NORA Board Meeting
Newport Marriott
Newport, RI
12.15 -2.00 Eastern Time
September 24, 2018

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United States: +1 (786) 535-3211
Access Code: 650-740-669

I. Introduction – Chairman Tom Santa and President John Huber

II. Approval of Minutes

III. Financial Information – Treasurer Eric Degesero

a. Review of Audit Letter
b. August Statement of Activity and Statement of Financial Position
c. Informational Reports - State Allocations
- State Disbursements

IV. Research and Development – Director of Laboratory Dr. Thomas Butcher

a. Review of Lab Operations
b. Review of Outside Projects
c. Technology Conference
d. Future Fuels

VI. Education and Training Activities – Don Farrell and John Levey

a. Online Education – Updated Site
b. Steam and Controls

VII. Consumer and Internal Education
a. Outreach to Groups
b. Ideas for Messaging and Outreach

VIII. Energy Efficiency

IX. Executive Committee and Officers

X. Status of NORA in Congress

XI. Old Business – Messaging Our Story

XII. New Business

XI. Adjournment

President's Remarks

1) Status of Programs
2) Status of Legislation and Impact on Budget
3) Outreach and Getting Message Through
4) Voluntary Leadership

Minutes
Board of Directors
National Oilheat Research Alliance
May 22, 2018
Ledyard, Connecticut

I. Introductions and Opening Remarks

Mr. Tom Santa called the meeting to order at 12:02 pm EST and directed Mr. John Huber to call the roll. Mr. Huber called the roll and the following members of the Board were present.

Greg Anderson	Joe Kennan
Peter Aziz	Quincy Longacre
Will Berry	Steve McCracken
Peter Boutte	Matt Meehan
Al Breda	John Miles
Steve Clark	Natalie Mondsini
Chris Daly	Ted Noonan
Kirk Darby	Ken Russ
Eric Degesero	Tom Santa (Chairman)
Mike Estes	Daniel Singer
Scott Hacker	Charles Ugiletto
Susan Hammond	Joe Willis
Bruce Harris	George McQueeny
Allison Heaney	Stephen Sack
Michael Januario	Kate Childs

Mr. Huber announced that quorum was met and the meeting started at 12:08 pm EST.

II. Approval of Minutes

A motion to approve the minutes from the September 22, 2017 board meeting was made by Mr. Joe Willis, seconded by Mr. Steve Clark and approved by voice. Mr. Chairman noted that the date would beadded to the minutes.

III. Financial Information – Treasurer Eric Degesero

a. Year End Financials 2017

Mr. Degesero discussed the year end financials and stated that the statement grew the first quarter of 2018. The 2017 revenue projection was 8.894 million dollars as of the close of the audit and calendar year, revenue was ay 8.851 million total revenue minus refunds. Therefore, the total income for 2017 was nearly 44,000 dollars under projection. Mr. Degesero stated, “pursuant to law and to ensure compliance with the maximum expenditure in the consumer education account, NORA must reduce consumer education spending by approximately 13,000 dollars". The auditor suggested that those funds from the consumer education account be removed from the balance sheet prior to the end of 2017 so we could close the audit out, Mr. Degesero stated that the adjustment had been made and referred to the board packet financial balance sheet that had been distributed and pointed out that the consumer education account has a balance of 30,690 dollars. Mr. Degesero discussed sales and grants. He stated that sales have decreased significantly with the NORA education store that is now being outsourced. NORA anticipated 100,000 dollars in sales and 80,000 in cost of goods sold. However now that the fulfillment is outsourced we are bringing in less revenue and have miscellaneous cost such as refunds. Grants come from the National Biodiesel Board and NYSERDA and we are grateful our partners continued support.

Central consumer education is 4,000 under budget, research and development for the central office was also under budget. The lab has two full-time employees as well as Dr. Butcher. The lab expenses are expected to grow over time and the lab getting projects underway and how much time is spent on each project is an important factor in the reauthorization and we want to ensure these projects are funded. The energy efficiency program is also under budget. NORA has investigated allocating more accounting time into this category. As rebate requests are driving the use of accounting. Salaries and consulting fees are over budget. Some of this is due to allocation of salaries and attorney's fees as well as administrative costs. Accounting is well under budget, comparison of the accounting line to the annual report line on the expense sheet, shows that the use of funds shifted from accounting to the annual report. NORA is not allowed to exceed four percent on administrative cost; the cost is currently at three percent with a fully flushed out budget.

Mr. Degesero discussed the balance sheet and as of 12/31 NORA has nearly 3 million in receivables. The quarter ended in 2018 and NORA received funding in January and February of 2018.

Property and equipment is 47,000 which is mostly equipment at the Plainview lab.

1.3 million in payables is a collection of state rebate requests, payment to grantees.

State obligation is described under liabilities and there is advance spending of 2018 funds. Some states used the 2018 funding early. The spend down in the state balances is getting better as states that hadn't been using their funds have been spending on engaging projects at the direction of the board.

Unrestricted assets are at a negative 400,044 dollars at the end of the year, however that was a adjusted on January 1st and the actual is +431,000. Each account has dedicated funding in the event of an interruption in funding.

b. Audit 2017

The audit total liabilities and net assets match with NORA's accounting at 875,882. The audit shows the financials differently, however the numbers match the presented financials

c. March Financials 2018

The first quarter of 2018 has been strong, but due to a warm February, the quarter's degree days were slightly warmer than normal. For New England, the weather on a census adjusted basis was 6 percent warmer than normal, and for the mid-Atlantic, approximately 3 percent warmer than normal.

However, the revenue for this quarter appears to be on schedule for us to meet budget. As of two weeks ago, total revenue from collections was approximately $4.35 million. Q1 has usually generated 44 percent of all revenue. Q 2 and Q3 have usually not been as directly impacted by weather, although the cold April may be helpful this year. However, they generally account for $3.2million of revenue. Q4 which is also very weather dependent usually accounts for 33 percent of revenue. Thus, if it is close to normal as Q1 was, we should expect $3.3 million. If these projections hold, the total revenue for the year, the total revenue would be $10.85 million. From this, we pay $1.3 million in refunds. Thus, the net for the year would be $9.65 million. The budget for 2018.

A motion to approve the financial report of 2017, the audit and the First Quarter financials was made, duly seconded and approved by voice vote.

IV. Research and Development – Director of Laboratory Dr. Thomas Butcher

a. Review of Lab Operations

Dr. Butcher discussed the research facility located in Plainview, NY, on Long Island, the 3,500-square-foor facility is operated by NORA. Dr. Butcher stated that the lab is fully functional with two new full time employees; Neehad Islam – Mechanical Engineer, Stony Brook University and Ryan Kerr –Chemical Engineer, Stony Brook University.

b. Review of Outside Projects

Dr. Butcher gave the following status update on the projects below:

1. Tankless Coil Boilers (Best Practices with NYSERDA)
    - Test work at NORA Lab Completed; A report on the tests is in progress, and Dr. Butcher delivered a presentation at the ACEEE Water Heating Forum; •Summer DHW efficiency 34-41% with conventional tankless coil boilers; •Oil Combi with External Plate HX and Advanced Controls is between 49-67%; •Annual Energy Use Implications Study in Progress.

2. Mini-split Heat Pumps Field Study (Best Practices with NYSERDA)
    - 5 of 6 Field Sites are in Operation. It should be noted that in-home use patterns vary greatly as homeowners control their use. No Consistent Control/Operating Pattern has been seen.

3. EL Bioblend Field Study

- NORA conducted a field study of a 10% Blend of Ethyl Levulinate in Heating Oil. This study was conducted in conjunction with Dead River Company in Maine and covered 11 Homes occupied by Service Techs. Regular sampling of bulk and home tanks (one outdoor) occurred. Deliveries started in Dec. 2017 and to date no separation observed. One pump failed and no other problems reported. In parallel, tests at NORA lab continue on pump durability and combustion performance.

4. Impact of Copper on Fuel Stability
    - Studies last year showed that exposure to copper, at a high surface to volume ratio, can dramatically reduce stability; The lab is currently focusing on a two-pipe systems. Does this present enough copper exposure to damage the fuel? •Testing at NORA lab, two-pipe coiled copper at 20 feet each. Continuous circulation of a tank for 2 months. •No impact on stability observed in the tank. Samples were taken weekly and we are doing a trace metals analysis courtesy of REG.
    -
5. Biodiesel Studies (with NBB)
    - Impact of B20 on pump seals. Pumps removed from the field (B0 and B20) for inspection. New pumps being cycled in the lab with B-20. •Detailed investigation of starts and stops and detailed tear down and inspection Additional cad cell testing at different biodiesel blend levels is underway.
    -
    - Other Biodiesel Topics - Pump Sticking Field trials of ultrafiltration in progress
    -
6. FSA Updates
    - Based on User Feedback, We have Worked With Primedia to Implement Some Important Updates: •Addition of Steam Boilers Including Old Units Dating Back to pre-1965;•Ability to Estimate Savings with Furnaces; •Updated Comparison Reports.

c.. Report on Greenhouse Gas Emission Comparison, Richard Sweetser

Mr. Sweetser gave a presentation on the study underway to compare heating oil, biodiesel and advanced biodiesels with natural gas. Mr. Sweetser indicated that this is a production through heating the home study. The ratios of equivalence increased slightly from the previous report due to better equipment in use and the cessation of LNG imports. Once finalized this study will be on the NORA website and made available.

V. Education and Training Activities –

a. Online Education – John Huber

Mr. Huber discussed the online education system and that NORA has been working to become active in the online education space. The online education system currently has 23,000 technicians that use the online education website and about 15 percent of that is active users.

Technicians can get CEU's online, there are currently 20 videos online for continuing education. Mr. Huber discussed that NORA is transitioning to a new vendor to run the online system. He stated that viewing details are being worked out which will make it easy for technicians to know where they are in the program. This transition will also be easier for management as it currently takes 42 key strokes to upload/update something in the current system; the new system will be significantly less key strokes to accomplish a task.

b. Status of Programs – Gold, CEUs, John Levey

Mr. Levey discussed the amount of online resources that are available and that a lot of them have bad information. NORA is working to provide an updated accurate resource for technicians to get information by adding classes and other ways to get CEU's. The biggest change is most of the Bronze and Silver certifications upgrades are being done online. This allows students to take the test and get results immediately and it also helps with the security of the test. Mr. Levey also discussed online certification is being done in places that don't have proctors by offering a remote proctor to a qualified student who can get to computer with a web camera.

Mr. Levey discussed the NORA Gold certification and that all eight classes are actively running. NORA is also working to recognize manufacturers classes that can be used toward NORA Gold certification. TACO, Peerless etc. have classes that are equivalent to NORA classes and that can be used in place of a NORA class.

NORA will be conducting a train the trainer at Planview Lab to help make classes more accessible. Some companies rate pay on certification and certifications are offered in some areas so NORA is working to have a central classroom for technicians looking to earn Gold certification.

Mr. Levey discussed that several CEU programs have been added to the leaning.noraweb.org website this year and we are working with various manufacturers to add additional online classes. Many of the videos were created by NORA and others have been produced by manufacturers of heating equipment and approved by NORA. As NORA identifies additional quality instructional videos, they will be added to the site.

VI. Energy Efficiency

John Huber indicated that most of the efficiency programs centered on rebates.

VII. Communications and Outreach – Don Farrell

Mr. Farrell discussed the communication that NORA has had with its audiences and that NORA is consistently working to improve digital communication by adding different offerings and ways to communicate. Currently NORA communicates through the following vehicles: NORAweb.org; Learning.NORAweb.org; Press Releases; and Article.

Mr. Farrell stated that NORA is constantly looking for writers and stated that they could email him if they are interested or know someone interested in being a featured writer.

NORA plans to introduce a regular series of educational content “e-newsletters” geared for technical personnel. The content will include service tips/help/updates; educational opportunities and research updates.

VIII. Old Business

NONE

IX. New Business

NONE

X. Adjournment

Mr. Chairman adjourned the meeting at 1:29pm.

Ross, Langan & McKendree, LLP

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September 10, 2018

Board of Directors
National Oilheat Research Alliance
600 Cameron Street, Suite 206
Alexandria, VA 22314

Dear Board Members:

We have audited the financial statements of the National Oilheat Research Alliance (the Alliance) for the year ended December 31, 2017, and have issued our report thereon dated June 5, 2018. Professional standards require that we provide you with information about our responsibilities under auditing standards generally accepted in the United States of America, as well as certain information related to the planned scope and timing of our audit. We have communicated such information in our letter to you dated January 11, 2018. Professional standards also require that we communicate to you the following information related to our audit.

The following specific matters must be communicated:

A. Qualitative Aspects of Accounting Practices
B. Difficulties Encountered in Performing the Audit
C. Disagreements with Management
D. Management Representations
E. Corrected and Uncorrected Misstatements
F. Management Consultations with Other Independent Accountants
G. Other Audit Findings or Issues
H. Other Matters

Our comments on the above matters are presented in the attachment (Exhibit A) to this letter. The information contained therein is intended solely for the use of the Board of Directors and management of the Alliance and is not intended to be, and should not be, used by anyone other than these specified parties. We would welcome the opportunity to discuss the matters contained in this communication with you since they are best communicated in person.

Sincerely,

ROSS, LANGAN & McKENDREE, L.L.P.

Jeffrey P. Hayden, Partner
Certified Public Accountant

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SIGNIFICANT AUDIT FINDINGS

A. Qualitative Aspects of Accounting Practices

Management is responsible for the selection and use of appropriate accounting policies. The significant accounting policies used by the Alliance are described in Note 2 to the financial statements. No new accounting policies were adopted and the application of existing policies was not changed during 2017. We noted no transactions entered into by the Alliance during the year for which there is a lack of authoritative guidance or consensus. All significant transactions have been recognized in the financial statements in the proper period.

Accounting estimates are an integral part of financial statements prepared by management and are based on management's knowledge and experience about past and current events and assumptions about future events. Certain accounting estimates are particularly sensitive because of their significance to the financial statements and because of the possibility that future events affecting them may differ significantly from those expected. The estimates affecting the financial statements were:

- Recognition of R & D payables based on estimates of stage completion provided by contractors
- Recognition of refund reserves based on subsequent payments
- Valuation of receivables based on subsequent and historical collections
- Allocation of expenses based on estimates of time spent per month
- Depreciation is recorded based on the estimated useful life and residual value of the assets

We evaluated the key factors and assumptions used to develop the estimates in determining that they are reasonable in relation to the financial statements taken as a whole.

The financial statement disclosures are neutral, consistent, and clear.

B. Difficulties Encountered in Performing the Audit

We encountered no significant difficulties in dealing with management in performing and completing our audit, however, there were some entries discussed in Paragraph E below that lengthened the audit.

C. Disagreements with Management

For purposes of this letter, a disagreement with management is a financial accounting, reporting, or auditing matter, whether or not resolved to our satisfaction, that could be significant to the financial statements or the auditor's report. We are pleased to report that no such disagreements arose during the course of our audit.

D. Management Representations

We have requested certain representations from management that are included in the management representation letter dated June 5, 2018.

SIGNIFICANT AUDIT FINDINGS (continued)

E. Corrected and Uncorrected Misstatements

Professional standards require us to accumulate all misstatements identified during the audit, other than those that are clearly trivial, and communicate them to the appropriate level of management. Management has corrected all such misstatements. The following material misstatements were corrected by management during the audit process:

- To reclassify state assessments payable for 2018 amounts spent in advance to prepaid assets and correct state assessments payable for revised consumer education budget – approximately $245,000
- To release commitment for signed National R & D contracts from designated net asset for amounts spent in 2017 and recognize additional liability for National R & D contracts – approximately $487,000
- To reclassify designated net assets reserved for future national spending – approximately $596,000

F. Management Consultations with Other Independent Accountants

In some cases, management may decide to consult with other accountants about auditing and accounting matters, similar to obtaining a "second opinion" on certain situations. If a consultation involves application of an accounting principle to the Alliance's financial statements or a determination of the type of auditor's opinion that may be expressed on those statements, our professional standards require the consulting accountant to check with us to determine that the consultant has all the relevant facts. To our knowledge, there were no such consultations with other independent accountants.

G. Other Audit Findings or Issues

We generally discuss a variety of matters, including the application of accounting principles and auditing standards, with management each year prior to retention as the Alliance's auditors. However, these discussions occurred in the normal course of our professional relationship and our responses were not a condition to our retention.

H. Other Matters

With respect to the supplementary information accompanying the financial statements, we made certain inquiries of management and evaluated the form, content, and methods of preparing the information to determine that the information complies with accounting principles generally accepted in the United States of America, the method of preparing it has not changed from the prior period, and the information is appropriate and complete in relation to our audit of the financial statements. We compared and reconciled the supplementary information to the underlying accounting records used to prepare the financial statements or to the financial statements themselves.

Ross, Langan & McKendree, LLP

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June 5, 2018

National Oilheat Research Alliance
Board of Directors
600 Cameron Street, Suite 206
Alexandria, Virginia 22314

Dear Board Members:

In planning and performing our audit of the financial statements of the National Oilheat Research Alliance (the Alliance) as of and for the year ended December 31, 2017, in accordance with auditing standards generally accepted in the United States of America, we considered the Alliance's internal control over financial reporting (internal control) as a basis for designing our audit procedures that are appropriate in the circumstances for the purpose of expressing our opinion on the financial statements, but not for the purpose of expressing an opinion on the effectiveness of the Alliance's internal control. Accordingly, we do not express an opinion on the effectiveness of the Alliance's internal control.

Our consideration of internal control was for the limited purpose described in the preceding paragraph and was not designed to identify all deficiencies in internal control that might be material weaknesses or significant deficiencies and, therefore, material weaknesses or significant deficiencies may exist that were not identified. In addition, because of inherent limitations in internal control, including the possibility of management override of controls, misstatements due to error or fraud may occur and not be detected by such controls. However, as discussed below, we identified certain deficiencies in internal control that we consider to be material weaknesses and other deficiencies that we consider to be significant deficiencies.

A deficiency in internal control exists when the design or operation of a control does not allow management or employees, in the normal course of performing their assigned functions, to prevent, or detect and correct, misstatements on a timely basis. A material weakness is a deficiency, or combination of deficiencies in internal control, such that there is a reasonable possibility that a material misstatement of the Alliance's financial statements will not be prevented, or detected and corrected, on a timely basis. We consider the following deficiencies in the Alliance's internal control to be material weaknesses:

- The Alliance enters into contracts to conduct national R&D activities as specified in the NORA Act. These contracts have multiple stages "gates" with specific deliverables or goals discussed in the contracts for each stage. Expense and liabilities should be recognized under these contracts, when the contractors have conducted the work under each stage and therefore when NORA is obligated to pay the contractor. However, to track these obligations to ensure NORA understands how much is committed, management has a mechanism to track the obligated amounts in the financial statements using designated net asset accounts. Management has improved its tracking of these commitments in the current year, however, during the audit a journal entry was proposed by us and made by management to record additional payables for completed stages and to reclassify net assets for completed, and therefore no longer committed, stages. We recommend that these obligations be tracked by contract and stage to ensure both the liability and designated net asset are accurately presented.

Management's Response

As noted above, NORA began a process in 2017 for preparing a schedule that tracks the contracts and due dates for deliverables under the R&D activities. As the tracking process is evolving and improving, management will add an additional field for tracking the stage of contact completion. In addition, management will implement a process for monthly review of this schedule between the Executive Director and the accounting team to ensure all new contracts are captured and contract completion stages are updated accordingly.

- Each year, NORA establishes and communicates a budget to the state agencies of how much NORA estimates the year's state assessment payable will be. As you know, actual amounts may vary due to differences in weather and other factors that impact oilheat sales in the states. Management tracks this very carefully and modifies the amount of the state assessment payable as appropriate. In 2017, this modification resulted in a lower state assessment payable. When this modification is communicated to the states, the liability is also modified within the general ledger. However, the consumer education change was mistakenly not modified in the general ledger. This resulted in an entry proposed by us and made by management to correct the accounting for the consumer education liability. The NORA Act has strict requirements for how much of the state assessments can be used for consumer education, safety, and training and how much must be used for research, development, and demonstration and heating oil efficiency and upgrade. Potentially, mistakes like this could jeopardize NORA's ability to stay within the parameters of the NORA Act. We recommend management implement a process to review the state assessment liability each time a new budget is set.

Management's Response

The annual budgets for the state assessments are imported into the accounting system for grant tracking purposes as noted above. An updated process has been implemented that provides that budget amendments are updated in the system as required per the NORA Act and reconciliation will be done between the accounting system and grant management reporting system as part of the monthly accounting. Once completed, this reconciliation will be forwarded to the Executive Director for review and approval. In addition, documentation for reallocation of assessment use between consumer education, safety and training will be maintained as part of the monthly accounting process.

A significant deficiency is a deficiency, or a combination of deficiencies, in internal control that is less severe than a material weakness, yet important enough to merit attention by those charged with governance. We consider the following deficiencies in the Alliance's internal control to be significant deficiencies:

- During our audit, we noted receivables were over-accrued for two payors. This resulted in an entry proposed by us and made by management to correct the receivable. This appears to have occurred due to duplicate reports submitted by the payors with different state details on the forms. We recommend management develop a process to identify such items at the data entry stage to prevent such issues in the future.

Management's Response

The amount adjusted was approximately $45,000. During 2017, the outsourced accounting firm experienced a change in staff that was involved in preparing the monthly reconciliations and financial

Management's Response (continued)

statements. The accounting firm has implemented an additional review process relating to the accrual for assessments receivable. The overall process requires that the accrual is compared to the actual cash receipts received in the following month to ensure the accrual matches the future amounts to be received.

- Management made improvements to its recordkeeping and recognition of payroll allocations in 2017. However, during the audit, we noted payroll expenses (salaries, benefits, and taxes) were still incorrectly allocated among the programs based on time reports. This resulted in a reclassification entry proposed by us and made by management during the audit. We recommend the salary allocation be reconciled to actual payroll expense in total, including benefits, taxes, and accrued vacation. The process could be made easier by changing the chart of accounts to add salaries, taxes, and benefits accounts within each program area. This would have the added benefit of making reporting under the *Financial Accounting Standards Board Accounting Standards Update No. 2016-14* more efficient. That standard was required to be implemented beginning January 1, 2018.

Management's Response

The total amount of the payroll and related costs have been recorded and posted correctly in the general ledger. In order to more easily determine the amounts being allocated to the various programs and management and general, we are in agreement with the recommendation of adding general ledger accounts within the various program areas. We have implemented this recommendation for 2018 in order to be in compliance with *Financial Accounting Standards Board Accounting Standards Update No. 2016-14* as well.

The Alliance's written responses to the significant deficiencies and material weaknesses identified in our audit have not been subjected to the audit procedures applied in the audit of the financial statements and, accordingly, we express no opinion on them.

This communication is intended solely for the information and use of management, the Board of Directors, and others within the Alliance, and is not intended to be, and should not be, used by anyone other than these specified parties.

Sincerely,

ROSS, LANGAN & MCKENDREE, L.L.P.

