no equipment is to be purchased.)

Reviewer 3A (Rating: 5)
The proposal does not request any equipment.

Reviewer 3B (Rating: 5)

Reviewer 3C (Rating: 5)

Response: *The EERC currently has 14 gasifiers; the HPFBG gasifier has initially been identified as the best testing unit for this project because of its scale and ability to feed and gasify biomass materials.*

9. **The facilities and equipment available and to be purchased for the proposed research** are: 1 – very inadequate; 2 – inadequate; 3 – adequate; 4 – notably good; or 5 – exceptionally good.

Reviewer 3A (Rating: 4)
EERC has tremendous analytical capabilities. Although not stated in details, the means of characterizing the trace elements, i.e., the ME-ST and EPA M29, are in place and ready for the project.

Reviewer 3B (Rating: 5)

Reviewer 3C (Rating: 5)
EERC facilities are capable of completing project.

Response: *Thank you. See the comment above.*

10. **The proposed budget "value"1 relative to the outlined work and the financial commitment from other sources** is of: 1 – very low value; 2 – low value; 3 – average value; 4 – high value; or 5 – very high value. (See below)

Reviewer 3A (Rating: 4)
The budget (total $500k and $250k from this program) seems high for the scope of work, especially no additional equipment is needed. The gasifier is to be run just for this project, which involves quite high expenses, instead of working with the gasification research. The personnel cost is significant.

No industrial partners contribute as match.

Reviewer 3B (Rating: 2)
I simply do not understand why measuring trace elements emitted during biomass gasification is an important problem. The concentration in biomass is low.

Reviewer 3C (Rating: 3)
The budget seems reasonable for laboratory operations.

Response: *We hope that this response has clarified the issues related to trace elements and has illucidated some of the difficulties in a gasification environment and the needs as expressed by equipment vendors and those who already conduct gasification or plan to do so.*

Methods development, especially for trace elements, is expensive. Sufficient samples must be obtained in a tightly controlled gasification environment to say with confidence that the method has met tight QA/QC requirements, requiring significant personnel for unit operation and sampling activities for this method and M29. Ultimately, if results are good, the statistical data that are generated will be used to develop an approved method through EPA, the National Institute of Standards for Technology (NIST), or ASTM International.

1 "Value" – The value of the projected work and technical outcome for the budgeted amount of the project, based on your estimate of what the work might cost in research settings with which you are familiar.

10a. **Financial commitment from other sources – A minimum of 50% of the total project must come from other sources to meet the program guidelines**. Higher priority is to be given if the application has private industry investment equal to or at least 50% or more of total cost.

The minimum 50% cash match is demonstrated.

Section C. Overall Comments and Recommendations:

Please comment in a general way about the merits and flaws of the proposed project and make a recommendation whether or not to fund.

Reviewer 3A (Funding May Be Considered)
It is recommended that the proposal be funded with a medium level priority.

(1) This is not a very well written research proposal. The topic to be explored is valid but not well formulated.
Response: *We believe we have addressed this concern and will provide a detailed test plan for review and approval prior to initiating any testing.*

(2) There is lack of details in methodology, literature review on current development in the topic area, and experimental plan.
Response: *We believe we have addressed this concern and will provide further details in the presentation and in the test plan, as mentioned.*

(3) The outcome out of this project will provide useful information for gasification operation, and evaluate the ME-ST instrumentation for its efficiency and cost effectiveness.
Response: *We believe this method will fill a gap for a reliable, economical method that is appropriate to those who use biomass, especially at a smaller scale.*

Reviewer 3B (Do Not Fund)
Good qualifications, good instruments. Weak on selecting a project that will actually advance biofuels. Trace elements are the least of the worries in producing clean syngas.

Response: *Based upon our interaction with gasification practioners, other researchers, and vendors of equipment, we believe this method will supply a need for a reliable, economical method that is appropriate to those who use biomass, especially at a smaller scale.*

Reviewer 3C (Funding May Be Considered)
The proposed project is the development of an alternative method for measuring trace elements in syngas steams. It will have a significant technological contribution to standard setting organizations and researchers as an alternative method that is less expensive than traditional techniques.

Response: *We believe the method will be easier to conduct, less likely to have interferences or biases, and more flexible for fuels of various elemental concentrations. We hope we have demonstrated the need for this method.*