Jeffrey P. Hayden, Partner
Certified Public Accountant

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National Oilheat Research Alliance
Statement of Activities
For the Eight Months Ending August 31, 2018

	August 2018	YTD 2018	2018 Budget	Remaining	YTD 2017
INCOME					
Collections and Assessments					
Collections	$77,657.41	$5,995,743.55	$9,380,256.00	$3,384,512.45	$5,666,049.59
Remittance Accrual	0.00	0.00	0.00	0.00	0.00
Refunds	(55,462.13)	(696,497.94)	0.00	696,497.94	(566,613.52)
Collection Costs	(5,029.75)	(61,085.74)	(115,000.00)	(53,914.26)	(60,632.63)
Net Collections	***17,165.53***	***5,238,159.87***	***9,265,256.00***	***4,027,096.13***	***5,038,803.44***
In Kind Contributions					
Sales Revenue	0.00	2,033.84	0.00	(2,033.84)	4,987.92
Other Revenue (Grants, etc)	0.00	2,531.71	0.00	(2,531.71)	47,590.00
Total Income	***17,165.53***	***5,242,725.42***	***9,265,256.00***	***4,022,530.58***	***5,091,381.36***
PROGRAM EXPENSES					
Consumer Education and Training (Max. 30%)	***42,983.89***	***2,712,761.31***	***2,814,073.46***	***101,312.15***	***2,643,168.04***
Education and Training (Central)	42,983.89	248,687.85	350,000.00	101,312.15	209,708.49
Education and Training (States)	(0.00)	2,464,073.46	2,464,073.46	0.00	2,433,459.55
Research Development and Demonstration (Min. 30%)	***85,677.15***	***1,472,663.99***	***2,814,077.87***	***1,341,413.88***	***1,460,265.58***
Research Development and Demonstration (Central)	85,677.15	758,586.12	2,100,000.00	1,341,413.88	901,803.99
Research Development and Demonstration (States)	0.00	714,077.87	714,077.87	0.00	558,461.59
Home Energy Efficiency Program (Min. 15%)	***7,317.46***	***1,376,204.09***	***1,407,039.43***	***30,835.34***	***1,277,501.89***
Home Energy Efficiency Program (Central)	7,317.46	49,164.66	80,000.00	30,835.34	43,271.72
Home Energy Efficiency Program (States)	0.00	1,327,039.43	1,327,039.43	0.00	1,234,230.17
Total Central	***135,978.50***	***1,056,438.63***	***2,530,000.00***	***1,473,561.37***	***1,154,784.20***
Total States	***0.00***	***4,505,190.76***	***4,505,190.76***	***0.00***	***4,226,151.31***
State Rebates	***0.00***	***2,023,968.71***	***1,942,964.07***	***(81,004.64)***	***1,893,536.37***
Old Grant Advertising	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***

Office Unallocated Expenses					
Salaries and Consulting (Admin)	15,961.68	90,875.63	75,000.00	(15,875.63)	80,725.68
Accounting (Admin)	2,291.32	20,556.20	50,000.00	29,443.80	19,242.13
Insurance (Admin)	1,114.20	7,941.11	15,000.00	7,058.89	11,795.18
Taxes	147.17	2,127.40	3,000.00	872.60	2,196.87
Postage	0.00	40.51	3,000.00	2,959.49	141.36
Web Pages	1,293.70	10,704.60	30,000.00	19,295.40	10,704.58
Annual Report	2,495.87	41,311.00	45,000.00	3,689.00	43,634.12
Rent and Telephone	1,468.10	11,369.84	22,000.00	10,630.16	9,775.84
Travel	0.00	0.00	1,000.00	1,000.00	0.00
Meeting Expenses	0.00	0.00	8,000.00	8,000.00	83.64
Office Supplies	820.23	1,228.27	2,000.00	771.73	1,350.21
Dues & Memberships	0.00	0.00	100.00	100.00	69.99
Bank Fees	(110.64)	4,041.90	6,000.00	1,958.10	3,620.35
Legal Expense	0.00	0.00	15,000.00	15,000.00	0.00
Professional Fees	0.00	2,760.25	3,000.00	239.75	3,566.00
Misc Expense	0.00	0.00	1,000.00	1,000.00	0.00
Advertising Expense	0.00	0.00	1,000.00	1,000.00	0.00
Fixed Assets <$1,000	0.00	0.00	1,000.00	1,000.00	0.00
Equipment Maintenance	0.00	0.00	5,000.00	5,000.00	3,963.75
Bad Debts	0.00	0.00	1,000.00	1,000.00	0.00
Total Unallocated Expenses	***25,481.63***	***192,956.71***	***287,100.00***	***94,143.29***	***190,869.70***
Other Expenses/(Income)					
Cost of Goods Sold	310.83	3,212.72	0.00	(3,212.72)	4,037.19
Interest Expense	0.00	0.00	1,000.00	1,000.00	0.00
Interest	(7,172.45)	(43,490.29)	(1,000.00)	42,490.29	(11,051.74)
Total Other Expenses/(Income)	***(6,861.62)***	***(40,277.57)***	***0.00***	***40,277.57***	***(7,014.55)***
Net Revenue/(Expense)	***(137,432.98)***	***(2,495,551.82)***	***1.17***	***2,495,552.99***	***(2,366,945.67)***

National Oilheat Research Alliance
Statement of Financial Position
August 31, 2018

	2018	2017
ASSETS		
CURRENT ASSETS:		
Cash and Cash Equivalents	$10,564,004.83	$11,514,095.11
Accounts Receivable	0.00	926.22
Assessments and Other Receivables	2,936.25	66,137.89
Security Deposit	21,146.10	21,146.10
Prepaid Assets	13,467.08	17,953.48
Total Current Assets	10,601,554.26	11,620,258.80
PROPERTY AND EQUIPMENT		
Office Furniture and Equipment	66,849.15	73,847.15
Website	45,450.00	45,450.00
Computer Equipment	2,778.64	10,723.64
Less: Accumulated Depreciation	(53,198.96)	(46,168.40)
Less: Accumulative Amortization (Web Site)	(35,529.99)	(26,439.99)
Total Property and Equipment	26,348.84	57,412.40
TOTAL ASSETS	$10,627,903.10	$11,677,671.20
LIABILITIES AND NET ASSETS		
CURRENT LIABILITIES:		
State Rebate Obligations 2014	42,286.13	125,695.61
State Rebate Obligations 2015	304,315.40	1,204,994.73
State Rebate Obligations 2016	586,794.40	3,220,907.77
State Rebate Obligations 2017	2,193,659.09	5,130,567.49
State Rebate Obligations 2018	4,660,117.10	0.00
Total Grants Payable	7,787,172.12	9,682,165.60
Accrued Salaries & Benefits	22,287.12	16,339.80
Reserve for BIO Diesel Testing	764.35	764.35
Accounts Payable	123,243.99	42,833.42
Contracts Payable	3,153.00	3,153.00
Accrued Expenses	28,403.78	16,812.58
Total Current Liabilities	$7,965,024.36	$9,762,068.75
NET ASSETS:		
Unrestricted Net Assets	(2,190,595.52)	(2,876,005.73)
Pre-2014 Reauthorization Net Assets	55,933.05	55,933.05
National Spending Not Yet Incurred		
Research, Development, and Demonstration - net yet obligated	4,053,608.01	3,116,149.96
Research, Development, and Demonstration - obligated under contract	465,610.00	1,338,461.50
Heating Oil Efficiency and Upgrade - net yet obligated	144,618.57	150,362.90
Consumer Education, Safety, and Training - net yet obligated	133,704.63	130,700.77
Total Net Assets	2,662,878.74	1,915,602.45
TOTAL LIABILITIES AND NET ASSETS	$10,627,903.10	$11,677,671.20

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See Accountants' Compilation Report

National Oilheat Research Alliance

For the Nine Months Ending September 30, 2018

	Total Budget	Actual 2014	Actual 2015	Actual 2016	Actual 2017	Actual 2018	Total Actual	Remaining
CT 14 E&T	$116,634.40		$116,634.40				$116,634.40	
CT 15 E&T	227,946.61		190,577.89	37,368.72			227,946.61	
CT 16 E&T	256,780.56			256,780.56			256,780.56	
CT 17 E&T	269,293.83			5,045.00	264,248.83		269,293.83	
CT 18 E&T	303,065.71				28,059.93	191,874.78	219,934.71	83,131.00
TOTAL CT E&T	1,173,721.11		307,212.29	299,194.28	292,308.76	191,874.78	1,090,590.11	83,131.00
CT 14 R&D	23,177.73			23,177.73			23,177.73	
CT 15 R&D	68,833.01			3,318.64	28,883.18	(528.67)	31,673.15	37,159.86
CT 16 R&D	61,194.59							61,194.59
CT 17 R&D	63,497.08							63,497.08
CT 18 R&D	87,827.13							87,827.13
TOTAL CT R&D	304,529.54			26,496.37	28,883.18	(528.67)	54,850.88	249,678.66
CT 14 EE	62,991.10		46,620.38	16,370.72			62,991.10	
CT 15 EE	118,657.03			91,120.34	27,536.69		118,657.03	
CT 16 EE	134,909.87				134,909.87		134,909.87	
CT 17 EE	140,331.97					85,921.72	85,921.72	54,410.25
CT 18 EE	163,217.51							163,217.51
TOTAL CT EE	620,107.48		46,620.38	107,491.06	162,446.56	85,921.72	402,479.72	217,627.76
CT 14 REBATE	84,766.95			84,766.95			84,766.95	
CT 15 REBATE	164,494.99			110,626.04	53,868.95		164,494.99	
CT 16 REBATE	213,059.19				75,945.56	137,113.63	213,059.19	
CT 17 REBATE	206,788.12							206,788.12
CT 18 REBATE	238,972.43							238,972.43
TOTAL CT REBATE	908,081.68			195,392.99	129,814.51	137,113.63	462,321.13	445,760.55
DC 14 E&T	985.31							985.31
DC 15 E&T	1,925.62							1,925.62
DC 16 E&T	1,271.60							1,271.60

DC 17 E&T	1,657.92							1,657.92
DC 18 E&T	782.14							782.14
TOTAL DC E&T	6,622.59							6,622.59
DC 14 R&D	195.80							195.80
DC 15 R&D	581.48							581.48
DC 16 R&D	303.04							303.04
DC 17 R&D	390.92							390.92
DC 18 R&D	226.66							226.66
TOTAL DC R&D	1,697.90							1,697.90
DC 14 EE	532.13							532.13
DC 15 EE	1,002.38							1,002.38
DC 16 EE	668.09							668.09
DC 17 EE	863.96							863.96
DC 18 EE	421.22							421.22
TOTAL DC EE	3,487.78							3,487.78
DC 14 REBATE	716.08							716.08
DC 15 REBATE	1,389.60							1,389.60
DC 16 REBATE	1,055.09							1,055.09
DC 17 REBATE	1,273.10							1,273.10
DC 18 REBATE	616.73							616.73
	5,050.60							5,050.60
DE 14 E&T	10,282.37		10,282.37				10,282.37	
DE 15 E&T	20,095.20		2,470.11	17,625.09			20,095.20	
DE 16 E&T	15,879.15			1,010.45	14,868.70		15,879.15	
DE 17 E&T	14,447.60				971.02	13,476.58	14,447.60	
DE 18 E&T	15,391.64					6,353.42	6,353.42	9,038.22
TOTAL DE E&T	76,095.96		12,752.48	18,635.54	15,839.72	19,830.00	67,057.74	9,038.22
DE 14 R&D	2,043.29							2,043.29
DE 15 R&D	6,068.15							6,068.15
DE 16 R&D	3,784.24							3,784.24
DE 17 R&D	3,406.62							3,406.62
DE 18 R&D	4,460.43							4,460.43
TOTAL DE R&D	19,762.73							19,762.73

DE 14 EE	5,553.14		2,510.44	3,042.70			5,553.14	
DE 15 EE	10,460.51			5,354.24	5,106.27		10,460.51	
DE 16 EE	8,342.74				8,342.74		8,342.74	
DE 17 EE	7,528.80							7,528.80
DE 18 EE	8,289.24							8,289.24
TOTAL DE EE	40,174.43		2,510.44	8,396.94	13,449.01		24,356.39	15,818.04
DE 14 REBATE	7,472.84			7,472.84			7,472.84	
DE 15 REBATE	14,501.47				14,501.47		14,501.47	
DE 16 REBATE	13,175.45				3,947.47	600.00	4,547.47	8,627.98
DE 17 REBATE	11,094.17							11,094.17
DE 18 REBATE	12,136.56							12,136.56
TOTAL DE REBATE	58,380.49			7,472.84	18,448.94	600.00	26,521.78	31,858.71
ID 14 E&T	1,121.74					1,121.74	1,121.74	
ID 15 E&T	2,192.26					2,192.26	2,192.26	
ID 16 E&T	894.57					894.57	894.57	
ID 17 E&T	947.38					540.91	540.91	406.47
ID 18 E&T	1,782.18							1,782.18
TOTAL ID E&T	6,938.13					4,749.48	4,749.48	2,188.65
ID 14 R&D	222.91							222.91
ID 15 R&D	662.00							662.00
ID 16 R&D	213.19							213.19
ID 17 R&D	223.38							223.38
ID 18 R&D	516.47							516.47
TOTAL ID R&D	1,837.95							1,837.95
ID 14 EE	605.81							605.81
ID 15 EE	1,141.17							1,141.17
ID 16 EE	470.00							470.00
ID 17 EE	493.69							493.69
ID 18 EE	959.80							959.80
TOTAL ID EE	3,670.47							3,670.47
ID 14 REBATE	815.24							815.24
ID 15 REBATE	1,582.02							1,582.02
ID 16 REBATE	742.25							742.25

ID 17 REBATE	727.49							727.49
ID 18 REBATE	1,405.28							1,405.28
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TOTAL ID REBATE	5,272.28							5,272.28
IN 14 E&T	2,792.20		1,925.58	610.00			2,535.58	256.62
IN 15 E&T	5,456.90							5,456.90
IN 16 E&T	4,308.49							4,308.49
IN 17 E&T	3,315.84							3,315.84
IN 18 E&T	3,127.72							3,127.72
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TOTAL IN E&T	19,001.15		1,925.58	610.00			2,535.58	16,465.57
IN 14 R&D	554.86							554.86
IN 15 R&D	1,647.82							1,647.82
IN 16 R&D	1,026.78							1,026.78
IN 17 R&D	781.85							781.85
IN 18 R&D	906.40							906.40
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TOTAL IN R&D	1,864,563.61		63,808.88	337,999.37	339,998.74	248,214.83	990,021.82	874,541.79
IN 14 EE	1,507.97		1,507.97				1,507.97	
IN 15 EE	2,840.57			1,221.53			1,221.53	1,619.04
IN 16 EE	2,263.63							2,263.63
IN 17 EE	1,727.92							1,727.92
IN 18 EE	1,684.45							1,684.45
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TOTAL IN EE	10,024.54		1,507.97	1,221.53			2,729.50	7,295.04
IN 14 REBATE	2,029.27		417.62	1,507.97			1,925.59	103.68
IN 15 REBATE	3,937.91							3,937.91
IN 16 REBATE	3,574.89							3,574.89
IN 17 REBATE	2,546.20							2,546.20
IN 18 REBATE	2,466.26							2,466.26
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TOTAL IN REBATE	14,554.53		417.62	1,507.97			1,925.59	12,628.94
KY 14 E&T	20,596.48	4,226.56	16,369.92				20,596.48	
KY 15 E&T	40,252.45		16,179.49	20,659.64	3,413.32		40,252.45	
KY 16 E&T	27,204.92				27,204.92		27,204.92	
KY 17 E&T	31,737.36				4,845.54	12,412.07	17,257.61	14,479.75
KY 18 E&T	34,334.88							34,334.88
	------------------------	--------------------	--------------------	--------------------	--------------------	--------------------	------------------------	------------------------
TOTAL KY E&T	154,126.09	4,226.56	32,549.41	20,659.64	35,463.78	12,412.07	105,311.46	48,814.63

KY 14 R&D	4,092.89	3,846.00	246.89				4,092.89	
KY 15 R&D	12,155.03		11,797.76	357.27			12,155.03	
KY 16 R&D	6,483.33			6,237.61	245.72		6,483.33	
KY 17 R&D	7,483.39				7,483.39		7,483.39	
KY 18 R&D	9,950.10					4,117.93	4,117.93	5,832.17
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TOTAL KY R&D	40,164.74	3,846.00	12,044.65	6,594.88	7,729.11	4,117.93	34,332.57	5,832.17
KY 14 EE	11,123.42	8,865.93	2,257.49				11,123.42	
KY 15 EE	20,953.31		16,687.63	4,265.68			20,953.31	
KY 16 EE	14,293.19			7,266.03	7,027.16		14,293.19	
KY 17 EE	16,538.68				16,538.68		16,538.68	
KY 18 EE	18,491.21					5,588.76	5,588.76	12,902.45
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TOTAL KY EE	81,399.81	8,865.93	18,945.12	11,531.71	23,565.84	5,588.76	68,497.36	12,902.45
KY 14 REBATE	14,968.76		14,968.76				14,968.76	
KY 15 REBATE	29,047.71			29,047.71			29,047.71	
KY 16 REBATE	22,572.81			22,200.28	372.53		22,572.81	
KY 17 REBATE	24,370.81				23,553.97	816.84	24,370.81	
KY 18 REBATE	27,073.63							27,073.63
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TOTAL KY REBATE	118,033.72		14,968.76	51,247.99	23,926.50	816.84	90,960.09	27,073.63
MA 14 E&T	138,514.41		138,514.41				138,514.41	
MA 15 E&T	270,703.73		59,543.18	201,516.92	9,643.63		270,703.73	
MA 16 E&T	301,645.43				301,645.43		301,645.43	
MA 17 E&T	286,820.44				116,696.35	170,124.09	286,820.44	
MA 18 E&T	312,427.69					168,495.12	168,495.12	143,932.57
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TOTAL MA E&T	1,310,111.70		198,057.59	201,516.92	427,985.41	338,619.21	1,166,179.13	143,932.57
MA 14 R&D	27,525.30		24,539.52	2,985.78			27,525.30	
MA 15 R&D	81,744.37		1,230.20	80,514.17			81,744.37	
MA 16 R&D	71,886.55				31,553.04	40,333.51	71,886.55	
MA 17 R&D	67,629.70					29,106.54	29,106.54	38,523.16
MA 18 R&D	90,540.19							90,540.19
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TOTAL MA R&D	339,326.11		25,769.72	83,499.95	31,553.04	69,440.05	210,262.76	129,063.35
MA 14 EE	74,806.66		69,076.57	5,730.09			74,806.66	
MA 15 EE	140,914.14			68,127.19	72,786.95		140,914.14	
MA 16 EE	158,481.41				158,481.41		158,481.41	

MA 17 EE	149,465.28				70,926.72	78,538.56	149,465.28	
MA 18 EE	168,259.45					168,259.45	168,259.45	
TOTAL MA EE	691,926.94		69,076.57	73,857.28	302,195.08	246,798.01	691,926.94	
MA 14 REBATE	100,667.12			100,667.12			100,667.12	
MA 15 REBATE	195,350.17			100,801.33	94,548.84		195,350.17	
MA 16 REBATE	250,285.04				250,285.04		250,285.04	
MA 17 REBATE	220,246.63					220,246.63	220,246.63	
MA 18 REBATE	246,354.51					78,571.12	78,571.12	167,783.39
TOTAL MA REBATE	1,012,903.47			201,468.45	344,833.88	298,817.75	845,120.08	167,783.39
MD 14 E&T	37,071.13	41,165.68	(4,094.55)				37,071.13	
MD 15 E&T	72,449.46		67,231.81	5,217.65			72,449.46	
MD 16 E&T	84,888.96			84,888.96			84,888.96	
MD 17 E&T	73,895.93				70,000.56	3,895.37	73,895.93	
MD 18 E&T	78,648.03					30,240.52	30,240.52	48,407.51
TOTAL MD E&T	346,953.51	41,165.68	63,137.26	90,106.61	70,000.56	34,135.89	298,546.00	48,407.51
MD 14 R&D	7,366.70	1,700.00		5,666.70			7,366.70	
MD 15 R&D	21,877.56			643.30	277.78	14,000.00	14,921.08	6,956.48
MD 16 R&D	20,230.29							20,230.29
MD 17 R&D	17,424.00							17,424.00
MD 18 R&D	22,791.86					2,700.00	2,700.00	20,091.86
TOTAL MD R&D	89,690.41	1,700.00		6,310.00	277.78	16,700.00	24,987.78	64,702.63
MD 14 EE	20,020.79	15,400.00	4,620.79				20,020.79	
MD 15 EE	37,713.38		1,087.81	36,625.57			37,713.38	
MD 16 EE	44,599.79			44,599.79			44,599.79	
MD 17 EE	38,507.98				27,257.98	11,250.00	38,507.98	
MD 18 EE	42,356.28					42,356.28	42,356.28	
TOTAL MD EE	183,198.22	15,400.00	5,708.60	81,225.36	27,257.98	53,606.28	183,198.22	
MD 14 REBATE	26,941.92		26,941.92				26,941.92	
MD 15 REBATE	52,282.30			52,282.30			52,282.30	
MD 16 REBATE	70,435.13			70,435.13			70,435.13	
MD 17 REBATE	56,743.97				56,743.97		56,743.97	
MD 18 REBATE	62,015.30					19,893.72	19,893.72	42,121.58
TOTAL MD REBATE	268,418.62		26,941.92	122,717.43	56,743.97	19,893.72	226,297.04	42,121.58

ME 14 E&T	70,733.00		38,206.01	32,526.99			70,733.00	
ME 15 E&T	138,236.06			138,236.06			138,236.06	
ME 16 E&T	153,735.76			49,749.34	103,986.42		153,735.76	
ME 17 E&T	175,502.84				132,782.06	35,640.53	168,422.59	7,080.25
ME 18 E&T	168,096.18					116,212.00	116,212.00	51,884.18
TOTAL ME E&T	706,303.84		38,206.01	220,512.39	236,768.48	151,852.53	647,339.41	58,964.43
ME 14 R&D	14,055.92		14,055.92				14,055.92	
ME 15 R&D	41,743.13			24,644.38	17,098.75		41,743.13	
ME 16 R&D	36,637.49				8,816.10	27,821.39	36,637.49	
ME 17 R&D	41,382.00					38,078.73	38,078.73	3,303.27
ME 18 R&D	48,713.55							48,713.55
TOTAL ME R&D	182,532.09		14,055.92	24,644.38	25,914.85	65,900.12	130,515.27	52,016.82
ME 14 EE	38,200.35		26,410.67	11,789.68			38,200.35	
ME 15 EE	71,958.43			715.80	71,242.63		71,958.43	
ME 16 EE	80,771.19				56,569.65	24,201.54	80,771.19	
ME 17 EE	91,456.46					83,341.50	83,341.50	8,114.96
ME 18 EE	90,529.01							90,529.01
TOTAL ME EE	372,915.44		26,410.67	12,505.48	127,812.28	107,543.04	274,271.47	98,643.97
ME 14 REBATE	51,406.11		18,498.23	32,907.88			51,406.11	
ME 15 REBATE	99,756.43			4,355.64	95,400.79		99,756.43	
ME 16 REBATE	127,559.56					127,559.56	127,559.56	
ME 17 REBATE	134,766.93							134,766.93
ME 18 REBATE	132,546.68							132,546.68
TOTAL ME REBATE	546,035.71		18,498.23	37,263.52	95,400.79	127,559.56	278,722.10	267,313.61
MI 14 E&T	38,065.57		25,865.00	12,200.57			38,065.57	
MI 15 E&T	74,392.92			39,365.43	35,027.49		74,392.92	
MI 16 E&T	49,072.79				49,072.79	(1,100.28)	47,972.51	1,100.28
MI 17 E&T	75,317.00				1,357.72	12,393.28	13,751.00	61,566.00
MI 18 E&T	52,482.58							52,482.58
TOTAL MI E&T	289,330.86		25,865.00	51,566.00	85,458.00	11,293.00	174,182.00	115,148.86
MI 14 R&D	7,564.31			7,564.31			7,564.31	
MI 15 R&D	22,464.42			11,385.29	11,079.13		22,464.42	
MI 16 R&D	11,694.77				11,694.77		11,694.77	

MI 17 R&D	17,759.08							17,759.08
MI 18 R&D	15,209.23							15,209.23
TOTAL MI R&D	74,691.81			18,949.60	22,773.90		41,723.50	32,968.31
MI 14 EE	20,557.85			10,722.49	9,835.36		20,557.85	
MI 15 EE	38,725.04			4,277.51	34,447.53		38,725.04	
MI 16 EE	25,782.34					25,782.34	25,782.34	
MI 17 EE	39,248.52					32,688.32	32,688.32	6,560.20
MI 18 EE	28,264.75							28,264.75
TOTAL MI EE	152,578.50			15,000.00	44,282.89	58,470.66	117,753.55	34,824.95
MI 14 REBATE	27,664.64			27,664.64			27,664.64	
MI 15 REBATE	53,684.77				53,684.77		53,684.77	
MI 16 REBATE	40,717.29				758.44	39,958.85	40,717.29	
MI 17 REBATE	57,835.20							57,835.20
MI 18 REBATE	41,383.40							41,383.40
TOTAL MI REBATE	221,285.30			27,664.64	54,443.21	39,958.85	122,066.70	99,218.60
NC 14 E&T	39,441.56	20,209.84	19,231.72				39,441.56	
NC 15 E&T	77,082.07		60,632.40	16,449.67			77,082.07	
NC 16 E&T	75,862.48			73,589.90	2,272.58		75,862.48	
NC 17 E&T	76,264.39				76,264.39		76,264.39	
NC 18 E&T	82,945.10				2,093.01	77,518.00	79,611.01	3,334.09
TOTAL NC E&T	351,595.60	20,209.84	79,864.12	90,039.57	80,629.98	77,518.00	348,261.51	3,334.09
NC 14 R&D	7,837.75	3,962.48	3,875.27				7,837.75	
NC 15 R&D	23,276.46		4,085.44	12,191.02	7,000.00		23,276.46	
NC 16 R&D	18,079.15			18,079.15			18,079.15	
NC 17 R&D	17,982.46				17,982.46		17,982.46	
NC 18 R&D	24,037.13				14,000.00	10,037.13	24,037.13	
TOTAL NC R&D	91,212.95	3,962.48	7,960.71	30,270.17	38,982.46	10,037.13	91,212.95	
NC 14 EE	21,300.97	21,920.00	(619.03)				21,300.97	
NC 15 EE	40,124.88		39,020.00	104.88	1,000.00		40,124.88	
NC 16 EE	39,857.37			39,857.37			39,857.37	
NC 17 EE	39,742.21				39,742.21		39,742.21	
NC 18 EE	44,670.48				88,047.80	(43,377.32)	44,670.48	
TOTAL NC EE	185,695.91	21,920.00	38,400.97	39,962.25	128,790.01	(43,377.32)	185,695.91	

NC 14 REBATE	28,664.66		28,664.66				28,664.66	
NC 15 REBATE	55,625.37			60,625.37	(9,000.00)	4,000.00	55,625.37	
NC 16 REBATE	62,945.57			30,183.67	32,761.90		62,945.57	
NC 17 REBATE	58,562.69				58,562.69		58,562.69	
NC 18 REBATE	65,403.61					65,403.61	65,403.61	
TOTAL NC REBATE	271,201.90		28,664.66	90,809.04	82,324.59	69,403.61	271,201.90	
NH 14 E&T	60,173.75		60,173.75				60,173.75	
NH 15 E&T	117,599.73		102,721.25	14,878.48			117,599.73	
NH 16 E&T	105,519.06			81,373.06	24,146.00		105,519.06	
NH 17 E&T	106,817.52				4,312.86	59,463.37	63,776.23	43,041.29
NH 18 E&T	110,092.56							110,092.56
TOTAL NH E&T	500,202.62		162,895.00	96,251.54	28,458.86	59,463.37	347,068.77	153,133.85
NH 14 R&D	11,957.60					11,957.60	11,957.60	
NH 15 R&D	35,511.58					420.75	420.75	35,090.83
NH 16 R&D	25,146.75							25,146.75
NH 17 R&D	25,186.62							25,186.62
NH 18 R&D	31,904.35							31,904.35
TOTAL NH R&D	129,706.90					12,378.35	12,378.35	117,328.55
NH 14 EE	32,497.68				32,497.68		32,497.68	
NH 15 EE	61,216.24				61,216.24		61,216.24	
NH 16 EE	55,438.63				55,438.63		55,438.63	
NH 17 EE	55,663.78				55,663.78		55,663.78	
NH 18 EE	59,290.88					59,490.88	59,490.88	(200.00)
TOTAL NH EE	264,107.21				204,816.33	59,490.88	264,307.21	(200.00)
NH 14 REBATE	43,732.04				43,732.04		43,732.04	
NH 15 REBATE	84,864.47				84,864.47		84,864.47	
NH 16 REBATE	87,552.60				87,552.60		87,552.60	
NH 17 REBATE	82,024.14				21,240.39	60,783.75	82,024.14	
NH 18 REBATE	86,809.85					78,552.20	78,552.20	8,257.65
TOTAL NH REBATE	384,983.10				237,389.50	139,335.95	376,725.45	8,257.65
NJ 14 E&T	106,379.25	76,697.13	29,682.12				106,379.25	
NJ 15 E&T	207,900.82		180,244.43	27,656.39			207,900.82	
NJ 16 E&T	183,364.89			183,364.89			183,364.89	

NJ 17 E&T	138,081.18			10,819.12	92,288.81	34,973.25	138,081.18	
NJ 18 E&T	142,181.51					24,218.96	24,218.96	117,962.55
TOTAL NJ E&T	777,907.65	76,697.13	209,926.55	221,840.40	92,288.81	59,192.21	659,945.10	117,962.55
NJ 14 R&D	21,139.47		21,139.47				21,139.47	
NJ 15 R&D	62,779.79			25,000.00	37,779.79		62,779.79	
NJ 16 R&D	43,698.55			29,885.41	13,620.21	192.93	43,698.55	
NJ 17 R&D	32,558.31					24,807.07	24,807.07	7,751.24
NJ 18 R&D	41,203.59							41,203.59
TOTAL NJ R&D	201,379.71		21,139.47	54,885.41	51,400.00	25,000.00	152,424.88	48,954.83
NJ 14 EE	57,451.61		57,451.61				57,451.61	
NJ 15 EE	108,222.25		85,832.49	22,389.76			108,222.25	
NJ 16 EE	96,338.03			25,418.91	70,919.12		96,338.03	
NJ 17 EE	71,955.62				59,542.90	12,412.72	71,955.62	
NJ 18 EE	76,572.54					76,572.54	76,572.54	
TOTAL NJ EE	410,540.05		143,284.10	47,808.67	130,462.02	88,985.26	410,540.05	
NJ 14 REBATE	77,312.48		77,312.48				77,312.48	
NJ 15 REBATE	150,029.18			144,129.18	5,900.00		150,029.18	
NJ 16 REBATE	152,143.82				152,143.82		152,143.82	
NJ 17 REBATE	106,031.20					106,031.20	106,031.20	
NJ 18 REBATE	112,112.52					841.29	841.29	111,271.23
TOTAL NJ REBATE	597,629.20		77,312.48	144,129.18	158,043.82	106,872.49	486,357.97	111,271.23
NV 14 E&T	598.47							598.47
NV 15 E&T	1,169.61							1,169.61
NV 16 E&T	418.70							418.70
NV 17 E&T	947.38							947.38
NV 18 E&T	646.97							646.97
TOTAL NV E&T	3,781.13							3,781.13
NV 14 R&D	118.93							118.93
NV 15 R&D	353.19							353.19
NV 16 R&D	99.78							99.78
NV 17 R&D	223.38							223.38
NV 18 R&D	187.49							187.49
TOTAL NV R&D	982.77							982.77

NV 14 EE	323.21							323.21
NV 15 EE	608.84							608.84
NV 16 EE	219.98							219.98
NV 17 EE	493.69							493.69
NV 18 EE	348.43							348.43
TOTAL NV EE	1,994.15							1,994.15
NV 14 REBATE	434.95							434.95
NV 15 REBATE	844.04							844.04
NV 16 REBATE	347.41							347.41
NV 17 REBATE	727.49							727.49
NV 18 REBATE	510.14							510.14
TOTAL NV REBATE	2,864.03							2,864.03
NYOHA 14 E&T	82,431.97	22,767.05	59,664.92				82,431.97	
NYOHA 15 E&T	146,546.55		63,985.22	82,561.33			146,546.55	
NYOHA 16 E&T	138,579.36			138,494.20	1,298.54	(1,213.38)	138,579.36	
NYOHA 17 E&T	139,130.41			31,311.39	106,987.47	831.55	139,130.41	
NYOHA 18 E&T	144,084.38				20,102.19	82,663.26	102,765.45	41,318.93
TOTAL NYOHA E&T	650,772.67	22,767.05	123,650.14	252,366.92	128,388.20	82,281.43	609,453.74	41,318.93
NYOHA 14 R&D	16,380.71		6,390.96	9,365.17	624.58		16,380.71	
NYOHA 15 R&D	54,083.16			14,989.94	34,177.96		49,167.90	4,915.26
NYOHA 16 R&D	40,362.76				36,693.42		36,693.42	3,669.34
NYOHA 17 R&D	32,805.71					2,495.00	2,495.00	30,310.71
NYOHA 18 R&D	41,755.04							41,755.04
TOTAL NYOHA R&D	185,387.38		6,390.96	24,355.11	71,495.96	2,495.00	104,737.03	80,650.35
NYOHA 14 EE	53,514.75	13,357.50	31,161.05		4,498.10		49,016.65	4,498.10
NYOHA 15 EE	93,230.67			35,194.43	49,563.12		84,757.55	8,473.12
NYOHA 16 EE	88,983.94				80,894.49		80,894.49	8,089.45
NYOHA 17 EE	72,502.39				9,876.13	10,298.85	20,174.98	52,327.41
NYOHA 18 EE	77,597.58					2,600.00	2,600.00	74,997.58
TOTAL NYOHA EE	385,829.33	13,357.50	31,161.05	35,194.43	144,831.84	12,898.85	237,443.67	148,385.66
NYOHA 14 REBATE	68,027.10		25,301.38	34,607.11	4,129.15		64,037.64	3,989.46
NYOHA 15 REBATE	129,246.25			50,707.18	66,792.74		117,499.92	11,746.33
NYOHA 16 REBATE	140,529.71				21,253.13	106,501.15	127,754.28	12,775.43

NYOHA 17 REBATE	106,836.89							106,836.89
NYOHA 18 REBATE	113,613.14							113,613.14
TOTAL NYOHA REBATE	558,253.09		25,301.38	85,314.29	92,175.02	106,501.15	309,291.84	248,961.25
UNYEA 14 E&T	58,846.62	(26,154.05)	85,000.67				58,846.62	
UNYEA 15 E&T	114,600.41		76,428.89	38,171.52			114,600.41	
UNYEA 16 E&T	108,791.27			108,786.59	957.24	(952.56)	108,791.27	
UNYEA 17 E&T	109,223.87				108,571.07	652.80	109,223.87	
UNYEA 18 E&T	113,112.97				6,536.74	69,553.64	76,090.38	37,022.59
TOTAL UNYEA E&T	504,575.14	(26,154.05)	161,429.56	146,958.11	116,065.05	69,253.88	467,552.55	37,022.59
UNYEA 14 R&D	11,693.88	(5,197.28)	5,197.28	11,693.88			11,693.88	
UNYEA 15 R&D	42,323.29			10,198.76	28,265.82		38,464.58	3,858.71
UNYEA 16 R&D	31,686.65				28,806.05		28,806.05	2,880.60
UNYEA 17 R&D	25,754.01				25,754.01		25,754.01	
UNYEA 18 R&D	32,779.66					28,351.21	28,351.21	4,428.45
TOTAL UNYEA R&D	144,237.49	(5,197.28)	5,197.28	21,892.64	82,825.88	28,351.21	133,069.73	11,167.76
UNYEA 14 EE	38,843.39	(14,124.87)	14,124.87	31,780.95	3,531.22		35,312.17	3,531.22
UNYEA 15 EE	72,958.54			5,750.00	60,556.75		66,306.75	6,651.79
UNYEA 16 EE	69,856.54				63,505.95		63,505.95	6,350.59
UNYEA 17 EE	56,917.76				56,917.76		56,917.76	
UNYEA 18 EE	60,917.72					60,917.72	60,917.72	
TOTAL UNYEA EE	299,493.95	(14,124.87)	14,124.87	37,530.95	184,511.68	60,917.72	282,960.35	16,533.60
UNYEA 14 REBATE	49,141.01			42,767.53	3,241.57		46,009.10	3,131.91
UNYEA 15 REBATE	101,142.88			66,505.52	25,415.94		91,921.46	9,221.42
UNYEA 16 REBATE	110,322.39				100,293.08		100,293.08	10,029.31
UNYEA 17 REBATE	83,871.96				83,871.96		83,871.96	
UNYEA 18 REBATE	89,191.62				28,467.80	53,686.95	82,154.75	7,036.87
TOTAL UNYEA REBATE	433,669.86			109,273.05	241,290.35	53,686.95	404,250.35	29,419.51
HVOHC 14 E&T	27,088.13		27,088.13				27,088.13	
HVOHC 15 E&T	67,441.84		34,167.61	33,274.23			67,441.84	
HVOHC 16 E&T	63,893.28			39,119.79	25,332.93	(559.44)	63,893.28	
HVOHC 17 E&T	64,147.36				63,763.96	383.40	64,147.36	
HVOHC 18 E&T	66,431.43				14,138.58	46,193.05	60,331.63	6,099.80
TOTAL HVOHC E&T	289,002.04		61,255.74	72,394.02	103,235.47	46,017.01	282,902.24	6,099.80

HVOHC 14 R&D	5,382.90			3,261.50	2,121.40		5,382.90	
HVOHC 15 R&D	24,897.84				22,631.62		22,631.62	2,266.22
HVOHC 16 R&D	18,609.62				16,917.84		16,917.84	1,691.78
HVOHC 17 R&D	15,125.38					7,005.05	7,005.05	8,120.33
HVOHC 18 R&D	19,251.54							19,251.54
TOTAL HVOHC R&D	83,267.28			3,261.50	41,670.86	7,005.05	51,937.41	31,329.87
HVOHC 14 EE	18,777.10		14,192.35	436.97	2,073.89		16,703.21	2,073.89
HVOHC 15 EE	42,919.90			35,106.68	3,906.61		39,013.29	3,906.61
HVOHC 16 EE	41,026.85				37,297.14		37,297.14	3,729.71
HVOHC 17 EE	33,427.89					46,927.89	46,927.89	(13,500.00)
HVOHC 18 EE	35,777.08							35,777.08
TOTAL HVOHC EE	171,928.82		14,192.35	35,543.65	43,277.64	46,927.89	139,941.53	31,987.29
HVOHC 14 REBATE	23,429.79		1,593.05	18,093.59	1,903.78		21,590.42	1,839.37
HVOHC 15 REBATE	59,500.13			22,408.76	31,675.61		54,084.37	5,415.76
HVOHC 16 REBATE	64,792.52				49,038.32	9,863.97	58,902.29	5,890.23
HVOHC 17 REBATE	49,258.13					34,235.14	34,235.14	15,022.99
HVOHC 18 REBATE	52,382.38							52,382.38
TOTAL HVOHC REBATE	249,362.95		1,593.05	40,502.35	82,617.71	44,099.11	168,812.22	80,550.73
OHILI 14 E&T	65,151.61	36,719.05	29,810.79	(1,378.23)	1,378.23	(1,378.23)	65,151.61	
OHILI 15 E&T	127,784.53		118,379.75	9,404.78			127,784.53	
OHILI 16 E&T	120,447.48			120,442.29	1,059.81	(1,054.62)	120,447.48	
OHILI 17 E&T	120,926.43			8,014.38	112,189.30	722.75	120,926.43	
OHILI 18 E&T	125,232.22				16,855.73	78,772.27	95,628.00	29,604.22
TOTAL OHILI E&T	559,542.27	36,719.05	148,190.54	136,483.22	131,483.07	77,062.17	529,938.05	29,604.22
OHILI 14 R&D	12,946.80	7,714.78	5,232.02				12,946.80	
OHILI 15 R&D	47,131.36		8,137.30	27,449.78	4,272.14	3,000.00	42,859.22	4,272.14
OHILI 16 R&D	35,081.65			28,703.17	3,189.24		31,892.41	3,189.24
OHILI 17 R&D	31,513.38			11,514.57	25,196.09	(5,197.28)	31,513.38	
OHILI 18 R&D	36,291.76				58.60	36,233.16	36,291.76	
TOTAL OHILI R&D	162,964.95	7,714.78	13,369.32	67,667.52	32,716.07	34,035.88	155,503.57	7,461.38
OHILI 14 EE	43,005.17	30,427.37	4,758.68		3,909.56		39,095.61	3,909.56
OHILI 15 EE	81,246.88		12,135.27	54,382.65	7,364.48		73,882.40	7,364.48
OHILI 16 EE	77,341.16			63,279.14	7,031.01		70,310.15	7,031.01

OHILI 17 EE	63,016.09			23,406.25	39,609.84		63,016.09	
OHILI 18 EE	67,444.62					36,214.12	36,214.12	31,230.50
TOTAL OHILI EE	332,053.92	30,427.37	16,893.95	141,068.04	57,914.89	36,214.12	282,518.37	49,535.55
OHILI 14 REBATE	54,406.14		47,349.77		3,588.89		50,938.66	3,467.48
OHILI 15 REBATE	112,633.07			92,214.21	10,209.43		102,423.64	10,209.43
OHILI 16 REBATE	122,142.65			99,934.89	11,103.88		111,038.77	11,103.88
OHILI 17 REBATE	92,858.23				92,858.23		92,858.23	
OHILI 18 REBATE	98,747.87					4,045.00	4,045.00	94,702.87
TOTAL OHILI REBATE	480,787.96		47,349.77	192,149.10	117,760.43	4,045.00	361,304.30	119,483.66
ESPA 14 E&T	25,946.48		25,946.48				25,946.48	
ESPA 15 E&T	50,708.15		45,906.39	4,801.76			50,708.15	
ESPA 16 E&T	47,965.87		469.86	47,496.01			47,965.87	
ESPA 17 E&T					3,780.00	(3,780.00)		
TOTAL ESPA E&T	124,620.50		72,322.73	52,297.77	3,780.00	(3,780.00)	124,620.50	
ESPA 14 R&D	5,156.03			5,156.03			5,156.03	
ESPA 15 R&D	(15,312.33)							(15,312.33)
ESPA 16 R&D	(11,430.97)							(11,430.97)
TOTAL ESPA R&D	(21,587.27)			5,156.03			5,156.03	(26,743.30)
ESPA 14 EE	(14,012.76)							(14,012.76)
ESPA 15 EE	(26,396.00)							(26,396.00)
ESPA 16 EE	(25,200.77)							(25,200.77)
TOTAL ESPA EE	(65,609.53)							(65,609.53)
ESPA 14 REBATE	(5,999.50)			6,428.72	(435.17)		5,993.55	(11,993.05)
ESPA 15 REBATE	(36,592.94)							(36,592.94)
ESPA 16 REBATE	(39,798.84)							(39,798.84)
TOTAL ESPA REBATE	(82,391.28)			6,428.72	(435.17)		5,993.55	(88,384.83)
OH 14 E&T	35,311.81		35,311.81				35,311.81	
OH 15 E&T	69,011.16		31,033.56	37,977.60			69,011.16	
OH 16 E&T	73,734.81			48,697.18	25,037.63		73,734.81	
OH 17 E&T	59,211.49				15,070.75	5,351.66	20,422.41	38,789.08
OH 18 E&T	66,084.91							66,084.91

TOTAL OH E&T	303,354.18		66,345.37	86,674.78	40,108.38	5,351.66	198,480.19	104,873.99
OH 14 R&D	7,017.09		7,017.09				7,017.09	
OH 15 R&D	20,754.20			570.00			570.00	20,184.20
OH 16 R&D	17,572.09							17,572.09
OH 17 R&D	13,961.54							13,961.54
OH 18 R&D	19,151.12							19,151.12
TOTAL OH R&D	78,456.04		7,017.09	570.00			7,587.09	70,868.95
OH 14 EE	19,070.64			19,070.64			19,070.64	
OH 15 EE	35,923.58							35,923.58
OH 16 EE	38,739.51							38,739.51
OH 17 EE	30,855.76							30,855.76
OH 18 EE	35,590.35							35,590.35
TOTAL OH EE	160,179.84			19,070.64			19,070.64	141,109.20
OH 14 REBATE	25,663.31		8,416.47	2,079.36	13,147.70		23,643.53	2,019.78
OH 15 REBATE	49,801.09							49,801.09
OH 16 REBATE	61,180.17							61,180.17
OH 17 REBATE	45,467.93							45,467.93
OH 18 REBATE	52,109.07							52,109.07
TOTAL OH REBATE	234,221.57		8,416.47	2,079.36	13,147.70		23,643.53	210,578.04
PA 14 E&T	168,801.05		168,801.05				168,801.05	
PA 15 E&T	329,894.00		8,996.53	320,897.47			329,894.00	
PA 16 E&T	341,369.79			6,384.31	318,550.61	16,434.87	341,369.79	
PA 17 E&T	332,531.70					184,738.02	184,738.02	147,793.68
PA 18 E&T	330,391.50							330,391.50
TOTAL PA E&T	1,502,988.04		177,797.58	327,281.78	318,550.61	201,172.89	1,024,802.86	478,185.18
PA 14 R&D	33,543.41			21,864.92	11,678.49		33,543.41	
PA 15 R&D	99,211.29				89,131.13	10,080.16	99,211.29	
PA 16 R&D	81,353.45					58,576.46	58,576.46	22,776.99
PA 17 R&D	78,408.01							78,408.01
PA 18 R&D	95,746.03							95,746.03
TOTAL PA R&D	388,262.19			21,864.92	100,809.62	68,656.62	191,331.16	196,931.03
PA 14 EE	91,162.35			87,943.79	3,218.56		91,162.35	
PA 15 EE	171,725.49				171,725.49	1,750.00	173,475.49	(1,750.00)

PA 16 EE	179,352.19				21,248.15	158,104.04	179,352.19	
PA 17 EE	173,285.92							173,285.92
PA 18 EE	177,933.95							177,933.95
TOTAL PA EE	793,459.90			87,943.79	196,192.20	159,854.04	443,990.03	349,469.87
PA 14 REBATE	122,676.94			75,110.06	47,566.88		122,676.94	
PA 15 REBATE	238,064.14				200,341.41	37,722.73	238,064.14	
PA 16 REBATE	283,245.63					190,688.84	190,688.84	92,556.79
PA 17 REBATE	255,347.87							255,347.87
PA 18 REBATE	260,519.28							260,519.28
TOTAL PA REBATE	1,159,853.86			75,110.06	247,908.29	228,411.57	551,429.92	608,423.94
RI 14 E&T	38,991.77	31,620.00	7,371.77				38,991.77	
RI 15 E&T	76,203.03		71,436.78	4,766.25			76,203.03	
RI 16 E&T	64,057.01			45,493.75	18,563.26		64,057.01	
RI 17 E&T	64,658.95				31,147.00	33,511.95	64,658.95	
RI 18 E&T	66,771.98					6,593.69	6,593.69	60,178.29
TOTAL RI E&T	310,682.74	31,620.00	78,808.55	50,260.00	49,710.26	40,105.64	250,504.45	60,178.29
RI 14 R&D	7,748.36		7,748.36				7,748.36	
RI 15 R&D	22,917.06		42,016.54		(19,099.48)		22,917.06	
RI 16 R&D	15,265.73			2,164.81	13,100.92		15,265.73	
RI 17 R&D	15,246.00				475.00	14,771.00	15,246.00	
RI 18 R&D	19,350.23							19,350.23
TOTAL RI R&D	80,527.38		49,764.90	2,164.81	(5,523.56)	14,771.00	61,177.15	19,350.23
RI 14 EE	21,058.06		21,058.06				21,058.06	
RI 15 EE	39,667.29		13,415.88	26,251.41			39,667.29	
RI 16 EE	33,654.90			5,417.50	28,237.40		33,654.90	
RI 17 EE	33,694.48				19,565.25	20,879.23	40,444.48	(6,750.00)
RI 18 EE	35,960.38							35,960.38
TOTAL RI EE	164,035.11		34,473.94	31,668.91	47,802.65	20,879.23	134,824.73	29,210.38
RI 14 REBATE	28,337.77		28,337.77				28,337.77	
RI 15 REBATE	54,991.02			24,450.54	11,441.00	19,099.48	54,991.02	
RI 16 REBATE	53,150.19			135.19	53,015.00		53,150.19	
RI 17 REBATE	49,650.97					41,684.27	41,684.27	7,966.70
RI 18 REBATE	52,650.84							52,650.84

TOTAL RI REBATE	238,780.79		28,337.77	24,585.73	64,456.00	60,783.75	178,163.25	60,617.54
SC 14 E&T	6,063.62				6,063.62		6,063.62	
SC 15 E&T	11,850.35				6,850.03	5,000.32	11,850.35	
SC 16 E&T	29,548.64					29,548.64	29,548.64	
SC 17 E&T	29,132.05					9,826.04	9,826.04	19,306.01
SC 18 E&T	34,663.01							34,663.01
TOTAL SC E&T	111,257.67				12,913.65	44,375.00	57,288.65	53,969.02
SC 14 R&D	1,204.95							1,204.95
SC 15 R&D	3,563.84							3,563.84
SC 16 R&D	7,041.88							7,041.88
SC 17 R&D	6,869.08							6,869.08
SC 18 R&D	10,045.19							10,045.19
TOTAL SC R&D	28,724.94							28,724.94
SC 14 EE	3,274.74				3,274.74		3,274.74	
SC 15 EE	6,168.67				4,843.45	1,325.22	6,168.67	
SC 16 EE	15,524.55					10,068.01	10,068.01	5,456.54
SC 17 EE	15,181.03							15,181.03
SC 18 EE	18,667.93							18,667.93
TOTAL SC EE	58,816.92				8,118.19	11,393.23	19,511.42	39,305.50
SC 14 REBATE	4,406.81				4,406.81		4,406.81	
SC 15 REBATE	8,551.67					8,551.67	8,551.67	
SC 16 REBATE	24,517.47					10,913.08	10,913.08	13,604.39
SC 17 REBATE	22,370.25							22,370.25
SC 18 REBATE	27,332.37							27,332.37
TOTAL SC REBATE	87,178.57				4,406.81	19,464.75	23,871.56	63,307.01
VA 14 E&T	35,296.90		20,378.87	14,918.03			35,296.90	
VA 15 E&T	68,982.01			43,441.21	25,540.80		68,982.01	
VA 16 E&T	83,982.86				67,952.70	16,030.16	83,982.86	
VA 17 E&T	76,264.39					6,650.44	6,650.44	69,613.95
VA 18 E&T	77,230.04							77,230.04
TOTAL VA E&T	341,756.20		20,378.87	58,359.24	93,493.50	22,680.60	194,912.21	146,843.99
VA 14 R&D	7,014.13			7,014.13			7,014.13	
VA 15 R&D	59,105.43			50,223.32	8,882.11		59,105.43	

VA 16 R&D	20,014.35				20,014.35		20,014.35	
VA 17 R&D	17,982.46					17,982.46	17,982.46	
VA 18 R&D	22,380.93							22,380.93
TOTAL VA R&D	126,497.30			57,237.45	28,896.46	17,982.46	104,116.37	22,380.93
VA 14 EE	19,062.59		13,860.76	5,201.83			19,062.59	
VA 15 EE	35,908.41			35,908.41			35,908.41	
VA 16 EE	44,123.73				44,123.73		44,123.73	
VA 17 EE	39,742.21					36,975.46	36,975.46	2,766.75
VA 18 EE	41,592.61							41,592.61
TOTAL VA EE	180,429.55		13,860.76	41,110.24	44,123.73	36,975.46	136,070.19	44,359.36
VA 14 REBATE	25,652.48		2,000.00	23,652.48			25,652.48	
VA 15 REBATE	49,780.06			9,191.59	40,588.47		49,780.06	
VA 16 REBATE	69,683.31				41,950.02	27,733.29	69,683.31	
VA 17 REBATE	58,562.69					447.54	447.54	58,115.15
VA 18 REBATE	60,897.19							60,897.19
TOTAL VA REBATE	264,575.73		2,000.00	32,844.07	82,538.49	28,180.83	145,563.39	119,012.34
VT 14 E&T	24,615.68		24,615.68				24,615.68	
VT 15 E&T	48,107.32		10,414.83	37,692.49			48,107.32	
VT 16 E&T	57,747.34			8,744.07	49,003.27		57,747.34	
VT 17 E&T	57,790.41				42,237.61	15,552.80	57,790.41	
VT 18 E&T	64,926.15					36,855.05	36,855.05	28,071.10
TOTAL VT E&T	253,186.90		35,030.51	46,436.56	91,240.88	52,407.85	225,115.80	28,071.10
VT 14 R&D	4,891.58		4,891.58				4,891.58	
VT 15 R&D	14,467.64			2,221.50	5,568.67	470.74	8,260.91	6,206.73
VT 16 R&D	13,762.04							13,762.04
VT 17 R&D	13,626.46							13,626.46
VT 18 R&D	18,815.32							18,815.32
TOTAL VT R&D	65,563.04		4,891.58	2,221.50	5,568.67	470.74	13,152.49	52,410.55
VT 14 EE	13,294.05	3,319.42	8,795.22	1,179.41			13,294.05	
VT 15 EE	25,042.14			1,646.66	23,395.48		25,042.14	
VT 16 EE	30,339.86					30,339.86	30,339.86	
VT 17 EE	30,115.22					5,294.91	5,294.91	24,820.31
VT 18 EE	34,966.29							34,966.29

TOTAL VT EE	133,757.56	3,319.42	8,795.22	2,826.07	23,395.48	35,634.77	73,970.96	59,786.60
VT 14 REBATE	17,889.76		9,735.67	8,154.09			17,889.76	
VT 15 REBATE	34,716.08				9,262.52	25,453.56	34,716.08	
VT 16 REBATE	47,914.85					18,916.58	18,916.58	28,998.27
VT 17 REBATE	44,376.69							44,376.69
VT 18 REBATE	51,195.36							51,195.36
TOTAL VT REBATE	196,092.74		9,735.67	8,154.09	9,262.52	44,370.14	71,522.42	124,570.32
WA 14 E&T	7,612.55		7,612.55				7,612.55	
WA 15 E&T	14,877.47		14,877.47				14,877.47	
WA 16 E&T	6,621.65		137.86	6,483.79			6,621.65	
WA 17 E&T	18,473.98				17,000.00		17,000.00	1,473.98
WA 18 E&T	12,074.09							12,074.09
TOTAL WA E&T	59,659.74		22,627.88	6,483.79	17,000.00		46,111.67	13,548.07
WA 14 R&D	1,512.75			1,512.75			1,512.75	
WA 15 R&D	4,474.20			3,470.94	1,003.26		4,474.20	
WA 16 R&D	1,578.04					1,578.04	1,578.04	
WA 17 R&D	4,356.00							4,356.00
WA 18 R&D	3,499.02							3,499.02
TOTAL WA R&D	15,420.01			4,983.69	1,003.26	1,578.04	7,564.99	7,855.02
WA 14 EE	4,111.26				2,250.00		2,250.00	1,861.26
WA 15 EE	7,744.43							7,744.43
WA 16 EE	3,478.94							3,478.94
WA 17 EE	9,627.00							9,627.00
WA 18 EE	6,502.56							6,502.56
TOTAL WA EE	31,464.19				2,250.00		2,250.00	29,214.19
WA 14 REBATE	5,532.52			5,532.52			5,532.52	
WA 15 REBATE	10,736.15			372.12	5,746.74	4,617.29	10,736.15	
WA 16 REBATE	5,494.20					2,304.67	2,304.67	3,189.53
WA 17 REBATE	14,185.99							14,185.99
WA 18 REBATE	9,520.63							9,520.63
TOTAL WA REBATE	45,469.49			5,904.64	5,746.74	6,921.96	18,573.34	26,896.15
WI 14 E&T	23,325.39		3,350.00	19,975.39			23,325.39	
WI 15 E&T	45,585.65			45,585.65			45,585.65	

WI 16 E&T	64,076.10			619.96	55,690.20	7,765.94	64,076.10	
WI 17 E&T	41,921.73					41,921.73	41,921.73	
WI 18 E&T	57,065.89					9,178.59	9,178.59	47,887.30
TOTAL WI E&T	231,974.76		3,350.00	66,181.00	55,690.20	58,866.26	184,087.46	47,887.30
WI 14 R&D	4,635.17							4,635.17
WI 15 R&D	13,709.28							13,709.28
WI 16 R&D	15,270.28							15,270.28
WI 17 R&D	9,884.77							9,884.77
WI 18 R&D	16,537.45							16,537.45
TOTAL WI R&D	60,036.95							60,036.95
WI 14 EE	12,597.20				9,238.62	3,358.58	12,597.20	
WI 15 EE	23,729.49							23,729.49
WI 16 EE	33,664.93							33,664.93
WI 17 EE	21,845.87							21,845.87
WI 18 EE	30,733.11							30,733.11
TOTAL WI EE	122,570.60				9,238.62	3,358.58	12,597.20	109,973.40
WI 14 REBATE	16,952.02					3,820.18	3,820.18	13,131.84
WI 15 REBATE	32,896.35							32,896.35
WI 16 REBATE	53,166.03							53,166.03
WI 17 REBATE	32,191.29							32,191.29
WI 18 REBATE	44,997.42							44,997.42
TOTAL WI REBATE	180,203.11					3,820.18	3,820.18	176,382.93

National Oilheat Research Alliance
REMITTANCE REVENUE, NET OF REFUNDS, BY STATE
June 30, 2018

	JAN 18 TO JUN 18	JUL 17 TO DEC 17	TOTAL	% OF TOTAL	JAN 17 TO JUN 17	JUL 16 TO DEC 16	TOTAL	% OF TOTA	COMBINED TOTAL	COMBINED % OF TOTAL	
CT REVENUE	$469,251.65	$515,349.69	$984,601.34	10.81%	$503,579.76	$582,267.72	$1,085,847.48	12.69%	$2,070,448.82	11.72%	
CT REFUNDS	(20,471.26)	(25,547.53)	(46,018.79)	(0.51%)	(16,282.38)	(17,862.62)	(34,145.00)	(0.40%)	(80,163.79)	(0.45%)	
CT TOTAL	448,780.39	489,802.16	938,582.55	10.31%	487,297.38	564,405.10	1,051,702.48	12.29%	1,990,285.03	11.27%	83.829396039168100%
DC REVENUE	1,989.54	1,291.37	3,280.91	0.04%	1,971.04	1,527.71	3,498.75	0.04%	6,779.66	0.04%	
DC REFUNDS	94.04	(438.86)	(344.82)	(0.00%)	100.00	(884.56)	(784.56)	(0.01%)	(1,129.38)	(0.01%)	
DC TOTAL	2,083.58	852.51	2,936.09	0.03%	2,071.04	643.15	2,714.19	0.03%	5,650.28	0.03%	101.612205405906000%
DE REVENUE	25,831.66	31,429.49	57,261.15	0.63%	23,908.43	42,902.73	66,811.16	0.78%	124,072.31	0.70%	
DE REFUNDS	(3,321.31)	(7,703.96)	(11,025.27)	(0.12%)	(3,977.82)	(9,421.09)	(13,398.91)	(0.16%)	(24,424.18)	(0.14%)	
DE TOTAL	22,510.35	23,725.53	46,235.88	0.51%	19,930.61	33,481.64	53,412.25	0.62%	99,648.13	0.56%	81.312069479416000%
GA TOTAL											
ID REVENUE	1,575.40	3,483.44	5,058.84	0.06%	2,980.08	3,204.45	6,184.53	0.07%	11,243.37	0.06%	76.835337445908100%
ID TOTAL	1,575.40	3,483.44	5,058.84	0.06%	2,980.08	3,204.45	6,184.53	0.07%	11,243.37	0.06%	
IL REVENUE	2.82	52.00	54.82	0.00%					54.82	0.00%	
IL TOTAL	2.82	52.00	54.82	0.00%					54.82	0.00%	
IN REVENUE	4,863.11	8,571.73	13,434.84	0.15%	4,073.14	6,789.06	10,862.20	0.13%	24,297.04	0.14%	
IN REFUNDS	(289.09)	(80.23)	(369.32)	(0.00%)	(8.35)		(8.35)	(0.00%)	(377.67)	(0.00%)	
IN TOTAL	4,574.02	8,491.50	13,065.52	0.14%	4,064.79	6,789.06	10,853.85	0.13%	23,919.37	0.14%	113.073189687242000%

KY REVENUE	52,103.82	160,560.00	212,663.82	2.34%	46,721.42	163,096.63	209,818.05	2.45%	422,481.87	2.39%	
KY REFUNDS	(22,870.93)	(102,795.19)	(125,666.12)	(1.38%)	9,677.45	(100,346.17)	(90,668.72)	(1.06%)	(216,334.84)	(1.22%)	
KY TOTAL	29,232.89	57,764.81	86,997.70	0.96%	56,398.87	62,750.46	119,149.33	1.39%	206,147.03	1.17%	68.585597460485600%
MA REVENUE	504,612.66	567,408.95	1,072,021.61	11.77%	550,527.02	562,000.13	1,112,527.15	13.00%	2,184,548.76	12.37%	
MA REFUNDS	(6,597.27)	(30,614.09)	(37,211.36)	(0.41%)	(11,398.10)	(16,938.51)	(28,336.61)	(0.33%)	(65,547.97)	(0.37%)	
MA TOTAL	498,015.39	536,794.86	1,034,810.25	11.36%	539,128.92	545,061.62	1,084,190.54	12.67%	2,119,000.79	12.00%	89.654453565964300%
MD REVENUE	172,389.12	182,961.87	355,350.99	3.90%	119,955.90	183,255.43	303,211.33	3.54%	658,562.32	3.73%	
MD REFUNDS	(8,438.01)	(32,437.09)	(40,875.10)	(0.45%)	(8,899.64)	(21,386.31)	(30,285.95)	(0.35%)	(71,161.05)	(0.40%)	
MD TOTAL	163,951.11	150,524.78	314,475.89	3.45%	111,056.26	161,869.12	272,925.38	3.19%	587,401.27	3.33%	108.233123239622000%
ME REVENUE	310,522.40	296,245.51	606,767.91	6.66%	299,737.38	288,268.94	588,006.32	6.87%	1,194,774.23	6.76%	
ME REFUNDS	(200.00)	(3,545.37)	(3,745.37)	(0.04%)	(2,525.17)	(2,151.65)	(4,676.82)	(0.05%)	(8,422.19)	(0.05%)	
ME TOTAL	310,322.40	292,700.14	603,022.54	6.62%	297,212.21	286,117.29	583,329.50	6.82%	1,186,352.04	6.72%	97.103831221616400%
MI REVENUE	91,699.82	324,155.32	415,855.14	4.57%	93,411.20	315,432.31	408,843.51	4.78%	824,698.65	4.67%	
MI REFUNDS	(57,574.65)	(143,100.16)	(200,674.81)	(2.20%)	(61,589.18)	(165,128.61)	(226,717.79)	(2.65%)	(427,392.60)	(2.42%)	
MI TOTAL	34,125.17	181,055.16	215,180.33	2.36%	31,822.02	150,303.70	182,125.72	2.13%	397,306.05	2.25%	110.980850110653000%
NC REVENUE	168,733.67	311,501.64	480,235.31	5.27%	120,235.60	306,777.36	427,012.96	4.99%	907,248.27	5.14%	
NC REFUNDS	(75,564.98)	(105,693.34)	(181,258.32)	(1.99%)	(34,523.93)	(104,651.90)	(139,175.83)	(1.63%)	(320,434.15)	(1.81%)	
NC TOTAL	93,168.69	205,808.30	298,976.99	3.28%	85,711.67	202,125.46	287,837.13	3.36%	586,814.12	3.32%	97.568068857809900%
NH REVENUE	202,246.49	200,786.24	403,032.73	4.43%	184,197.92	197,982.46	382,180.38	4.47%	785,213.11	4.45%	
NH REFUNDS	(286.42)	(847.36)	(1,133.78)	(0.01%)	(93.89)	(41.87)	(135.76)	(0.00%)	(1,269.54)	(0.01%)	
NH TOTAL	201,960.07	199,938.88	401,898.95	4.41%	184,104.03	197,940.59	382,044.62	4.47%	783,943.57	4.44%	98.814241862237500%
NJ REVENUE	386,783.56	448,983.10	835,766.66	9.18%	238,561.37	346,306.79	584,868.16	6.84%	1,420,634.82	8.04%	
NJ REFUNDS	(30,373.83)	(56,089.50)	(86,463.33)	(0.95%)	(36,967.57)	(54,500.50)	(91,468.07)	(1.07%)	(177,931.40)	(1.01%)	
NJ TOTAL	356,409.73	392,893.60	749,303.33	8.23%	201,593.80	291,806.29	493,400.09	5.77%	1,242,703.42	7.04%	142.651123989542000%
NV REVENUE	800.63	2,425.78	3,226.41	0.04%	1,005.38	1,239.73	2,245.11	0.03%	5,471.52	0.03%	
NV TOTAL	800.63	2,425.78	3,226.41	0.04%	1,005.38	1,239.73	2,245.11	0.03%	5,471.52	0.03%	134.989096459551000%
NY REVENUE	782,343.53	937,030.93	1,719,374.46	18.88%	723,275.28	869,037.64	1,592,312.92	18.61%	3,311,687.38	18.75%	

NY REFUNDS	(13,865.51)	(24,381.73)	(38,247.24)	(0.42%)	(13,315.47)	(21,352.23)	(34,667.70)	(0.41%)	(72,914.94)	(0.41%)	
NY TOTAL	768,478.02	912,649.20	1,681,127.22	18.46%	709,959.81	847,685.41	1,557,645.22	18.21%	3,238,772.44	18.34%	101.379184415127000%
OH REVENUE	$113,859.60	$316,547.18	$430,406.78	4.73%	$97,869.47	$277,299.19	$375,168.66	4.39%	$805,575.44	4.56%	
OH REFUNDS	(103,701.52)	(124,909.12)	(228,610.64)	(2.51%)	(35,070.69)	(110,769.26)	(145,839.95)	(1.70%)	(374,450.59)	(2.12%)	
OH TOTAL	10,158.08	191,638.06	201,796.14	2.22%	62,798.78	166,529.93	229,328.71	2.68%	431,124.85	2.44%	82.655391304493400%
OR REVENUE	26.40	(62.23)	(35.83)	(0.00%)	1,844.41	1,941.01	3,785.42	0.04%	3,749.59	0.02%	
OR REFUNDS		(4,814.58)	(4,814.58)	(0.05%)					(4,814.58)	(0.03%)	
OR TOTAL	26.40	(4,876.81)	(4,850.41)	(0.05%)	1,844.41	1,941.01	3,785.42	0.04%	(1,064.99)	(0.01%)	-120.359711449994000%
PA REVENUE	625,436.75	825,821.55	1,451,258.30	15.94%	542,018.08	710,883.70	1,252,901.78	14.65%	2,704,160.08	15.31%	
PA REFUNDS	(28,236.32)	(68,821.89)	(97,058.21)	(1.07%)	(33,264.24)	(73,108.74)	(106,372.98)	(1.24%)	(203,431.19)	(1.15%)	
PA TOTAL	597,200.43	756,999.66	1,354,200.09	14.87%	508,753.84	637,774.96	1,146,528.80	13.40%	2,500,728.89	14.16%	110.946761438429000%
RI REVENUE	154,693.19	151,522.12	306,215.31	3.36%	111,326.71	120,828.41	232,155.12	2.71%	538,370.43	3.05%	
RI REFUNDS	(452.13)	(3,389.71)	(3,841.84)	(0.04%)	(13.25)	(428.88)	(442.13)	(0.01%)	(4,283.97)	(0.02%)	
RI TOTAL	154,241.06	148,132.41	302,373.47	3.32%	111,313.46	120,399.53	231,712.99	2.71%	534,086.46	3.02%	122.577303165505000%
SC REVENUE	61,073.64	115,193.52	176,267.16	1.94%	42,301.05	116,274.66	158,575.71	1.85%	334,842.87	1.90%	
SC REFUNDS	(26,128.75)	(31,602.08)	(57,730.83)	(0.63%)	(11,636.88)	(26,650.81)	(38,287.69)	(0.45%)	(96,018.52)	(0.54%)	
SC TOTAL	34,944.89	83,591.44	118,536.33	1.30%	30,664.17	89,623.85	120,288.02	1.41%	238,824.35	1.35%	92.5647985557763000%
VA REVENUE	138,328.45	241,197.76	379,526.21	4.17%	132,871.22	243,567.60	376,438.82	4.40%	755,965.03	4.28%	
VA REFUNDS	(23,166.99)	(78,258.51)	(101,425.50)	(1.11%)	(15,331.22)	(93,102.94)	(108,434.16)	(1.27%)	(209,859.66)	(1.19%)	
VA TOTAL	115,161.46	162,939.25	278,100.71	3.05%	117,540.00	150,464.66	268,004.66	3.13%	546,105.37	3.09%	97.471244649329300%
VT REVENUE	88,211.40	125,222.57	213,433.97	2.34%	98,419.86	129,243.62	227,663.48	2.66%	441,097.45	2.50%	
VT REFUNDS	(41.10)	(1,048.55)	(1,089.65)	(0.01%)	(648.03)	(1,707.91)	(2,355.94)	(0.03%)	(3,445.59)	(0.02%)	
VT TOTAL	88,170.30	124,174.02	212,344.32	2.33%	97,771.83	127,535.71	225,307.54	2.63%	437,651.86	2.48%	88.528209861239400%
WA REVENUE	8,473.46	34,240.28	42,713.74	0.47%	16,871.87	25,027.80	41,899.67	0.49%	84,613.41	0.48%	
WA TOTAL	8,473.46	34,240.28	42,713.74	0.47%	16,871.87	25,027.80	41,899.67	0.49%	84,613.41	0.48%	95.757711177321400%
WI REVENUE	84,733.62	268,812.11	353,545.73	3.88%	77,749.64	254,798.13	332,547.77	3.89%	686,093.50	3.88%	
WI REFUNDS	(32,177.14)	(114,272.34)	(146,449.48)	(1.61%)	(27,895.60)	(106,621.40)	(134,517.00)	(1.57%)	(280,966.48)	(1.59%)	

WI TOTAL	52,556.48	154,539.77	207,096.25	2.27%	49,854.04	148,176.73	198,030.77	2.31%	405,127.02	2.29%	98.232753687803600%
TOTALS	3,996,920.40	5,110,288.73	9,107,209.13	100.00%	3,731,749.27	4,822,897.25	8,554,646.52	100.00%	17,661,855.65	100.00%	
	453,663.17	960,391.19	1,414,054.36	15.53%	303,663.96	927,055.96	1,230,719.92	14.39%	2,644,774.28	14.97%	
	453,663.17	960,391.19	1,414,054.36	15.53%	303,663.96	927,055.96	1,230,719.92	14.39%	2,644,774.28	14.97%	
MISSING ACCOU	4,450,583.57	6,070,679.92	10,521,263.49	115.53%	4,035,413.23	5,749,953.21	9,785,366.44	114.39%	20,306,629.93	114.97%	

		2019 New Law)				(No Law)			
		Ed and Train)	R and D)	En Efficiency)	Rebate)	Ed and Train)	R and D)	En Efficiency)	Rebate)
	adj 9-2018	2,407,793.00	657,797.00	129,898.00	1,894,063.00	481,558.60	131,559.40	25,979.60	378,812.60
		.75 times budget)	.75 times budget)	.75 times budget)					
Connecticut	10.31%	186,182.59	50,864.15	10,044.36	146,458.42	49,648.63	13,563.73	2,678.54	39,055.62
		-	-	-	-	-	-	-	-
District of Columbia	0.03%	541.75	148.00	29.23	426.16	144.47	39.47	7.79	113.64
		-	-	-	-	-	-	-	-
Delaware	0.51%	9,209.81	2,516.07	496.86	7,244.79	2,455.95	670.95	132.50	1,931.95
		-	-	-	-	-	-	-	-
Idaho	0.06%	1,083.51	296.01	58.45	852.33	288.93	78.94	15.59	227.29
		-	-	-	-	-	-	-	-
Indiana	0.14%	2,528.18	690.69	136.39	1,988.77	674.18	184.18	36.37	530.34
		-	-	-	-	-	-	-	-
Kentucky	0.96%	17,336.11	4,736.14	935.27	13,637.25	4,622.96	1,262.97	249.41	3,636.60
		-	-	-	-	-	-	-	-
Massachusetts	11.36%	205,143.96	56,044.30	11,067.31	161,374.17	54,704.99	14,945.10	2,951.33	43,033.16
		-	-	-	-	-	-	-	-
Maryland	3.45%	62,301.64	17,020.50	3,361.11	49,008.88	16,613.75	4,538.79	896.31	13,069.05
		-	-	-	-	-	-	-	-
Maine	6.62%	119,546.92	32,659.62	6,449.44	94,040.23	31,879.14	8,709.21	1,719.88	25,077.42
		-	-	-	-	-	-	-	-
Michigan	2.36%	42,617.94	11,643.01	2,299.19	33,524.92	11,364.77	3,104.79	613.13	8,939.99
		-	-	-	-	-	-	-	-
Norh Carolina	3.29%	59,412.29	16,231.14	3,205.23	46,736.00	15,843.26	4,328.29	854.74	12,462.95
		-	-	-	-	-	-	-	-
New Hampshire	4.41%	79,637.75	21,756.64	4,296.38	62,646.13	21,236.71	5,801.75	1,145.72	16,705.65
		-	-	-	-	-	-	-	-
New Jersey	8.22%	148,440.44	40,553.19	8,008.21	116,768.98	39,584.07	10,814.15	2,135.56	31,138.43
		-	-	-	-	-	-	-	-
Nevada	0.04%	632.05	172.67	34.10	497.19	168.55	46.05	9.09	132.58
		-	-	-	-	-	-	-	-
New York	18.45%	333,178.36	91,022.66	17,974.64	262,090.97	88,847.45	24,272.64	4,793.31	69,891.00
		106,950.14	29,218.38	5,769.98	84,131.21	28,519.89	7,791.63	1,538.55	22,435.01
		92,956.66	25,395.42	5,015.03	73,123.39	24,788.31	6,772.17	1,337.25	19,499.59
		49,310.34	13,471.40	2,660.30	38,789.47	13,149.36	3,592.40	709.36	10,343.87
		83,960.86	22,937.80	4,529.70	66,046.93	22,389.44	6,116.80	1,207.84	17,612.53
		-	-	-	-	-	-	-	-
Ohio	2.21%	39,909.17	10,902.99	2,153.06	31,394.09	10,642.43	2,907.45	574.16	8,371.77
		-	-	-	-	-	-	-	-
Pennsylvania	14.86%	268,348.53	73,311.48	14,477.13	211,093.32	71,559.52	19,549.67	3,860.63	56,291.61
		-	-	-	-	-	-	-	-
Rhode Island	3.32%	59,954.05	16,379.15	3,234.46	47,162.17	15,987.73	4,367.76	862.54	12,576.59
		-	-	-	-	-	-	-	-
South Carolina	1.30%	23,475.98	6,413.52	1,266.51	18,467.11	6,260.25	1,710.27	337.74	4,924.57
		-	-	-	-	-	-	-	-
Virginia	3.05%	55,078.26	15,047.11	2,971.42	43,326.69	14,687.52	4,012.55	792.39	11,553.80
		-	-	-	-	-	-	-	-
Vermont	2.33%	42,076.18	11,495.00	2,269.97	33,098.75	11,220.30	3,065.32	605.33	8,826.34
		-	-	-	-	-	-	-	-
Washington	0.46%	8,306.89	2,269.40	448.15	6,534.52	2,215.17	605.17	119.51	1,742.54
		-	-	-	-	-	-	-	-
Wisconsin	2.27%	40,992.68	11,198.99	2,211.51	32,246.42	10,931.37	2,986.39	589.75	8,599.06

Report on NORA Internal R&D
NORA Board of Directors
September 24, 2018

T. Butcher

Slide: 1

Tankless Coil Boiler Project with NYSERDA*

- All experimental work complete
- Project report near completion
- Hot water production efficiency ranged from 33 to 67%
- Impact of increased hot water efficiency on annual fuel use ~ 15%
- Key Best Practices recommendations:
  - Minimize jacket heat loss
  - Improved thermal coupling between boiler water and DHW to enable lower water temps

* Full presentation in NORA Tech Workshop

Air Source Heat Pump Field Study with NYSERDA*

- Study of why and how these heat pumps are being installed and how they are controlled
- Best practices guide to be developed
- Six sites to be included in New York
- Five sites were monitored last heating season
- Planning to add one additional plus more sites in New England
- Project in progress
- Key findings to date:
    - Heat pumps often installed to solve a local problem
    - Control of operation of both boiler and heat pump informally implemented

* Full presentation in NORA Tech Workshop

Fuel-Fired Heat Pump (SMTI)

- Paper presented at ASHRAE Annual Meeting that shows a biofuel fired heat pump can have the same or better greenhouse gas impact as electric heat pumps in the Northeast*.
- Preproposal submitted to NYSERDA for combustion studies of the SMTI heat pump with 100% biofuel. Full proposal encouraged, decision pending.

* Full presentation in NORA Tech Workshop

Field Study of Blends of 10% Ethyl Levulinate*

- Dead River Company in Maine
- 11 homes, service technicians
- Strong support from the NORA lab
- Tests started in December 2017
- Results of field tests:
  - Analysis indicated fuels well mixed and did not separate even under very cold conditions
  - One problem observed with one specific fuel pump solenoid. Alternative pump now being used.
  - NORA explored elastomer response – swell typically high
  - Test will continue to Spring 2019
- Overall test considered successful. Plans under development for a single-boiler, EL100 test this year.
- Studies to identify a suitable pump for EL 100 in progress.

* Full presentation in NORA Tech Workshop

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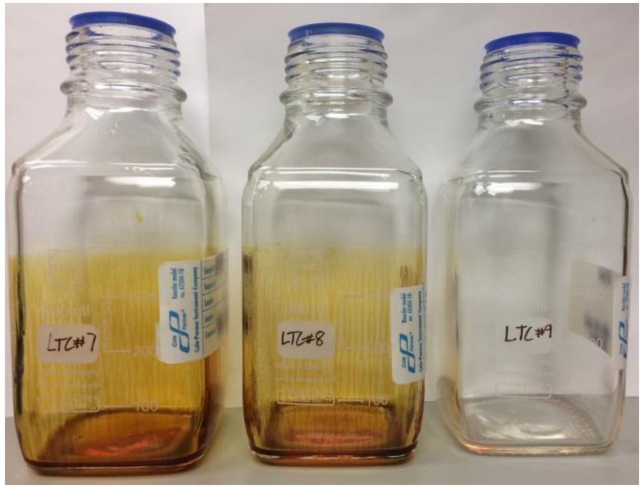
Practical Impact of Copper on Fuels*

- A range of studies conducted on impact of copper exposure on degradation of petroleum No. 2 and biodiesel blends.
- Results show very strong effect if the surface to volume ratio is high.
- Efforts to evaluate practical impact in heating systems has not yet developed a case for replacing copper lines. Work in progress.
- Publication with REG on this work prepared for submission to a Journal.

* Full presentation in NORA Tech Workshop

Lab Studies on Biofuels*

- Basic studies of separation, stability, elastomer compatibility, of EL/petroleum (No. 2) blends
- Studies to achieve high biofuel blend level with EL/biodiesel/No. 2 oil
- Basic studies on synthetic diesel properties for use as heating oil.
- Stability and low temperature flow properties of EL very good. Clear concern about elastomers.
- Synthetic diesel shows outstanding stability properties



* Full presentation in NORA Tech Workshop by Ryan Kerr

Slide: 7

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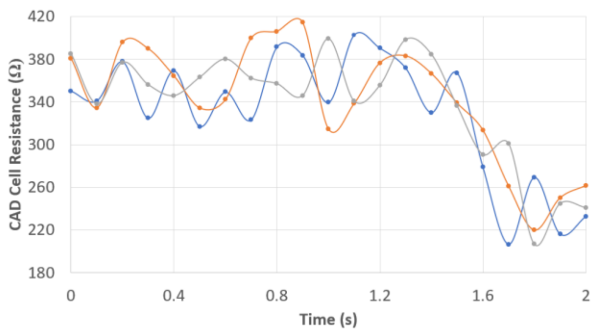
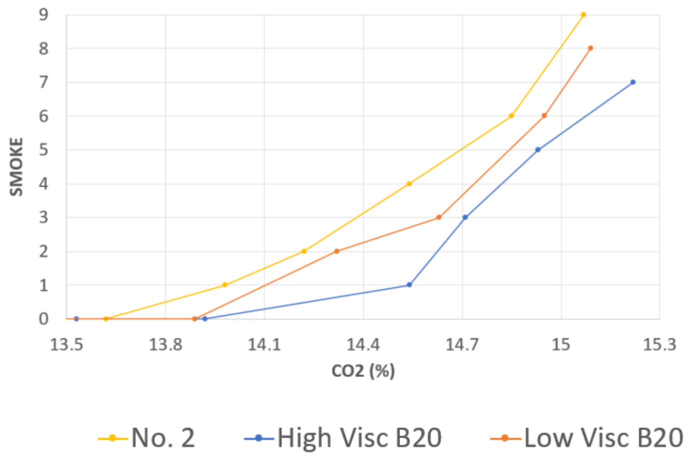
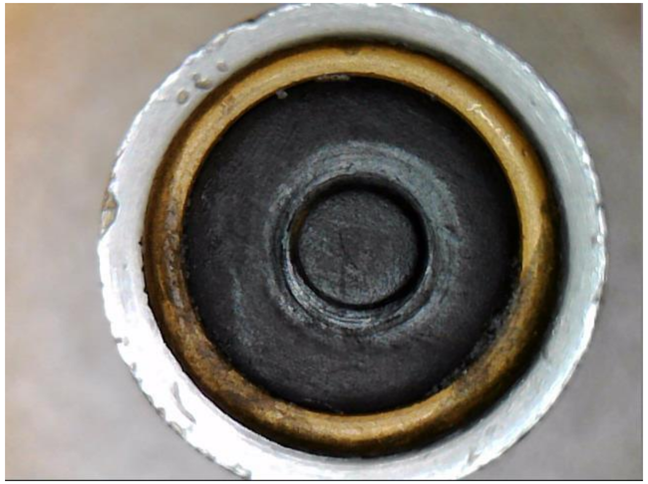
Combustion Studies*

- Cad Cell steady state and transient response with a range of fuels
- Steady state combustion and emissions with a range of fuels
- In-burner performance of regulator pistons, field samples, B0 and B20
- Tear-down and examination of field samples, B0 and B20







* Full presentation in NORA Tech Workshop by Neehad Islam

Slide: 8

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Biodiesel Review

A comprehensive report has just been completed covering much of the earlier work done on biodiesel blends – combustion, field testing, pump testing, stability, and elastomer compatibility.
Purpose – to document this earlier work.

R&D Focus Areas for the Near Future

- EL-10 Field Studies
- EL-100 Commercial Boiler Test
- Air Source Heat Pump Field Study
- Explore other wood-based fuels
- Resilient Heating Systems
- Domestic Water Heating
- Continued Fuel Stability / Quality Studies
- Lubricity Evaluation from Field Samples
- SMTI – Testing with Biodiesel and EL (NYSERDA Proposal)
- Field Trials with the Babington Burner
- Other Advanced Burner Concepts
- Remote Diagnostics and Controls (again)
- Tests to Support Novatio at NORA?
- Pushing the Envelope on Biodiesel Blend Levels – with NBB

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Richard Sweetser
NORA Sr. Advisor on Research
NORA Board of Director's Meeting
September 24, 2018

NORA UPDATE

Technical Program Update

NORAweb.org
NATIONAL OILHEAT RESEARCH ALLIANCE

B100 Multi-Fuel Burner (PON 2014)
B50-Compatible Boiler with AMC (PON 2016)

Babington

Design – Product Development – Testing – Market Commercialization

Program Objectives: Develop an advanced multi-fuel burner and boiler prototypes that improve traditional oil-heat appliances and enable new bio-heat™ appliances up to B100
Long-Term Market Goal: Demonstrate a viable and economic pathway for sustainable energy-efficient home heat that meets large-scale GHG emissions reduction targets and climate action goals

Development Effort: Combine a proven air-atomizing burner technology with advancements made in power-electronics and integrate them with commercially available boilers to demonstrate that we can:

- Convert oil-heat appliances to bio-heat™ appliances easily and trouble-free
- Improve AFUE energy efficiency and service models and reduced total cost of ownership (TCO) over time
- Improve long-standing fuel compatibility and reliability problems and extend maintenance intervals
- Enable adaptive heating systems via Internet of Things (IoT) compatibility

Slide: 2

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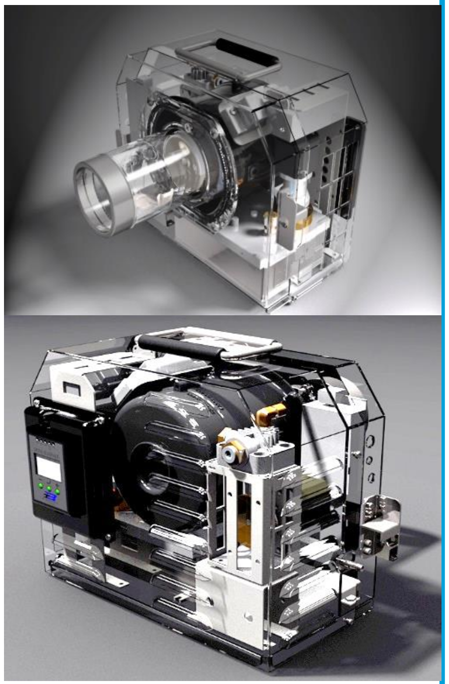
B100 Multi-Fuel Smart Burner (PON 2014)

A Computer that Makes Clean Fire – Using Any Liquid Fuel. The FlexFire™ converts a traditional oil-fired heating appliance to a high-efficiency biodiesel-fired appliance – and makes it ***Smart!***

The base model has a fixed-firing rate that can be set between 0.35 to 0.75 GPH, uses any fuel between No. 2 to B100 without parts change, and is self-tuning for optimum combustion efficiency performance



Standard Features:

- Fixed firing rate modulation between 0.35 – 0.75 GPH
- Flexible fuel compatibility (No. 2 fuel up to B100)
- Self-turning with closed-loop feedback control
- Easy plug and play installation, compatible with 0.85 GPH capacity boilers and furnaces (85% of the market)

Optional Features:

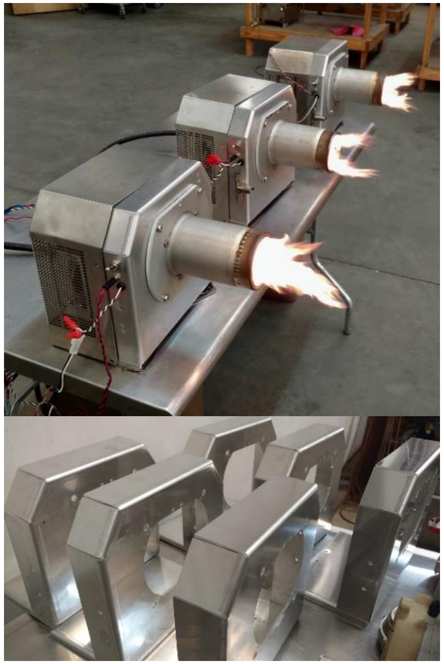
- Automatic modulation, adjusts firing rate and flame size during steady-state operation
- High-Firing rate capacity: 0.625 – 1.25 GPH
- IoT Compatibility, for remote operation and real-time performance monitoring & troubleshooting

B100 Multi-Fuel Smart Burner (PON 2014)

Program Objectives – Value Engineering and Prototype Fabrication

✓ Stage 1:	✓ Stage 2:	✓ Stage 3:	✓ Stage 4:	✓ Stage 5:
Value Eng & Component Eval	Prototype Fabrication	Systems Integration/Testing	Performance & Biofuel Testing	Commercialization & Planning

Design Goals: Based on market-driven needs and built into a value-engineering development plan to maximize product functionality at the lowest possible cost



Design Innovations Leading to Key Product Features:

- Independent combustion control for automatic modulation (stage 1)
- Value-engineering and streamlined packaging for easy installation, reduced service and low cost manufacture (stage 2)
- Multi-fuel compatibility in combustion chamber for B50+ blends and greater tolerance with contaminated and viscous fuels (stage 3)
- Real-Time Performance Mapping for greater combustion, steady-state, cycle and AFUE efficiency (stage 4)
- IoT compatibility for real-time (Smart) performance monitoring, troubleshooting and data analytics (stage 5 … currently in process)

Slide: 4

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B100 Multi-Fuel Smart Burner (PON 2014)

Program Objectives – Systems Integration & Performance Testing

- ✓ Stage 1: Value Eng & Component Eval
- ✓ Stage 2: Prototype Fabrication
- ✓ Stage 3: Systems Integration/Testing
- ✓ Stage 4: Performance & Biofuel Testing
- ✓ Stage 5: Commercialization & Planning

Systems Integration & Biofuels Testing:

- Burner component functionality and whole product testing
- Biofuels testing: B20, B50 and B100 and ULSD
- Boiler testing: Energy Kinetics, Peerless, Slant/Fin, NORA lab
- Current Motor Power Consumption:
  - Air compressor / blower motor: 35 watts / 20 watts
  - Fuel transfer / metering pump: 3 watts / 2 watts

Testing Objectives:

- Component and reliability testing
- Combustion performance across multiple firing rates
- Material compatibility and interchangeability with biodiesel blends up to B100
- Ongoing boiler testing for UL/ETL certification testing

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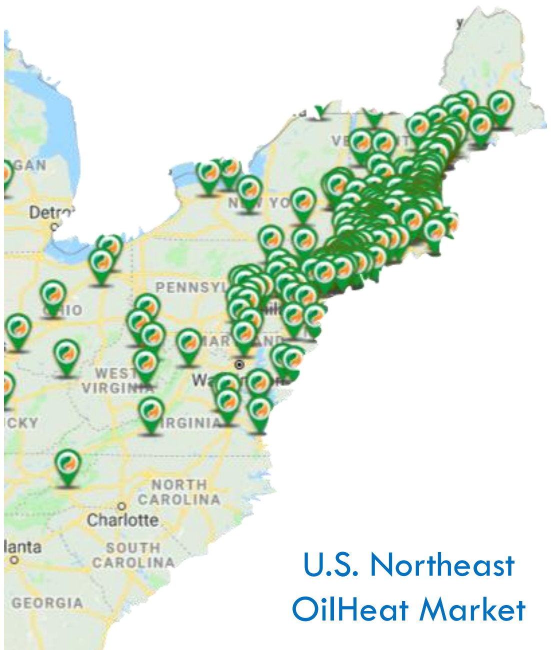
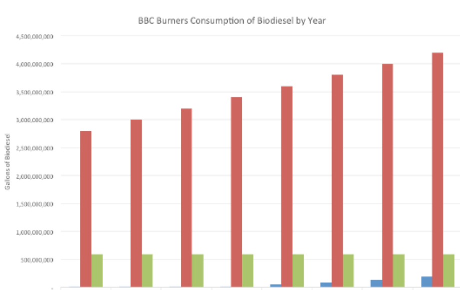
B100 Multi-Fuel Smart Burner (PON 2014)

✓ Stage 1: Value Eng & Component Eval → ✓ Stage 2: Prototype Fabrication → ✓ Stage 3: Systems Integration/Testing → ✓ Stage 4: Performance & Biofuel Testing → ✓ Stage 5: Commercialization & Planning



U.S. Northeast OilHeat Market



	1	2	3	4	5	6	7	8
BBC Burners	403,988	1,461,836	4,610,196	13,896,021	49,507,671	90,355,296	137,936,046	188,336,396
Total Production	2,800,000,000	3,000,000,000	3,200,000,000	3,400,000,000	3,600,000,000	3,800,000,000	4,000,000,000	4,200,000,000
REG 2017 Sales	587,000,000	587,000,000	587,000,000	587,000,000	587,000,000	587,000,000	587,000,000	587,000,000

Commercialization and Sales Plan Highlights:

- Product launch and market introduction scheduled for 2019
- Industry partner discussions are advancing
- Babington financial & organizational development expanding
- Winter field trials to begin Oct 2018 and expand over 12 months – leading to pre-sales to targeted early customers
- Winter field trials designed to a) prove market application and b) quantify a <u>clean energy economic model</u> for oil marketers
- ETL / UL certification is in process and targeted for Q1 2019
- ETL / UL timing is somewhat dependent on an upgraded control design and UL-296 testing for <u>both</u> No. 2 and B100
- Early sales projections show exponential 10-yr biodiesel growth
- Sales plan to target Bioheat™ early adopters clustered in NY and Boston Metro region … expanded to Connecticut

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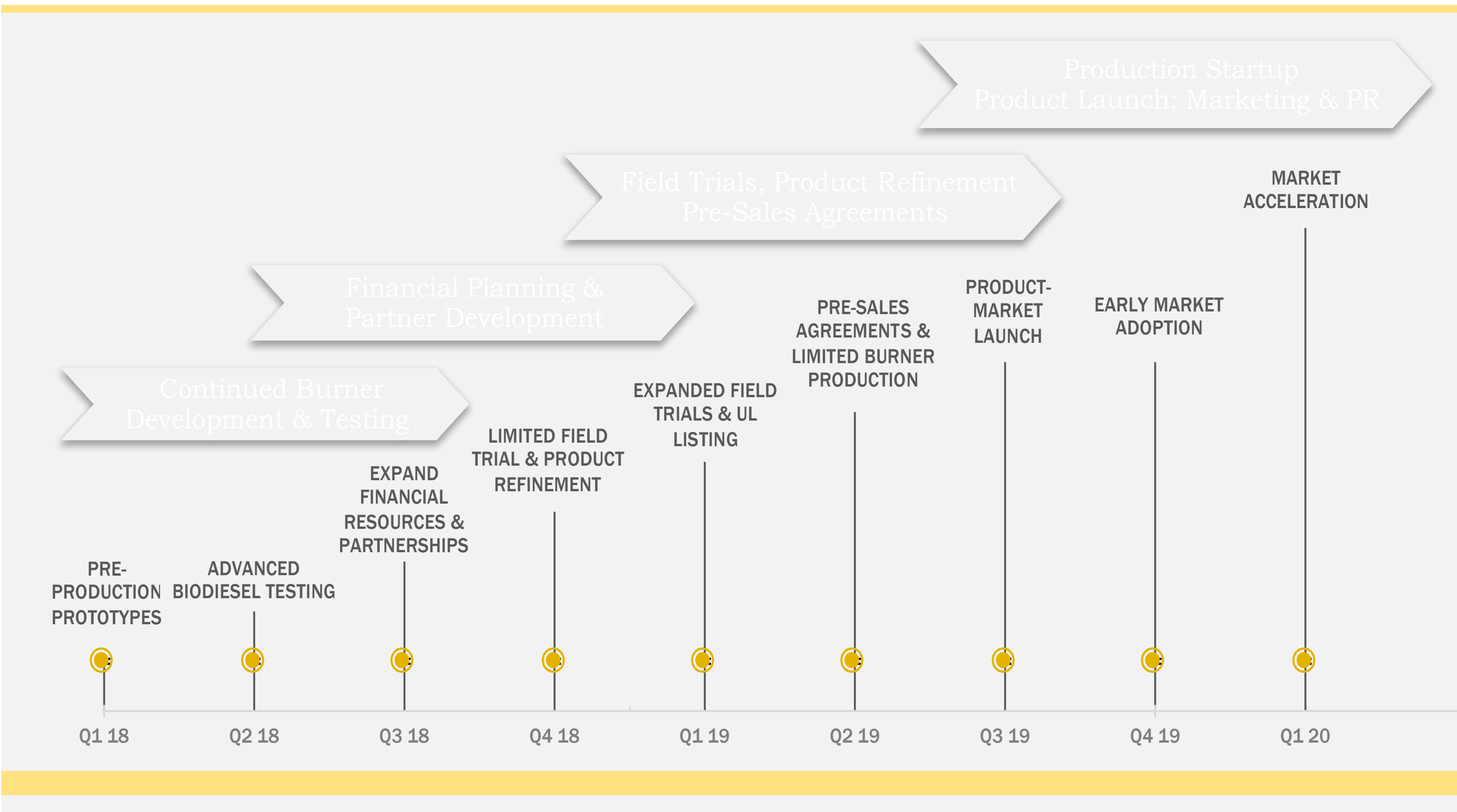
FlexFire Multi-Fuel Burner Commercialization

Program Milestones and Commercialization Timeline



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B50 Compatible Boiler with AMC (PON 2016)

Program Objectives – Burner-Boiler Design, Installation and Testing

✓ Stage 1: Product Definition & Technical Requirements	✓ Stage 2: Design Refinement	✓ Stage 3: Boiler Installation	✓ Stage 4: Prototype Developmental Testing	__ Stage 5: Prototype Delivery

Market Requirements Driving Advanced Combustion Innovations:

- Technical performance requirements defined with market partners & advisors
- Burner integration and testing with boilers:
  - Energy Kinetics 90+ Resolute and EK-1 Frontier
  - Peerless WBV cast iron boiler
  - Slant/Fin TR30
- Performance mapping prove-out highly successful where “air-fuel curves” are used to optimize combustion performance for different boiler models
- *Example*: EK 90+R may recommend a target CO_2 of 12% in the exhaust gas
- This has led to a <u>self-tuning</u> innovation. *Example*: if a home has inadequate air flow (due to dryer lint or animal hair), the FlexFire™ will adjust its blower “on-the-fly” and correct itself to deliver the prescribed 12% CO_2 target level
- AFUE performance improvements can also be made with older, less energy efficient legacy boiler systems by improving efficiency at lower firing rates.

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B50 Compatible Boiler with AMC (PON 2016)

Program Objectives – Field Trials

2018-2019 Field Trial Highlights:

- Working with NORA and industry partners for staggered rollout of 40-50+ burners
- Field trials and burner production refinements will progress concurrently to accelerate product to market
- Babington partnering with biodiesel producers and 4-5 leading oil marketers who want to strongly promote Bioheat™
- Initial burners to be installed in the homes of Service Technicians
- Testing B20 up to B100 at various locations including Plainvew NY, Boston, Maryland, Virginia, and Sweden
- Key objective is to prove market application and value proposition – leading to a clean energy economic market-model for Bioheat™
- Packaging the FlexFire™ for easy installation, service and support is also a key focus and prove-out for the field trial
- Kick-off training collaboration with Babington and experienced NORA experts is scheduled for mid-October. Focus is on training materials and deep-dive training agenda on burner operation

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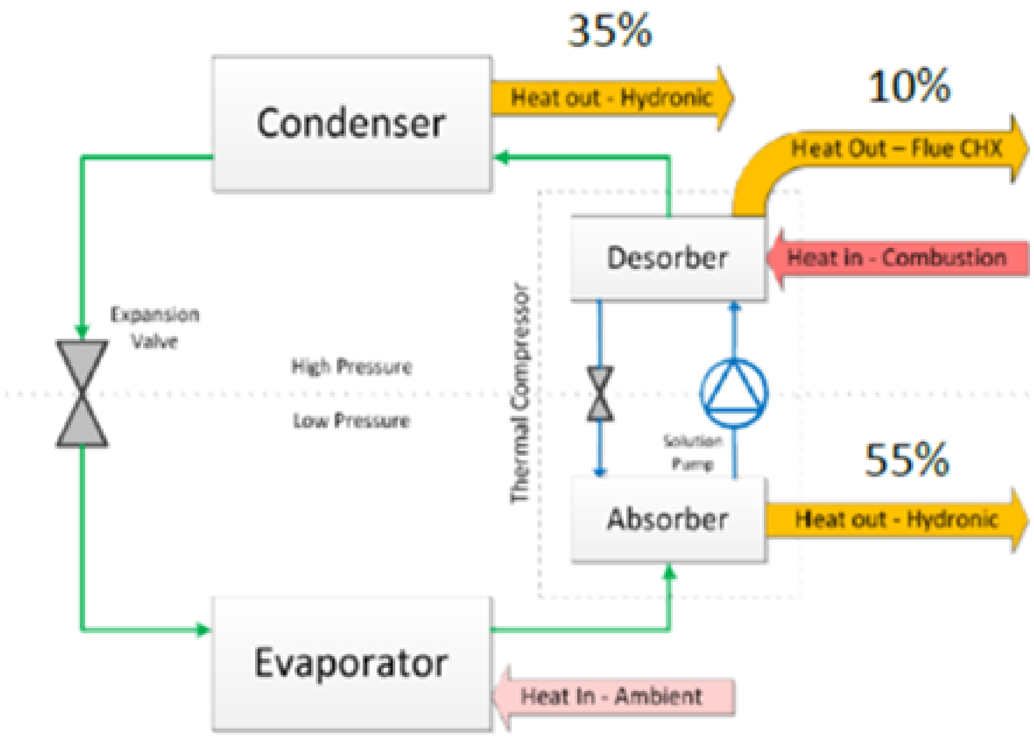
Stone Mountain Technology Inc



Absorption Cycle

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Stone Mountain

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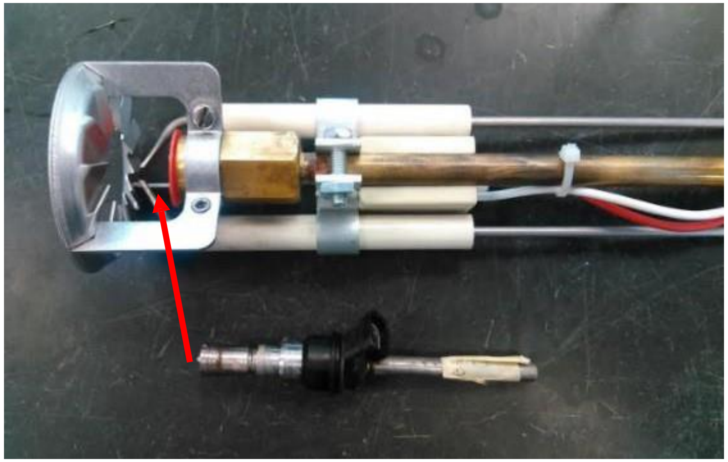
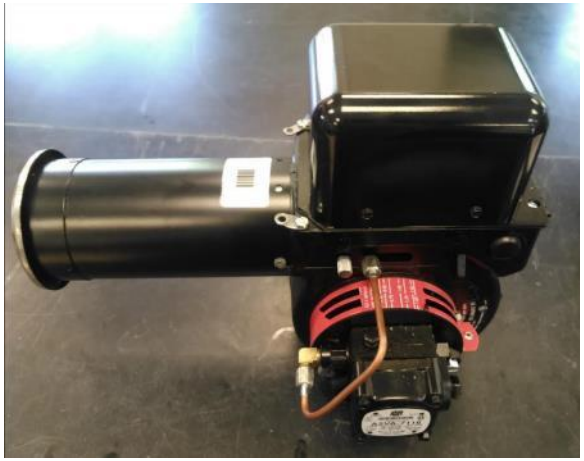
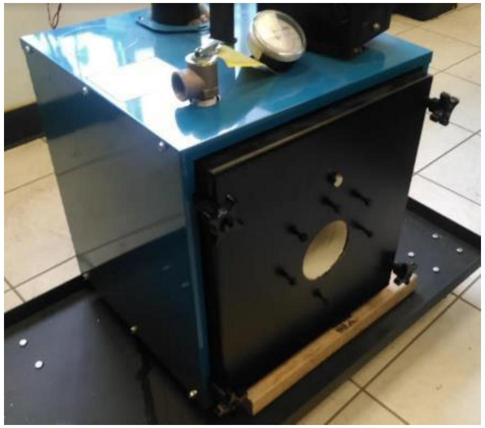
NOVATIO Engineering



Nozzle replacement with fuel injector



Carlin EZ-1



Axemann Boiler (combustion chamber)

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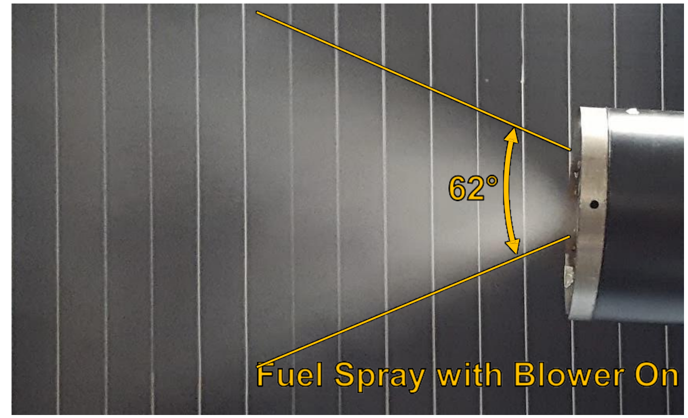
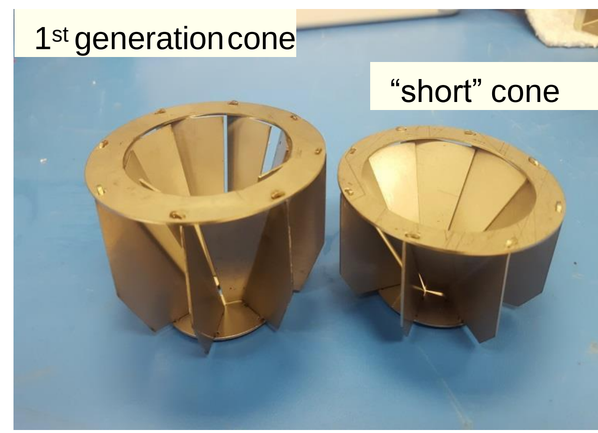
NOVATIO Engineering





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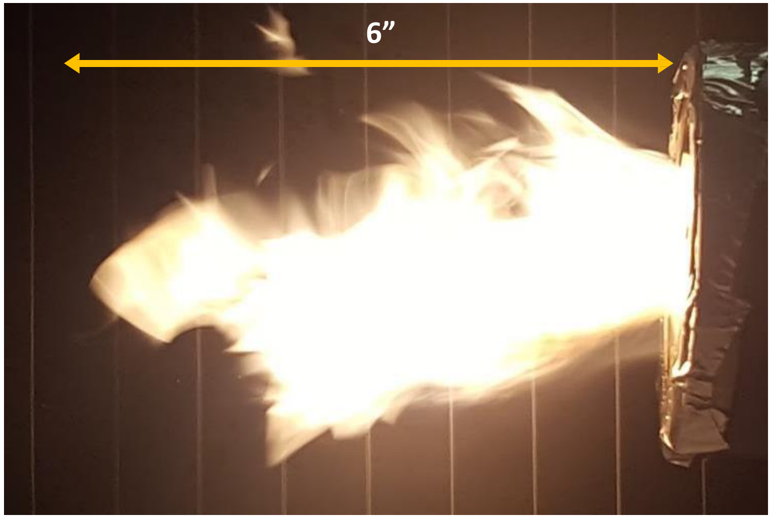
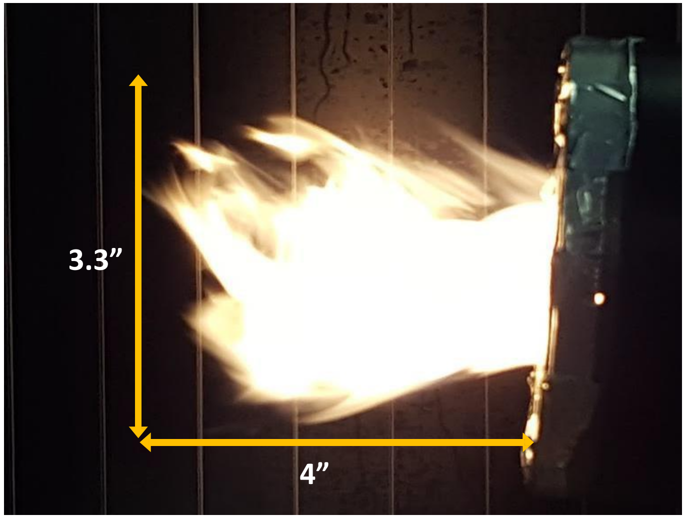
NOVATIO Engineering

- Best open flame results with this configuration
- Results in boiler improved but not as clean as open flame appearance would indicate
  - Best results to date in boiler: CO <10PPM (air-free) and Smoke Number ~3
- Working to improve CO and Smoke Number
- Provide Closeout report with recommendations for the future



62,000 Btu/h



22,000 Btu/h

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Program Status

	Task	NORA funding	Expected completion Date
√	Task 1. Selection of Retention Head Burner Baseline	$10,000	February 1, 2017
√	Task 2. Baseline Burner Testing	$25,000	March 15, 2017
√	Task 3. Modification of the Burner to Replace a Conventional Pressure Atomized Nozzle with the CAG	$30,000	April 15, 2017
√	Task 4. Basic Combustion Testing with Iterative Optimization	$70,000	July 15, 2017
√...	Task 5. Combustion Testing in a Typical Residential Boiler	$50,000	September 15, 2017
	Task 6. Evaluation of Commercialization Pathways	$15000	October 15, 2017
	Task 7. Final report	$5000	November 1, 2017
	Total	**$205,000**	

Future Research

Modular supply of heat

- Integration in any existing heating system
- Universal use thanks to modular add-ons
- Prepared connections for DHW and heating circuits on the buffer vessel
- Connected using plug & play

Dachs	
Electric output:	5.0 – 5.5 kW[1)]
Thermal output:	11.7 – 14.8 kW[1)]
Fuel[2)]:	Natural gas, LPG Fuel oil, RME

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Policy driven "Beneficial Electrification" a.k.a. fuel switching from fossil fuels to electric heat pumps is not the best or the only way forward!

The future of home heating is the focus of the environmental community, some policy makers and, of course, electric utilities (who increase load when fossil fuel customers switch to electric heat pumps). Many of these groups have been promoting Beneficial Electrification which assumes that by 2050 all or most home heating energy will be supplied by an electric grid that is exclusively powered by renewables.

There are a number of fundamental flaws in this policy-driven movement that affects the heating oil industry and all other energy providers:

> **"The capability of the oil heating industry to innovate and meet state's decarbonization agenda has not been adequately recognized. It is not furnaces or boilers that produce carbon emissions, it's the fuel they run on. Therefore, it is premature for policy makers to consider regulating against oil heating when all liquid fuel furnaces and boilers could be run on a low carbon alternative fuel before 2035."**
>
> ***John Huber***
> ***National OilHeat Research Alliance***

1. Policy-driven electrification would increase the average residential household cost – largely because intermittent renewables and batteries would substantially increase the electric infrastructure. A vastly oversized grid and a dramatic increase in production will be necessary to ensure that the electric operating system does not collapse during a sustained freeze when demand is high and heat pump efficiency is low or fails to provide heat.
2. Despite the desire to move to renewably-fueled electric power plants, the electric grid in 2050 will not be 100% renewable. It will likely require natural gas combined cycle combustion turbines (CCCTs) operating, at the margin, to fulfill the increased demand of millions of households currently using natural gas or heating oil. In fact, the Electric Power Research Institute's April 2018 National Grid Assessment predicts, in its Transformation Model, that the final delivered energy from the electric grid will account for only 47% of the total delivered energy needed by end-users.

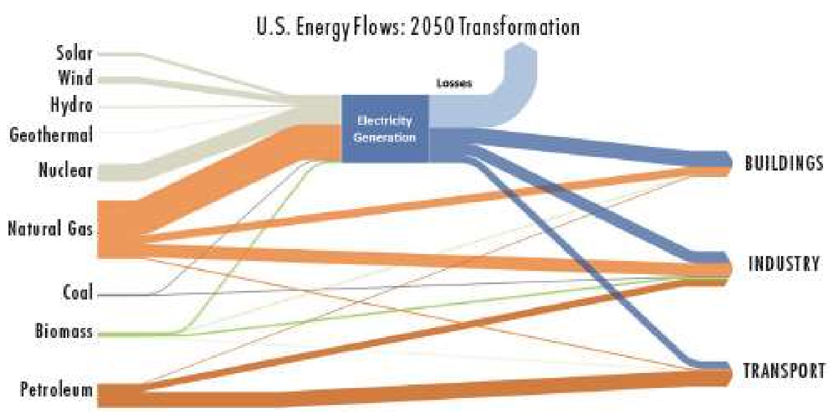

Figure 1 Sankey view of 2050 EPRI's Transformation scenario projection[1].

[1] This EPRI Sankey diagram represents the flow of electric energy from generation source on the left (solar, wind, coal, oil, natural gas, nuclear, etc.) to the load served on the right (buildings, industry and transportation). The width of the arrows is shown proportionally to the energy flow quantity used.

Figure 1 shows EPRI's model results for its most aggressive carbon reduction scenario (Transformation) in 2050. Most notable is large dependence on nuclear and natural gas power generation and significant requirement for fossil fuel combustion in buildings and industry.

3. Fuel switching residential heating (oil and gas) to electric heat pumps would only result in GHG emissions reduction by 1 to 1.5 percent.
4. The heating oil industry today is moving away from traditional oil-based fuels to biofuels with the goal of fleet conversion from B5-B20 to a $^{1}/_{3}$ Biodiesel - $^{1}/_{3}$ Advanced Biofuel[2] and $^{1}/_{3}$ ULSD by 2035. The advanced biofuel under consideration yields negative carbon due to avoided carbon emissions. As a result, this fuel would yield carbon free combustion for heating.
5. The U.S. Department of Energy is supporting the development of thermal heat pump technology[3] that will be more efficient, provide much more comfortable heating and be lower cost. Additionally, it would make the electric grid less vulnerable to failure, and any make any failure less catastrophic.

Biodiesel and advanced biofuels must not be ignored by policy makers when developing their carbon and methane reduction plans for the future. Renewable biofuels may provide the most cost-effective method to reduce carbon and can make other GHG reduction strategies more easily obtainable.

Policy-driven electrification

Policy-driven electrification by fuel switching residential heating to electric heat pumps would increase the average residential household energy-related costs about 38 percent to 46 percent.

Policy-driven electrification would increase the average residential household energy-related costs (amortized appliance and electric system upgrade costs and utility bill payments) of affected households by between $750 and $910 per year, or about 38 percent to 46 percent. Widespread residential electrification will lead to increases in peak electric demand and could shift the U.S. electric grid from summer peaking to winter peaking in every region of the country, resulting in the need for new investments in the electric grid including generation capacity, transmission capacity, and distribution capacity.

"Several reduced carbon liquid fuels in the field and under development would offer an almost drop-in replacement for heating oil, overcoming the significant cost and practical issues of replacing an entire heating system, as well as, upgrading expensive energy delivery networks. There is also a well-developed and competent network of supply, installer and servicing businesses already in place who could continue to support consumers at little or no additional cost."

Dr. Thomas Butcher
Brookhaven National Laboratory

[2] There are several pathways moving toward advanced biofuels, two of which are listed. 1) Biofine Technology, LLC. Has developed a cellulosic biodiesel for use in residential heating, and 2) Synthetic Genomics, Inc. (SGI) and ExxonMobil have developed a strain of algae able to convert carbon into a record amount of energy-rich fat, which can then be processed into biodiesel.
[3] See Pathway to Energy Efficiency for description of thermal heat pump technology

Liquid fuels-based heating technologies (boilers, furnaces and thermal heat pumps) coupled with three already identified fuel approaches in the field and under development today reduces carbon emissions greater than cold climate electric heat pumps using a future grid with projected electricity from low emissions advanced CCCTs.

Fuel switching residential heating to electric heat pumps would only result in GHG emissions reduction by 1 to 1.5 Percent

The U.S. Energy Information Administration (EIA) projects that by 2035, the sum of natural gas, propane and fuel oil used in the residential sector will account for less than 6 percent of total GHG emissions. Reductions from policy-driven residential electrification would reduce GHG emissions by 1 to 1.5 percent of U.S. GHG emissions in 2035. The potential reduction in emissions from the residential sector is partially offset by an increase in emissions from the power generation sector, even in a case where all incremental generating capacity is renewable.

Pathway to Energy Efficiency

Details do matter. New homes are different from existing homes and boilers are different from furnaces and heat pumps.

Energy efficiency is a significant factor in achieving carbon reduction. The less fuel used in generating electricity or in directly fueling appliances, the lower the carbon emissions. One important aspect with respect to carbon emissions is that site efficiency (energy used in the home like kilowatts and Btus) must be considered in evaluating different heating fuels. More importantly for electricity, the source energy and impact of demand fluctuations on efficiency, grid reliability and total carbon emissions must be considered when comparing heating energy sources.

Boilers: typical fossil fueled boilers sold today, to existing homes, are 82-86% efficient. This is largely because the hydronic loops were designed for high temperatures. New hydronically heated homes can use condensing boilers at 96% efficiency.

Furnaces: all homes can take advantage of higher cost modern condensing furnaces at 96% efficiency.

Electric Heat Pumps: an electric heat pump with a site-based COP of 3.2 heating has a source-based COP of 1.09[4]. Note: delivered electricity is a mere 34 percent efficient when measured from fuel to the power plant to electricity delivered to the electric socket in your home.

Thermal Heat Pumps: an exciting new technology, in late stage development, is the air-sourced thermally-driven heat pump. This technology would, in today's world, deliver heating at a source coefficient of performance (COP) of about 1.3. Thermal heat pumps, when fully developed can be integrated with existing and new home furnaces and boilers. And their coefficient of performance and delivered air temperature would not drop precipitously during cold weather like electric heat pumps.

[4] Site efficiency 3.2 COP x 34% efficient electric grid = source efficiency of

Pathway to Low Carbon Fuels

Based on a peer reviewed site energy performance and emissions study[5], Tables 1 and 2 show that moving from non-condensing appliances to condensing appliances and finally to thermal heat pump technologies significantly reduces carbon emissions. Furthermore, shifting to low carbon fuel blends dramatically reduces greenhouse gas emissions. Looking forward to the industry's 2035 implementation goal, Tables 1 and 2 show that in the case of boiler and furnace-based home heating and cooling systems, all three liquid fuels-based heating technologies coupled with three specific fuel approaches [100% biodiesel and ultra-low sulfur diesel (ULSD), biodiesel and one advanced biofuel (ethyl levulinate)] reduces carbon emissions greater that cold climate electric heat pumps using electricity from low emissions advanced CCCTs. The yellow cells indicate liquid fuel pathways to no carbon combustion. Note that the remaining carbon emissions for liquid fuels pathways in the last two columns are from the electric grid (marginal CCCT production) for cooling and ancillary equipment. Zero net carbon is from combustion.

	2018	2025	2030	2035		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
Standard Boiler, 14 SEER Minisplit AC	0%	14%	29%	71%	95%	95%
Condensing Boiler, 14 SEER Minisplit AC	14%	26%	39%	74%	95%	95%
Heating only LF-AHP and 14 SEER Minisplit	35%	43%	54%	78%	93%	93%
14 SEER Minisplit Heat Pump with Boiler Back-up	25%	34%	46%	70%	85%	85%
18 SEER 5 RT Cold Climate Heat pump with Boiler Backup	57%	59%	64%	66%	69%	69%

Table 1 Percent Reduction in CO_{2e} Annual Emissions from Heating and Cooling a Single-Family Home (Hydronic-Cold Air)

	2018	**2025**	**2030**	**2035**		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
Non-Condensing Furnace, 14 SEER Central AC	0%	14%	28%	72%	83%	87%
Condensing Furnace, 14 SEER Central AC	14%	26%	38%	75%	84%	88%
Heating only LF-AHP and 14 SEER Central AC	38%	47%	55%	81%	87%	89%
14 SEER Electric Heat Pump with Resistance Back-up	28%	28%	28%	41%	28%	28%
18 SEER 5 RT Cold Climate Heat pump with Resistance Backup	58%	58%	58%	66%	58%	58%

Table 2 Percent Reduction in CO_{2e} Annual Emissions from Heating and Cooling a Single-Family Home (Hot-Cold Air)

[5] "Energy, Cost and CO2e Analyses of Reversible, Hybrid and Heating- Only LF-AHP in the Northeast", Christopher Keinath, PhD, Thomas Butcher, PhD and Michael Garrabrant, PE, ASHRAE, June 2018

*future*fuel

understanding the viability of advanced biofuels and combustion technologies to deliver zero net carbon combustion in the future

and

examining advanced biofuels as an alternative to electric heat pumps and other fossil fuel combustion in tomorrow's homes

national oilheat research alliance

september 2018

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executive summary

Electricity, natural gas, heating oil and biodiesel blended with heating oil provide space heating and hot water services in the residential sector. Choosing a specific energy source for these services has significant implications in terms of energy efficiency, economics and environmental impact. While the ultimate fuel choice is made by builders and consumers, and most often based on economics, this choice is also influenced by perceptions of how efficiently, or inefficiently, our energy resources are being used and how the choice might impact the environment, including the release of greenhouse gases (GHG) into the atmosphere.

Jurisdictions that are generally interested in facilitating future residential energy supply and usage trajectories should focus on four specific impact attributes: 1) energy efficiency, 2) economic impact, 3) environmental impact and 4) efficacy. Narrowing this question to consider how we will heat our homes in the future, each approach should be measured by these four benchmarks.

Table 1 provides a ranking of these four specific impact attributes looking at five energy sources. Green circles mean best possible outcome versus the other alternatives presented. Blue means a good outcome versus the other alternatives presented. Finally, black is the lease favorable outcome versus the other alternatives presented. What should be clear from Table 1 is that liquid biofuels (B100 and Tri-Mix) provide the best possible outcome for all impact attributes.

"The capability of the oil heating industry to innovate and meet state's decarbonization agenda has not been adequately recognized. It is not furnaces or boilers that produce carbon emissions, it's the fuel they run on. Therefore, it is premature for policy makers to consider regulating against oil heating when all liquid fuel furnaces and boilers could be run on a low carbon alternative fuel before 2035."

John Huber
National OilHeat Research Alliance

	efficiency[1]	economic impact[2]	environmental impact	Heating Comfort
Natural Gas	🟢	🔵	🔵	🟢
Electricity	🔵	⚫	🔵	🔵
ULSD[3]	🟢	🟢	⚫	🟢
B100	🟢	🟢	🟢	🟢
Tri-Mix[4]	🟢	🟢	🟢	🟢

Table 1 - Impact Assessment of Achieving Low Carbon Goals in 2050

[1] Electric heat-pump source-based COP of 1.09, thermal heat pump source-based COP of 1.3
[2] Economic impact refers to the cost of transitioning from a home with one energy source to another e.g. from liquid-fueled furnace to electric heat pump including any infrastructure costs to support the transition e.g. transmission and distribution capacity upgrades or battery storage for internment renewable power sources.
[3] ULSD - < 15 ppm sulfur diesel
[4] 1/3 ULSD, 1/3 B100 and 1/3 Ethyl Levulinate

introduction

Recent studies and position papers advocating development of public policies and public incentives for fuel switching from fossil fuel-based residential heating systems to electric heat pumps must be corrected. This is particularly true with the case of the oil heating industry. The oil heating industry has been investing in its transformation into an energy efficient renewably-fueled supply industry for the future. Table 2 shows the common errors in recent reports and position papers in need of correction.

ACEEE's July 2018 report titled: "*Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps*", recommends "*... programs to promote high-efficiency heat pumps to replace less-efficient oil and electric systems ... Such efforts can build on successful programs in the Northeast and Northwest. In addition, programs to promote heat pumps in new construction deserve attention."*

In addition, the ACEEE *"calculated the life-cycle cost for each system type and location, assuming a 21-year equipment life and a 5% real discount rate"* using DOE estimates and utility cost of capital. The fuel-switching capital costs were not explained. The conclusions differ dramatically from the June 18, peer reviewed ASHRAE paper[5] which found[6] that renewable liquid-fueled thermal heat pumps integrated with multi-split air conditioning units are generally more cost effective than cold climate high efficiency electric heat pumps.

Rocky Mountain Institute's "RMI's" – "*The Economics of Electrifying Buildings*" paper concludes: *"Prioritize rapid electrification of buildings currently using propane and heating oil in space and water heating. Although these represent less than 10% of US households, they account for more than 20% of space and water heating emissions. Electrification is very cost-effective for propane customers, and has a comparable cost to heating oil depending on local pricing."* Like ACEEE, RMI misses the mark assessing oil as the industry's *futurefuel*, does not appear to know about research and development work on a renewably liquid-fueled thermal heat pump, and does not fully evaluate fuel switching cost.

National Grid's *80 x50 Pathway* brochure, created by a large electric and natural gas utility, states: "*A transformation of the heat sector, by doubling the rate of efficiency retrofits and converting nearly all of the region's 5 million oil-heated buildings to electric heat pumps or natural gas"* is the only residential pathway to 80 x 50. National Grid further encouraged policymakers to allow public funds for fuel switching saying, *"Additional incentives for heat electrification and green gas production will be important."* Being a gas utility, National Grid knows about thermal heat pumps, but apparently only natural gas-fired ones, as well as, renewable gas, but apparently biodiesel and advanced liquid biofuels are not mentioned. "Beyond 2030, the heat sector will require sustained efficiency investment and conversion to heat pumps, the steady decarbonization of natural gas supply (through renewable natural gas, hydrogen, and synthetic fuels), and conversion of many natural gas homes to hybrid natural gas-heat pump configuration".

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[5] "*Energy, Cost and CO_{2e} Savings Analyses of Reversible, Hybrid and Heating-Only Liquid Fuel Fired Absorption Heat Pumps in the Northeastern United States*", ASHRAE Summer Meeting, Christopher Keinath, PhD, Thomas Butcher, PhD, Michael Garrabrant, PE, June 2018

[6] See "*heat pump economics in the northeast*" section of this report for details. (Hybrid THP/14 SEER AC or Heating only THP and 14 SEER AC boilers more cost effective than 18SEER- 12 HSPF CCEHP with Boiler backup or Hybrid THP/14 SEER AC or Heating only THP and 14 SEER AC furnace is more cost effective than 18SEER- 12 HSPF CCEHP with Furnace backup or 18SEER- 12 HSPF CCEHP with Resistance backup)

	Does not evaluate biodiesel	Does not evaluate advanced biofuels	Does not evaluate thermal liquid-fueled heat pumps	Does not cost grid upgrades required for 80% renewables	Does not evaluate low ambient comfort
ACEEE's July 2018 report	●	●	●	●	●
RMI's - The Economics of Electrifying Buildings	●	●	●	●	●
National Grid's 80 x50 Pathway brochure	●	●	●	●	●

Table 2 - Assumption Errors in Recent Residential Heating Policy Studies and Promotions

This report examines three approaches to fuel a low carbon future in residential heating systems. The data presented in the report is compiled from the following studies:

1. "*Analysis of Fuel Cycle Energy Use and Greenhouse Gas Emissions from Residential Heating Boilers*", Bruce Hedman, Entropy Research LLC, June 2018
2. "*Energy, Cost and CO_{2e} Savings Analyses of Reversible, Hybrid and Heating-Only Liquid Fuel Fired Absorption Heat Pumps in the Northeastern United States*", ASHRAE Summer Meeting, Christopher Keinath, PhD, Thomas Butcher, PhD, Michael Garrabrant, PE, June 2018
3. "*Implications of Policy-Driven Residential Electrification*", American Gas Association Study, prepared by ICF, July 2018
4. "*Comparison of Ethyl Levulinate with Gasoline and Diesel: Well to Wheels Analysis*", Harnoor Dhaliwal and Lise Laurin, EarthShift, June 2009
5. "*U. S. National Electrification Assessment*", Electric Power Research Institute, April 2018
6. *"Northeast 80x50 Pathway*" National Grid, June 2018

Residential heating energy in the U.S. is largely supplied by fossil fuels with 64% of households currently using fossil fuel combustion to heat their homes according to the Department of Energy's 2015 Residential Energy Consumption Survey (RECS). Table 3 provides overall energy use by climate zone and Table 4 focuses on homes where space heating is mainly provided by electricity or fossil fuel combustion. It is easy to see that fossil fuels dominates cold/very cold and mixed-humid climates for home heating. This reflects current market conditions driven by customer economics and comfort.

	Total U.S.[8]	Climate region[7] Very cold/ cold	Mixed-humid	Mixed-dry/ Hot-dry	Hot-humid	Marine
All homes	118.2	42.5	33.5	12.7	22.8	6.7
Fuels used for any use (more than one may apply)						
Electricity	118.2	42.5	33.5	12.7	22.8	6.7
Natural gas	68.6	29.3	17.5	10.4	7.5	3.9
Propane[4]	11.6	5.0	3.9	0.6	1.5	0.6
Wood	12.5	5.0	3.7	0.8	1.7	1.2
Fuel oil/kerosene	6.9	4.1	2.7			

Table 3 - Fuels Used for Primary and Secondary Heating in U.S. Homes by Climate Region (Millions)

	Total U.S.[2]	Climate region[3] Very cold/ cold	Mixed-humid	Mixed-dry/ Hot-dry	Hot-humid	Marine
Electricity mainly used for heating	40.9	7.5	13.1	3.7	14.0	2.7
Natural gas, Propane, Wood, and Fuel oil/kerosene mainly used for heating	72.0	34.8	20.3	6.9	6.1	3.3
Fossil fuel Percent of Total	64%	82%	61%	65%	30%	55%

Table 4 - Fuels Used as the Primary Heating Source in U.S. Homes by Climate Region (Millions)[9]

Table 5 shows current market share of residential fossil-fueled heating systems by fuel type. Natural gas dominates this sector because of current fuel cost. Homes with a biodiesel blend of at least 20% biodiesel and 80% ULSD is used in less than 1% of the fossil fueled homes today. Recognizing that carbon reduction is an increasing requirement and that biodiesel and advanced liquid biofuels appear to be one of the most viable pathways toward zero carbon residential heating, one might expect to see significant bioblend market share growth in the next ten years.

	Total U.S.[2]	Percent
Natural Gas	40.9	74.1%
Propane	5	9.1%
Wood	3.5	6.3%
Oil	5.3	9.6%
~B20 or more	0.5	0.9%
Total	55.2	100.0%

Table 5 - Current Residential Heating Market Share by Fuel Type, Exclusive of Electricity (Millions)

[7] These climate regions were created by the Building America program, sponsored by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE).
[8] Total U.S. includes all primary occupied housing units in the 50 states and the District of Columbia. Vacant housing units, seasonal units, second homes, military houses, and group quarters are excluded.
[9] 118.2 million homes are heated in the US, 112.9 million homes use energy as a primary means of heating. The remaining homes 5.3 million homes have only spot or secondary means of home heating.

beneficial electrification for home heating

The future of home heating is the focus of the environmental community, some policy makers and, of course, electric utilities (who increase load when fossil fuel customers switch to electric heat pumps). Many of these groups have been promoting Beneficial Electrification which assumes that by 2050 all or most home heating energy will be supplied by an electric grid that is exclusively powered by renewables.

There are a number of fundamental flaws in this policy-driven movement that affects the heating oil industry and all other energy providers:

1. Policy-driven electrification would increase the average residential household cost – largely because intermittent renewables and batteries would substantially increase the electric infrastructure. A vastly oversized grid and a dramatic increase in production will be necessary to ensure that the electric operating system does not collapse during a sustained freeze when demand is high and heat pump efficiency is low or fails to provide heat.

2. Despite the desire to move to renewably-fueled electric power plants, the electric grid in 2050 will not be 100% renewable. It will likely require natural gas combined cycle combustion turbines (CCCTs) operating, at the margin, to fulfill the increased demand of millions of households currently using natural gas or heating oil. In fact, the Electric Power Research Institute's April 2018 National Grid Assessment predicts, in its Transformation Model, that the final delivered energy from the electric grid will account for only 47% of the total delivered energy needed by end-users.

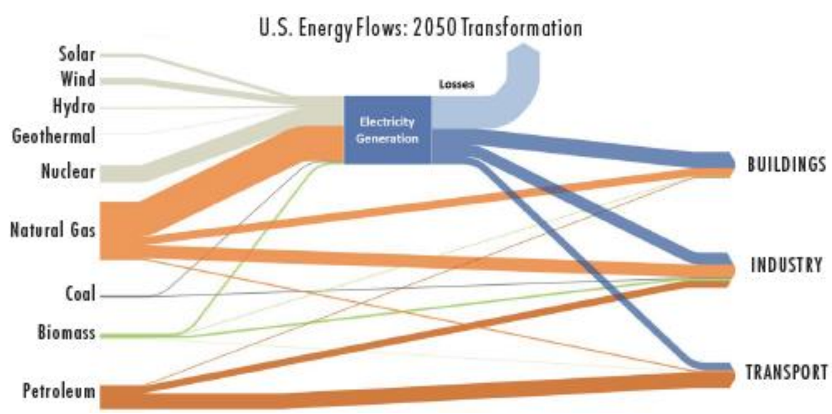

Figure 1 - Sankey view of 2050 EPRI's Transformation scenario projection[10].

Figure 1 shows EPRI's model results for its most aggressive carbon reduction scenario (Transformation) in 2050. Most notable is large dependence on nuclear and natural gas power generation and significant requirement for fossil fuel combustion in buildings and industry.

3. According to the AGA Report[11]., fuel switching residential heating (oil, propane and gas) to electric heat pumps would only result in GHG emissions reduction by 1 to 1.5 percent.

4. Decarbonized power systems dominated by variable renewables such as wind and solar energy are physically larger, requiring much greater total installed capacity.

[10] This EPRI Sankey diagram represents the flow of electric energy from generation source on the left (solar, wind, coal, oil, natural gas, nuclear, etc.) to the load served on the right (buildings, industry and transportation). The width of the arrows is shown proportionally to the energy flow quantity used.

[11] "Implications of Policy-Driven Residential Electrification", American Gas Association Study, prepared by ICF, July 2018. *"See fuel switching residential heating to electric heat pumps would only result in GHG emissions reduction by 1 to 1.5 percent"* for more detail.

   a. Due to the variability of wind and solar energy, power systems with high shares of these resources have much greater overall installed capacity than more diversified power systems, and must maintain significant dispatch-able capacity to ensure demand can be met at all times. For example:

   b. Pleßmann and Blenchinger[12] present a scenario for decarbonizing the European power system by 2050 (achieving 98.4% below 1990 emissions levels) that relies heavily on an expansion of wind and solar energy. Total installed capacity in this scenario is 4.2-times larger than the peak demand.

   c. Similarly, a 100% renewable electricity scenario for Australia outlined by Elliston, MacGill, and Diesendorf[13] features total capacity roughly three times the peak demand in the system.

   d. Brick and Thernstrom[14] likewise conclude that total installed capacity is 3.5 to 5.5 times larger for wind and solar-dominated power systems than more balanced systems.

   e. Total U.S. generating capacity is roughly double today's installed capacity in a set of 80% renewable electricity scenarios described by Mai, Mulcahy, et al.[15].

   f. Greater required installed capacity and the lower energy-density of wind and solar resources also significantly increase the land use consequences of power systems dominated by variable renewable resources.

5. The heating oil industry today is moving away from traditional oil-based fuels to biofuels with the goal of fleet conversion from B5-B20 to a $^1/_3$ Biodiesel - $^1/_3$ Advanced Biofuel[16] and $^1/_3$ ULSD by 2035. The advanced biofuel under consideration yields negative carbon due to avoided carbon emissions. As a result, this fuel would yield carbon free combustion for heating.

6. The U.S. Department of Energy is supporting the development of thermal heat pump technology[17] that will be more efficient, provide much more comfortable heating and be lower cost. Additionally, it would make the electric grid less vulnerable to failure, and make any failure less catastrophic.

Biodiesel and advanced biofuels <u>must not</u> be ignored by policy makers when developing their carbon and methane reduction plans for the future. Renewable biofuels may provide the most cost-effective method to reduce carbon and can make other GHG reduction strategies more easily obtainable.

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[12] Pleßmann, G., and P. Blechinger. 2017. "How to Meet EU GHG Emission Reduction Targets? A Model Based Decarbonization Pathway for Europe's Electricity Supply System until 2050." Energy Strategy Reviews 15: 19–32. doi:10.1016/j.esr.2016.11.003.
[13] Elliston, B., I. MacGill, and M. Diesendorf. 2014. "Comparing Least Cost Scenarios for 100% Renewable Electricity with Low Emission Fossil Fuel Scenarios in the Australian National Electricity Market." Renewable Energy 66: 196–204. doi:10.1016/j. renene.2013.12.010.
[14] Brick, S., and S. Thernstrom. 2016. "Renewables and Decarbonization: Studies of California, Wisconsin and Germany." The Electricity Journal 29 (3): 6–12.
doi:10.1016/j.tej.2016.03.001.
[15] Mai, Trieu, David Mulcahy, M. Maureen Hand, and Samuel F. Baldwin. 2014. "Envisioning a Renewable Electricity Future for the United States." Energy 65. Elsevier Ltd: 374–86. doi:10.1016/j. energy.2013.11.029.
[16] There are several pathways moving toward advanced biofuels, two of which are listed. 1) Biofine Technology, LLC. Has developed a cellulosic biodiesel for use in residential heating, and 2) Synthetic Genomics, Inc. (SGI) and ExxonMobil have developed a strain of algae able to convert carbon into a record amount of energy-rich fat, which can then be processed into biodiesel.
[17] See Pathway to Energy Efficiency for description of thermal heat pump technology

beneficial residential electrification

policy-driven electrification by fuel switching residential heating to electric heat pumps would increase the average residential household energy-related costs about 38 percent to 46 percent.

Policy-driven electrification would increase the average residential household energy-related costs (amortized appliance and electric system upgrade costs and utility bill payments) of affected households by between $750 and $910 per year, or about 38 percent to 46 percent. Widespread residential electrification will lead to increases in peak electric demand and could shift the U.S. electric grid from summer peaking to winter peaking in every region of the country, resulting in the need for new investments in the electric grid including generation capacity, transmission capacity, and distribution capacity.

The Energy Innovation Reform Project outlined daunting barriers to developing a low/no carbon renewable electric solution by 2050.[18]

The electric power sector is widely expected to be the linchpin of efforts to reduce greenhouse gas (GHG) emissions. Most studies exploring climate stabilization pathways envision a decline in global anthropogenic GHGs of 50-90% below current levels by 2050[19]. To reach these goals, the power sector would need to cut emissions nearly to zero, while expanding to electrify (and consequently decarbonize) portions of the transportation, heating, and industrial sectors[20].

1. Deep decarbonization of the power sector is significantly more difficult than more modest emissions reductions.
2. Achieving deep decarbonization primarily (or entirely) with renewable energy may be theoretically possible but it would be significantly more challenging and costlier than pathways employing a diverse portfolio of low-carbon resources.
3. Decarbonized power systems dominated by variable renewables such as wind and solar energy are physically larger, requiring much greater total installed capacity.
4. Wind and solar-heavy power systems require substantial dispatchable power capacity to ensure demand can be met at all times. This amounts to a "shadow" system of conventional generation to back up intermittent renewables.
5. Without a fleet of reliable, dispatchable resources able to step in when wind and solar output fade, scenarios with very high renewable energy shares must rely on long-duration seasonal energy storage.
6. Very high shares of wind and solar entail significant curtailment—even with energy storage, transmission, or demand response.
7. High renewable energy scenarios also envision a significant expansion of long-distance transmission grids.

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[18] "*Deep Decarbonization of the Electric Power Sector Insights from Recent Literature*", Jesse D. Jenkins and Samuel Thernstrom, March 2017

[19] "*A critical review of global decarbonization scenarios: what do they tell us about feasibility?*", Peter J. Loftus, Armond M. Cohen, Jane C. S. Long, Jesse D. Jenkins, 06 November 2014

[20] "Transport Electrification: A Key Element for Energy System Transformation and Climate Stabilization." McCollum, David, Volker Krey, Peter Kolp, Yu Nagai, and Keywan Riahi. 2014. Climatic Change 123 (3–4): 651– 64. doi:10.1007/s10584-013-0969-z. and "Getting from Here to There – Energy Technology Transformation Pathways in the EMF27 Scenarios", Krey, Volker, Gunnar Luderer, Leon Clarke, and Elmar Kriegler. 2014.." Climatic Change 123 (3–4): 369–82. doi:10.1007/s10584-013-0947-5.

fuel switching residential heating to electric heat pumps would only result in GHG emissions reduction by 1 to 1.5 percent

The U.S. Energy Information Administration (EIA) projects in their baseline case that by 2035, the sum of natural gas, propane and fuel oil used in the residential sector will account for less than 6 percent of total GHG emissions. Reductions from policy-driven residential electrification would reduce GHG emissions by 1 percent to 1.5 percent of U.S. GHG emissions in 2035 from the EIA AEO 2017 Baseline emissions. This result is based on the efficiency of the average newly installed heat pump is assumed to increase by about 1 percent per year, reaching an HSPF of 12.5 by 2035. This results in an average reported HSPF of 11.5 (COP of 3.4) for the heat pumps used to replace the furnaces converted to electricity due to the residential electrification policy over the time period from 2023 through 2035. New furnace efficiency was assumed to be same as the existing furnace efficiency to ensure that the analysis does not overstate potential furnace efficiency. This compares an all renewable grid solution versus a market-based grid solution.

the cost impacts from electrification policies include

Consumer Costs: The direct costs to consumers of policy-driven electrification include:

1. The incremental costs for new or replacement electric heating and hot water equipment relative to the natural gas or other direct fuel alternative.
2. Costs of upgrading or renovating existing home HVAC and electrical systems.
3. Difference in energy costs (utility bills) between the electricity options and the natural gas and other direct fuel options.

Most of the affected households will be existing households retrofitting from natural gas, heating oil, propane, biodiesel blends and advanced biodiesel blends. The costs for these customers typically will be higher than the incremental costs for new households installing the equipment.

Power Generation Costs: The capital cost of new electric generating capacity needed to supply the increased electricity demand.

Transmission Costs: The cost of new electric transmission infrastructure required to serve the increased load and generation.

The latter two costs are often neglected by most studies that promote the concept of beneficial electrification. The reason generally stated is that electric heat pump high efficiency and future energy efficiency programs will essentially reduce electric demand. Note, since the cost of these future energy efficiency programs is never calculated and added into consumer energy costs. Therefore, additional electric capacity (generation, transmission and distribution capacity) "fuel-switching" for a fossil fuel to electricity must be added.

"Table 6 summarizes these costs for the Renewables- Only Case showing that the total cumulative cost increase relative to the Reference Case is nearly $1.2 trillion by 2035. Roughly half of this cost is the increase in consumer energy costs. One third is the cost of new generating capacity and consumer equipment, and transmission costs make up the remainder. The Market-Based Generation Case has a total cumulative cost increase of $590 billion by 2035, shown in Table 6. The consumer energy costs are lower in this case because it does not include electrification of the Midwestern, Plains, and Rockies regions, which have higher heating loads, greater saturation of gas heating equipment, and colder temperatures, which result in lower efficiency for electric heat pumps. The other costs are also somewhat lower, especially the capital cost of new generating capacity. The generating cost is lower because the model is selecting the lowest cost option, rather than being limited to only renewable sources, which increases costs, especially for battery storage, in the Renewables-Only Case.

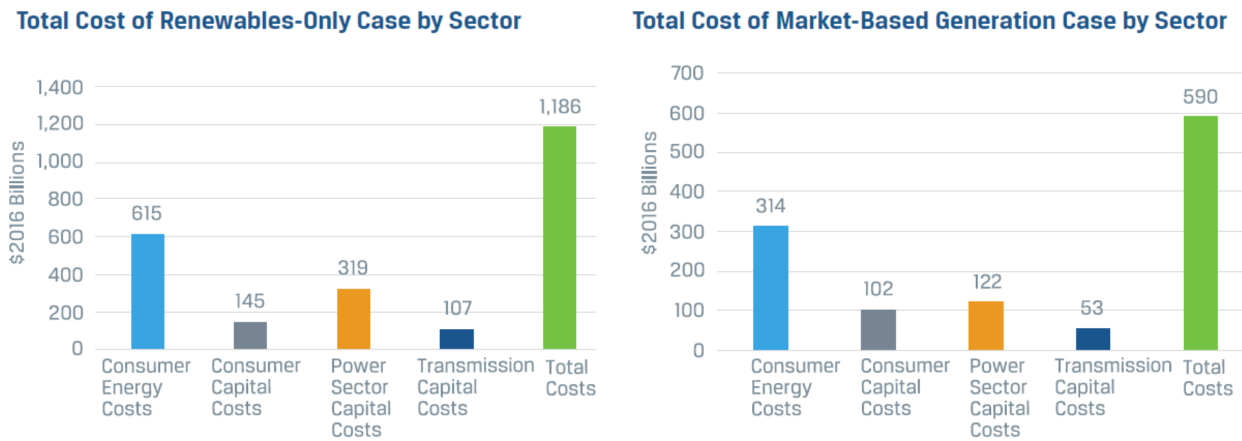

Table 6 - Renewables- Only Case and Market-Based Generation Case

The overall magnitude of the costs of policy-driven residential electrification is expected to place a significant burden on consumers. Table 7 shows the cumulative and annualized costs of the conversion to electricity spread out over the total number of converted households. These costs include the direct costs per household, including the direct consumer costs (appliance and energy costs), and an allocation of the capital cost for electric generating plants and electric transmission. The costs are discounted to 2023 and expressed in real 2016 dollars."[21]

Region	Renewables-Only Case		Market-Based Generation Case	
	Cumulative Change In Costs Per Converted Household	Annualized Change In Costs Per Converted Household	Cumulative Change In Costs Per Converted Household	Annualized Change In Costs Per Converted Household
East Coast	18,440	1,240	16,550	1,110
Midwest	25,920	1,740	Policy Not Implemented	
New York	58,580	3,930	57,770	3,880
New England	41,210	2,770	35,340	2,370
Plains	29,120	1,950	Policy Not Implemented	
Rockies	25,060	1,680	Policy Not Implemented	
South	7,820	520	650	40
Texas	1,970	130	740	50
West	5,880	390	5,140	340
Total U.S.	**21,140**	**1,420**	**15,830**	**1,060**

Table 7 - Annual Per Household Total Costs of Electrification Policies (Real 2016 $)

Figure 2 provides an understanding of the fuel/energy cost tracked by U.S. DOE's Energy Information Administration. These energy costs combined with appliance efficiency (electric heat pump source energy COP 1.09 and liquid fueled thermal heat pump source energy COP 1.3 provide a reasonable assessment

[21] "*Implications of Policy-Driven Residential Electrification*", An American Gas Association Study prepared by ICF, July 2018

that renewable liquid fueled heat pumps will have low operating costs compared to other electric heat pumps.

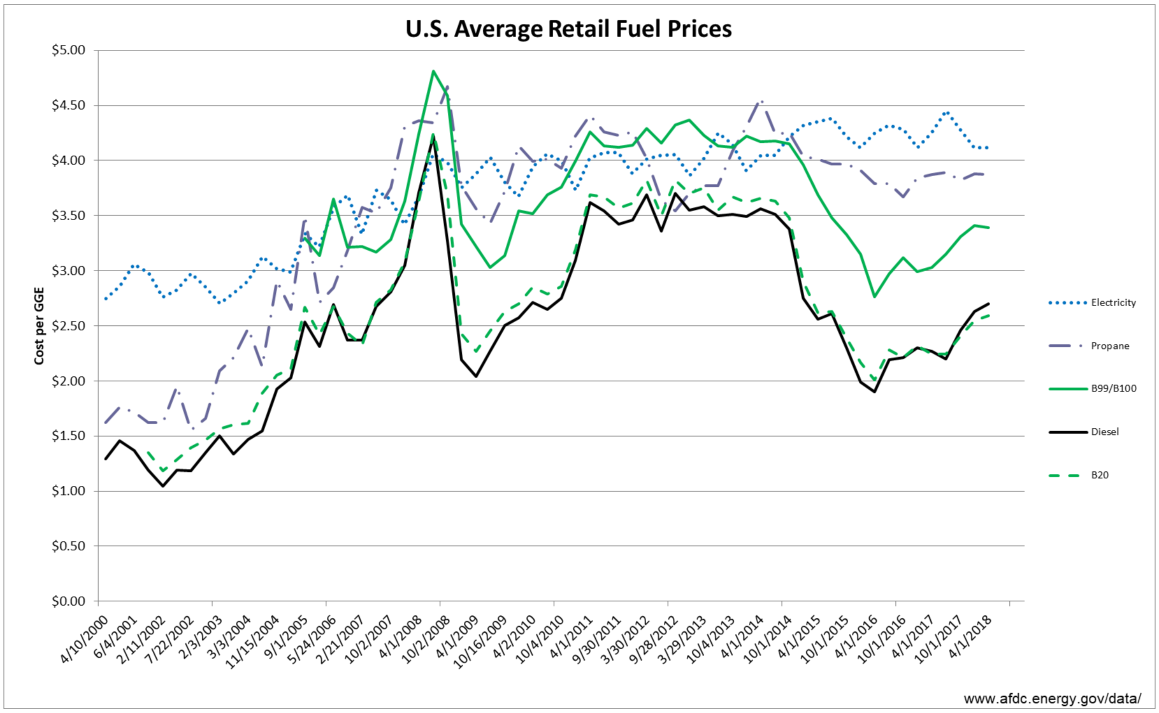

Figure 2 - EIA U.S. Average Retail Fuel Prices[22]

heat pump economics in the northeast[23]

The simple payback and 15-year total cost for two thermal heat pump (THP) installation configurations were investigated. The first configuration assumed a heating only THP would be nested or installed in the same package as an electric air conditioner (EAC). This design is designated as the "Hybrid" system. The design of this system allows for the highest efficiency heating and cooling to be performed by "one" system. The second configuration assumed a heating only THP and EAC are installed as separate entities. The two configurations are identical for the purpose of seasonal modeling and correspond to the heating only THP and 14 SEER electric air conditioning system. The installation cost specific to each configuration will be different and will factor into payback and 15-year life calculations. In addition to the THP configurations, the simple payback and 15-year total cost of the cold climate electric heat pump (CCEHP) with boiler, furnace and resistance backup were investigated.

Installed cost of each system was estimated based on equipment pricing estimates and feedback from contractors in the Northeast. Capital cost for commercially available equipment was estimated based on available pricing. Capital cost estimates for the THP equipment were developed from a supply chain

[22] The Alternative Fuel Price Report is a snapshot in time of retail fuel prices for vehicles presenting data in dollars per gasoline gallon equivalent (GGE) which allows an equivalent comparison. The data is presented as delivered by EIA except electricity is changed to remove the 3.4 factor to adjusted for efficiency because electric vehicles are 3.4 times as efficient as internal combustion engines. In fact, electric heat pumps have a source efficiency of 1.09 COP and liquid-fueled thermal heat pumps have a source energy efficiency of 1.3 COP.

[23] "Energy, Cost and CO2e Savings Analyses of Reversible, Hybrid and Heating-Only Liquid Fuel-Fired Absorption Heat Pumps in the Northeastern United States", ASHRAE Summer Meeting, Christopher Keinath, PhD, Thomas Butcher, PhD, Michael Garrabrant, PE, June 2018

analysis to include reasonable mark-ups and assuming a minimum production level.[24] Table 8 shows that an integrated THP/EAC system ranks among the best economic alternatives for future residential space conditioning (heating and cooling) even without evaluating the infrastructure costs of expanding and hardening the electric grid to service electric heat pumps.

Baseline Heating / Cooling System	Radiator Based Boiler, 14 SEER Minisplit AC			Forced Air System with Condensing Furnace, 14 SEER Central AC			
Replacement Technology	Hybrid THP/14 SEER AC	Heating only THP and 14 SEER AC	18SEER- 12 HSPF CCEHP with Boiler backup	Hybrid THP/14 SEER AC	Heating only THP and 14 SEER AC	18SEER- 12 HSPF CCEHP with Furnace backup	18SEER- 12 HSPF CCEHP with Resistance backup
Location	**Payback Period, Years**						
Portland, ME	0.8	3.6	8.6	4.7	4.8	9.5	5
Hartford, CT	0.7	3.4	9.8	4.3	4.4	12	7.6
NYC, NY	0.9	3.9	Never[25]	5	5.1	Never[15]	Never[15]
Albany, NY	0.6	2.9	7.8	3.8	3.8	9.3	5.2
Concord, NH	0.7	3.3	14	4.2	4.3	20.9	Never[15]
Burlington, VT	0.6	3	15.5	3.9	3.9	Never[15]	Never[15]
Worcester, MA	0.7	3.2	10	4.1	4.1	13	7.3
Location	**15 Year Total Cost, USD**						
Portland, ME	$33,625	$35,575	$36,728	$31,250	$31,300	$31,833	$28,876
Hartford, CT	$36,889	$38,839	$42,729	$34,435	$34,485	$38,063	$36,433
NYC, NY	$37,240	$39,190	$49,964	$35,061	$35,111	$45,703	$42,441
Albany, NY	$39,081	$41,031	$43,119	$36,444	$36,494	$38,444	$36,231
Concord, NH	$39,365	$41,315	$49,640	$36,710	$36,760	$44,585	$46,941
Burlington, VT	$43,153	$45,103	$55,576	$40,244	$40,294	$50,106	$56,924
Worcester, MA	$37,405	$39,355	$44,226	$34,913	$34,963	$39,809	$37,087

Table 8 - Simple Payback and 15 Year Total Cost

comparing liquid biofuels with natural gas

This analysis compares the relative energy resources consumed and GHG impacts associated with pipeline natural gas, ultra-low sulfur heating oil, and soybean-based biodiesel blends (B5, B20 and B100) used for residential space heating boilers and water heating. Consideration was given not only to impacts at the point of ultimate energy consumption -- i.e., the efficiency of use at the residence -- but also to those impacts associated with the production, conversion, transmission and distribution of energy to the household. The analysis presents the total resource energy requirements and fuel cycle GHG emissions for heating services supplied by high efficiency natural gas, heating oil and biodiesel products based on typical residential usage.

analysis

The three main GHG emissions from the oil and natural gas fuel cycle are methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O). While CO_2 is considered the primary contributor to global warming, methane and nitrous oxide also have significant global warming potential. The analysis estimated the GHG emissions of each fuel at each stage of the fuel cycle, from well to burner-tip, in terms of CO_2 equivalent, or

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[24] Local heating oil (IEA, NYSERDA, CT.GOV, New England Oil, Maine Oil, 2016) and electricity (Electricity Local, 2016) prices assumed for each location. The table shows that there is a significant range in heating oil ($2.049 to $2.753/gallon) and electricity ($0.0694 to $0.2321/kWh) pricing in the Northeast. This variation in pricing impacted the savings potential for each location. Higher fuel prices will result in increased savings per gallon of heating oil saved. Variation in electricity cost impacted savings because the AHP and EHP systems use more electricity than the boiler and furnace systems.

[25] Never indicates payback over 25 years

CO_2e [26]. This report also presents GHG emissions results for both conventional 100-Year Atmospheric Lifetime assessment and short-term carbon forcing assessment at 20-Year Atmospheric Lifetime[27]. The individual GHG sources along the fuel cycle were classified into three categories: vented, fugitive, and combustion emissions.

- Vented emissions are the designed and intentional equipment vents to the atmosphere. For example, pneumatic devices are engineered to leak small amounts of natural gas when in operation and these emissions are classified as vents.
- Fugitive emissions are the unintentional equipment leaks. For example, leaks from flanges and valves at a wellhead are classified as fugitives, and
- Combustion emissions are the emissions associated with the combustion of fuel. Combustion emissions may be for either energy use or non-energy use. Energy use refers to any combustion of fuel where energy is extracted for beneficial use, such as natural gas used as fuel and combusted in compressor engines and heaters. Non-energy combustion refers to any combustion of fuel in flares where there is no energy extraction.

assessing Biodiesel – Land Use Change

Calculating biodiesel GHG impact requires understanding that the cultivation of energy crops on agricultural land can lead to an indirect or induced land use change (ILUC). The impact of ILUC is that agricultural land now used for the energy crop area is no longer available for food and feed production, and cultivation for these purposes may be moved to other, possibly new, cultivated areas. To prevent the deforestation of tropical rainforests potentially caused by the cultivation of energy crops, there are calls to create induced land use change (ILUC) factors, which are then added to the carbon footprint of biofuels as additional CO_2 emissions. This approach is very controversial, especially since indirect land-use changes are extremely difficult to quantify. It is, for example, generally not known whether a replacement foodstuff is grown specifically due to a certain land use change or, if it is grown, in the exact location. To achieve this, all regional and global trade relations would theoretically have to be included in the evaluation. The range of different studies and models are correspondingly broad. Nevertheless, this report includes the best available ILUC factors when presenting this data[28].

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[26] CO_2e (CO_2 equivalent) emissions include CO_2, N_2O and methane all calculated for their global warming potential (GWP) in terms of a CO_2 baseline = 1. This analysis used the recognized 100-year GWP time horizon with carbon feedback in evaluating the relative GWP of methane (36 x CO_2) and nitrous oxide N_2O (298 x CO_2) and recognized 20-year GWP time horizon in evaluating the relative GWP of methane (85 x CO_2) and nitrous oxide N_2O (264 x CO_2)

[27] In the mid-90s, policymakers for the Kyoto Protocol chose a 100-year time frame for comparing greenhouse gas impacts using GWPs. The choice of time horizon determines how policymakers weigh the short- and long-term costs and benefits of different strategies for tackling climate change. According to the Intergovernmental Panel on Climate Change, the decision to evaluate global warming impacts over a specific time frame is strictly a policy decision—it is not a matter of science: "the selection of a time horizon of a radiative forcing index is largely a 'user' choice (i.e. a policy decision)" [and] "if the policy emphasis is to help guard against the possible occurrence of potentially abrupt, non-linear climate responses in the relatively near future, then a choice of a 20-year time horizon would yield an index that is relevant to making such decisions regarding appropriate greenhouse gas abatement strategies." Short-lived pollutants that scientists are targeting today, which actually warm the atmosphere, are methane and hydrofluorocarbons (HFCs) which are greenhouse gases like CO_2, trapping radiation after it is reflected from the ground. There is a growing scientific movement to calculate GHG emissions potential based on the short-term carbon forcing gases.

[28] Awgustow A, et al, "Production of GHG-reduced liquid fuels", September 21 2017, TU Bergakademie Freiberg for Institut für Warm und Oeltechnik IWO e.V.

summary of results

- It is critical to compare the energy and emissions performance of fuels in terms of the full fuel-cycle and actual (as opposed to rated) efficiencies at the point of use.
- Combustion of ultra-low sulfur heating oil (< 15 ppm sulfur) is the equivalent of natural gas combustion with respect to SO_2, NOx and particulates.
- Heating oil, with modest levels of soybean-based biofuel blending (20 to 25 percent), remains a competitive alternative to natural gas for residential heating in terms of overall energy use and GHG emissions based on conventional 100-year atmospheric lifetime calculations.

  To illustrate, Boston is one of six cities where boiler performance and GHG emissions were calculated for natural gas, heating oil and heating oil/biofuel blends. Figure 3 shows that, for Boston, the GHG emissions of a typical replacement residential oil boiler using a B20[29] blend are equivalent to the emissions from a typical replacement natural gas boiler based on 100-year atmospheric lifetime calculations without considering induced land use change impacts. Blends up to B100[30] have been used in the field today, with B20 blend being quite typical.

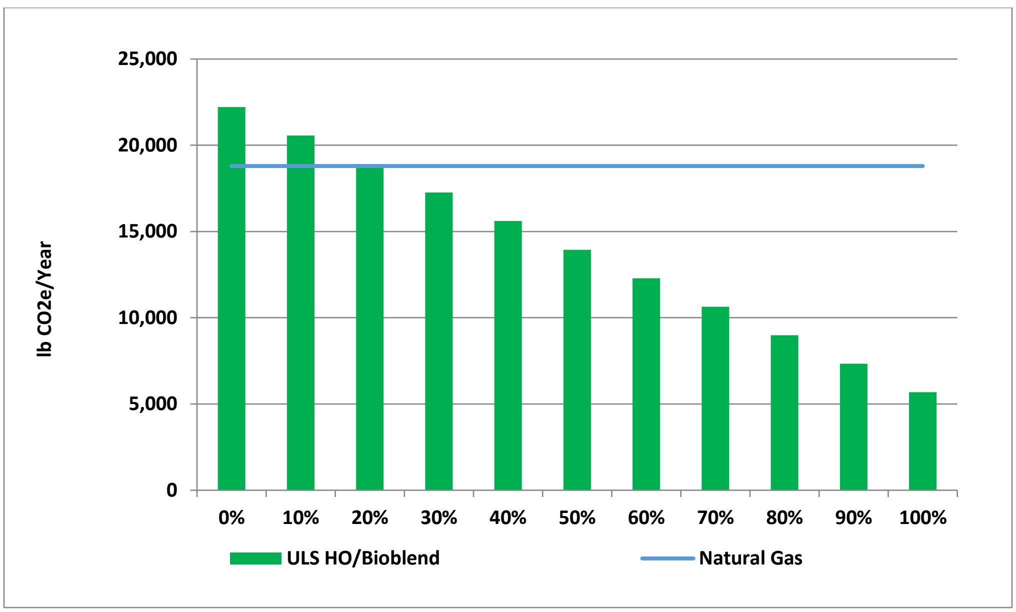

Figure 3 - 100 Year Atmospheric Lifetime with Feedback and without Indirect Land Use

- Heating oil with even lower levels of biofuel blending (7 percent) remains a competitive alternative to natural gas for residential heating in terms of overall energy use and GHG emissions based on carbon forcing 20-year atmospheric lifetime calculations.

  Figure 4 shows that, for Boston, the GHG emissions of a typical replacement residential oil boiler using a B7[31] blend of heating oil are equivalent to the emissions from a typical replacement natural gas boiler

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[29] B20 is 20% biodiesel and 80% ultra-low sulfur diesel
[30] B100 (100% biodiesel) has been applied in the field, but very special care must be taken with respect to cold flow properties.
[31] B7 is 7% biodiesel and 93% ultra-low sulfur diesel

based on 20-year atmospheric lifetime calculations without considering induced land use change impacts. Again, blends up to B100[32] have been used in the field today, with B20 blend being quite typical.

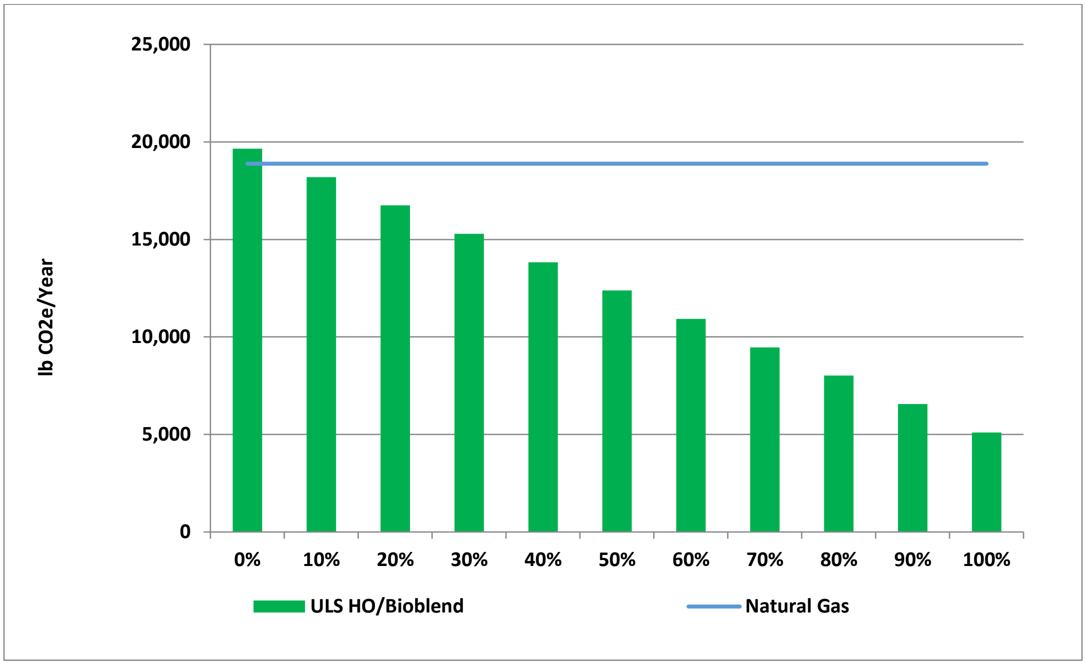

Figure 4 - 20 Year Atmospheric Lifetime without Indirect Land Use

- The heating oil industry is actively incorporating existing biofuels into product blends in order to reduce GHG emissions and is working with suppliers to ensure these product blends are compatible with existing and new oil heating equipment.
- Advanced biofuels, such as ethyl levulinate, show even greater promise at reducing the GHG footprint of heating oil blends, well beyond the levels of competing fuels such as natural gas. Figure 5 illustrates the total annual GHG emissions from providing heating and hot water services to a representative 2,500 square foot house in the Boston area for typical replacement boilers being sold today using a blend of ULS heating oil, biodiesel and ethyl levulinate as fuel. A blend of just 10% biodiesel, 10% ethyl levulinate and 80% ULSD has lower annual GHG emissions than natural gas. The graph shows that increasing biodiesel and ethyl levulinate blend content significantly improves GHG emission compared to natural gas. In fact, because of the feedstock used, production techniques and multiple usable products, ethyl levulinate actually enables the potential for reduction of GHG beyond a neutral point – a blend of 79% soybean-based biodiesel and 21% ethyl levulinate contributes zero total fuel cycle GHG emissions, based on using the 100-year atmospheric lifetime global warming potential (GWP) factors with carbon feedback.

[32] B100 (100% biodiesel) has been applied in the field, but very special care must be taken with respect to cold flow properties.

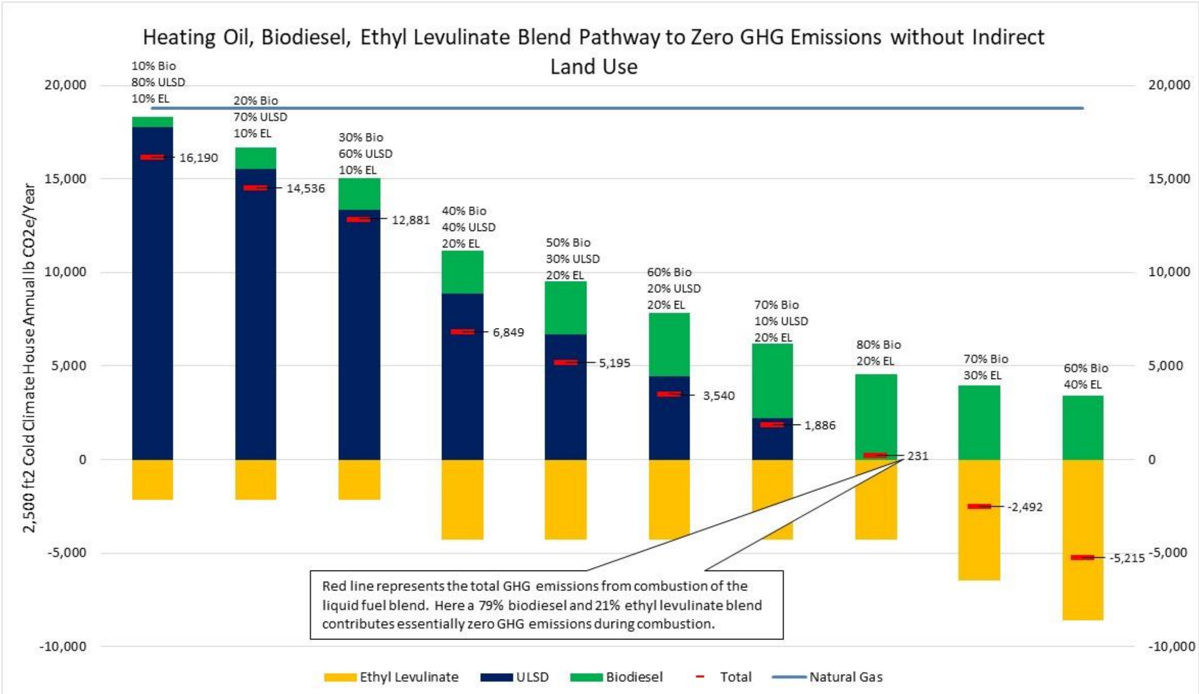

Figure 5 - Heating System Emissions Comparison with Advanced Biodiesel Blends

residential heating policy implications

There are discussions among policy makers about converting the existing, primarily fossil-fueled residential energy infrastructure to electricity in order to meet GHG emissions goals. Such a conversion would require an unparalleled increase in renewable electricity production to meet increased demand without increasing GHG emissions from the power sector. Wind and solar energy are variable resources, and increased reliance on these resources opens the question of how to provide power if the immediate output of these resources cannot continuously meet instantaneous demand. The primary options to address this issue are to (i) curtail load (i.e., modify or fail to satisfy demand) at times when energy is not available, (ii) deploy large amounts of energy storage, or (iii) provide supplemental energy sources that can be dispatched when needed. It is not yet clear if it is possible to curtail loads, especially over long durations, without incurring large economic costs. There are no electric storage systems available today that can affordably and dependably store the vast amounts of energy needed to reliably satisfy demand using expanded wind and solar power generation alone. These facts have led many analysts to recognize the importance of maintaining a broad portfolio of electricity generation technologies, including low-carbon, high efficiency fossil-fueled sources, that can be dispatched when needed.

In addition to technical limits on the sole reliance of renewable resources to meet the increased demand of economy-wide electrification, there are economic limits. The costs of expanding renewable capacity to meet this increased demand would be significant. Added to that would be the equally significant cost of expanding the electric transmission and distribution system. The Electric Power Research Institute (EPRI) evaluated both technical and economic limitations to electrification in its recent U.S. National Electrification Assessment.[33] EPRI concluded that there are significant cost and technology questions about

[33] U.S. National Electrification Assessment, Electric Power Research Institute, April 2018,

the ability to convert more than 47% of end-use energy use to electricity even under the most aggressive scenario. It seems clear that ultimate decarbonization of the economy will require a mix of electrification in areas where technology and costs can support such conversions, and deployment of high efficiency, low carbon fossil-fuel end-use alternatives in many other regions.

Domestic liquid fuels have the potential to play an important role in the future national energy mix, with or without increased electrification. The high energy density of liquid fuels makes transporting and storage simple and cost-efficient, and technical advancements in biofuels and technology can provide low carbon energy services at the point of use, unburdening the electricity supply and transmission system, supporting grid stability and enhancing energy resilience:

- Advanced biofuel blends with ultra-low sulfur diesel heating oil can become a clean and cost-effective net zero GHG emissions residential heat source alternative before 2050.
- Development of new, renewably fueled, thermally driven (heating only) heat pump technologies promise to rival source energy efficiencies of electric heat pumps and provide greater comfort at low ambient temperatures.

pathway to energy efficiency

Details do matter. New homes are different from existing homes and boilers are different from furnaces and heat pumps.

Energy efficiency is a significant factor in achieving carbon reduction. The less fuel used in generating electricity or in directly fueling appliances, the lower the carbon emissions. One important aspect with respect to carbon emissions is that site efficiency (energy used in the home like kilowatts and Btus) must be considered in evaluating different heating fuels. More importantly for electricity, the source energy and impact of demand fluctuations on efficiency, grid reliability and total carbon emissions must be considered when comparing heating energy sources.

Boilers: typical fossil fueled boilers sold today, to existing homes, are 82-86% efficient. This is largely because the hydronic loops were designed for high temperatures. New hydronically heated homes can use condensing boilers at 96% efficiency.

Furnaces: all homes can take advantage of higher cost modern condensing furnaces at 96% efficiency.

Electric Heat Pumps: an electric heat pump with a site-based COP of 3.2 heating has a source-based COP of 1.09[34]. Note: delivered electricity is 34 HHV[35] percent efficient when measured from fuel to the power plant to electricity delivered to the electric socket in your home.

Thermal Heat Pumps: an exciting new technology, in late stage development, is the air-sourced thermally-driven heat pump. This technology would, in today's world, deliver heating at a source coefficient of performance (COP) of about 1.3. Thermal heat pumps, when fully developed can be integrated with existing and new home furnaces and boilers. And their coefficient of performance and delivered air temperature would not drop precipitously during cold weather like electric heat pumps.

[34] Site efficiency 3.2 COP x 34% efficient electric grid = source efficiency of 1.09

[35] Higher Heating Value

thermal heat pump

A thermal heat pump (THP) uses the heat energy from combustion to drive a thermodynamic cycle that can produce heating or cooling (or both at the same time). Most often used for air-conditioning for more than 100 years, the cycle is actually much better (more efficient) for heating than cooling. Absorption cycles are a thermally driven cousin to conventional vapor compression cycles driven by electric energy.

In heating mode, thermal energy (at a relatively low temperature) from outside ambient air enters the heat pump through the evaporator coil, and is raised to a higher useful temperature using the thermodynamic leverage of heat from combustion. Energy from both the colder outdoor air and a liquid fuel is combined and delivered to the heating target (building or water). Thus, the total useful energy is greater than the fuel energy alone, resulting in a net fuel-input efficiency greater than 100% - breaking the so-called "100% barrier". In addition, because approximately 35% of the delivered heat energy comes from the outdoor air, the THP is a partially renewable energy technology, and is recognized as such in some regulatory systems.

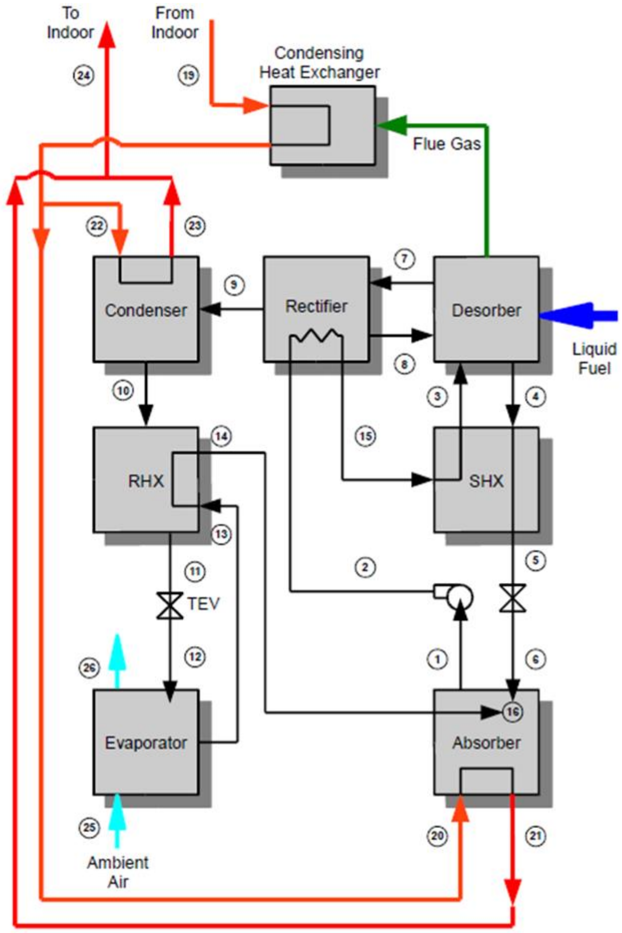

Figure 6 - The Single Effect Ammonia-Water Cycle

A THP is comprised of a set of specialized heat exchangers and small custom pump, all of which circulate the refrigerant and absorbent pair. This set of heat exchangers and pump is often called a "sealed system" or Thermal Compressor. To complete the end-user heating product, certain controls, fans, motors, piping and a surrounding cabinet must be added to the Thermal Compressor.

The ammonia-water absorption cycle (Figure 6) heats a heat-delivery fluid (water or glycol-water mixture) through a heat-exchanger. The ammonia-water mix is separate, always remains sealed inside the Thermal Compressor, and is NOT circulated throughout the building or in hot water tanks. Stone Mountain's overall design and the separate use of water as a "working" or heat-delivery fluid enables many positive attributes for building space and water heating:

- The main heating equipment can sit outside next to the building, freeing up space inside tight mechanical rooms.
- Liquid fuel-fired heating COP's range between 110% and 160% depending on the outside and water temperatures.
- Superior performance at very low ambient temperatures compared to electric heat pumps.

- Ammonia is a natural refrigerant with a greenhouse gas impact and ozone depletion level of zero. It is not under threat of being phased out as are the most common vapor compression fluids used in electric heat pumps and air conditioning.
- Combination space and domestic hot water heating systems can be provided from the same unit.
- The cycle can also be used for cooling (either simultaneously or separately) if there is an appropriate cooling load (e.g. hospitality and restaurants).
- A THP can easily be retrofitted to existing forced air heating systems by tying the heat-delivery fluid (water) to the existing central blower or air-handler.
- The THP's heat-delivery fluid can easily be routed and divided between multiple fan-coil units for zoned heating applications, including baseboard registers, 4-pipe systems, and in-floor radiant heating applications.
- The GHAP cycle operates at relatively low pressure (below 400 psi), resulting in small heat exchanger wall thicknesses with low materials and production costs.
- Ammonia has a high enthalpy of vaporization (hfg) and thermal conductivity, making it suitable for low flow rates, compact heat exchangers, and smaller pump sizes.
- Expensive stainless steel or copper is not needed for heat exchanger construction.

Cycle: The majority of NH_3-H_2O heat pump research and technology development over the past 30 years has focused on high efficiency cooling cycles (such as GAX), using exotic proprietary heat and mass transfer surfaces. Impact on the market has been negligible, as the manufacturing cost to execute these complicated cycles and heat exchangers has out-paced the energy cost savings due to the efficiency improvements. Additionally, advances in electric vapor compression for cooling have outpaced gains made by absorption.

Instead of emphasizing the cooling side, Stone Mountain's focus is on heating applications, which allows use of the much simpler single-effect cycle. The maximum temperature of the single-effect cycle is also below the point where metal corrosion becomes a reliability concern.

How It Works: A schematic for a single-effect heating cycle is shown in Figure 1. Ammonia is vaporized from ammonia-water solution at the high side pressure using fuel combustion heat applied to the desorber. NH_3 is then purified in the rectifier and condensed in the hydronically cooled condenser. The liquid ammonia is evaporated in the ambient air-coupled evaporator after expanding to the low-side pressure in the thermal expansion valve (TEV). Energy from the outside air enters the cycle through the evaporator coil. The vapor is re-absorbed into the water solution in the hydronically cooled absorber (HCA) before being pumped back to the high pressure desorber by a small positive displacement pump.

The thermal energy delivery loop (i.e. the "working fluid") is coupled to the inside conditioned space via an air handler or radiant system. This loop takes its heat via energy extracted from the condenser and absorber. Generally, energy from the condenser equals the energy harvested from the outdoor air in the evaporator, and energy from the absorber equals the fuel energy input to the desorber. Condensing combustion efficiencies are obtained using the cool hydronic fluid returning from the indoor space.

Thermal Compressor: The “sealed system” or Thermal Compressor is a set of specialized heat exchangers and a small pump that circulates the ammonia-water solution. The components that comprise the Thermal Compressor (Figure 7) include the liquid fuel-fired desorber, absorber, rectifier, solution heat exchanger (SHX), refrigerant heat exchanger (RHX), evaporator coil, condenser, and solution pump. All of the heat exchangers are fabricated using low-cost thin-wall tubing. The solution pump is a specialized pump designed specifically for this application.

Figure 7 - Thermal Compressor

Balance of System: By itself, the Thermal Compressor does not provide a fully functional heat pump and several components and sub-systems need to be added. These added components and features can be tailored to match the market segment or application. However, the Thermal Compressor is identical across all applications.

Applications Configurations:

Figures 8 – 10 provide three typical configurations for boiler, furnace and combination boiler/furnace and domestic hot water heating.

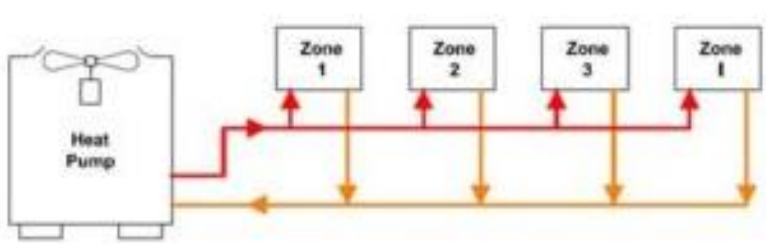

Figure 8 - Hydronic

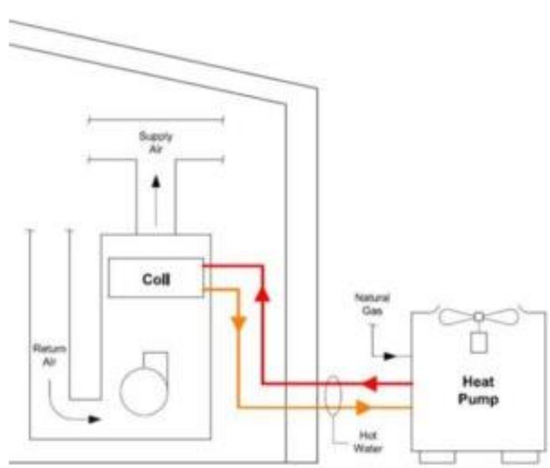

Figure 9 - Forced Air

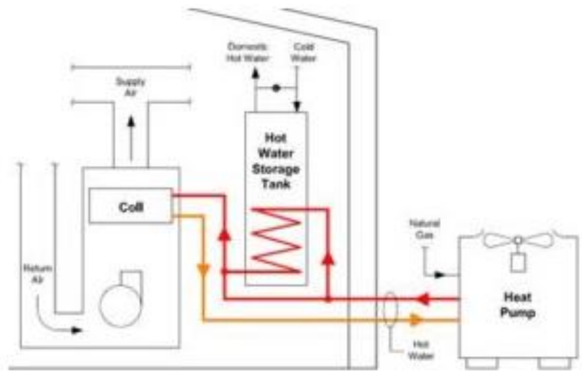

Figure 10 - Combi

pathway to low carbon fuels

"Several reduced carbon liquid fuels in the field and under development would offer an almost drop-in replacement for heating oil, overcoming the significant cost and practical issues of replacing an entire heating system, as well as, upgrading expensive energy delivery networks. There is also a well-developed and competent network of supply, installer and servicing businesses already in place who could continue to support consumers at little or no additional cost."

Dr. Thomas Butcher, Brookhaven National Laboratory

Based on a peer reviewed site energy performance and emissions study[36], Tables 1 and 2 show that moving from non-condensing appliances to condensing appliances and finally to thermal heat pump technologies significantly reduces carbon emissions. Furthermore, shifting to low carbon fuel blends dramatically reduces greenhouse gas emissions. Looking forward to the industry's 2035 implementation goal, Tables 1 and 2 show that in the case of boiler and furnace-based home heating and cooling systems, all three liquid fuels-based heating technologies coupled with three specific fuel approaches [100% biodiesel and ultra-low sulfur diesel (ULSD), biodiesel and one advanced biofuel (ethyl levulinate)] reduce carbon emissions greater than cold climate electric heat pumps using electricity from low emissions advanced CCCTs. The yellow cells indicate liquid fuel pathways to no carbon combustion. Note that the remaining carbon emissions for liquid fuels pathways in the last two columns are from the electric grid (marginal CCCT production) for cooling and ancillary equipment. Zero net carbon is from combustion.

	2018	2025	2030	2035		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
Standard Boiler, 14 SEER Minisplit AC	0%	14%	29%	71%	95%	95%
Condensing Boiler, 14 SEER Minisplit AC	14%	26%	39%	74%	95%	95%
Heating only LF-AHP and 14 SEER Minisplit	35%	43%	54%	78%	93%	93%
14 SEER Minisplit Heat Pump with Boiler Back-up	25%	34%	46%	70%	85%	85%
18 SEER 5 RT Cold Climate Heat pump with Boiler Backup	57%	59%	64%	66%	69%	69%

Table 9 - Percent Reduction in CO_{2e} Annual Emissions from Heating and Cooling a Single-Family Home (Hydronic-Cold Air)

	2018	**2025**	**2030**	**2035**		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
Non-Condensing Furnace, 14 SEER Central AC	0%	14%	28%	72%	83%	87%
Condensing Furnace, 14 SEER Central AC	14%	26%	38%	75%	84%	88%
Heating only LF-AHP and 14 SEER Central AC	38%	47%	55%	81%	87%	89%
14 SEER Electric Heat Pump with Resistance Back-up	28%	28%	28%	41%	28%	28%
18 SEER 5 RT Cold Climate Heat pump with Resistance Backup	58%	58%	58%	66%	58%	58%

Table 10 - Percent Reduction in CO_{2e} Annual Emissions from Heating and Cooling a Single-Family Home (Hot-Cold Air)

Liquid fuels-based heating technologies (boilers, furnaces and thermal heat pumps) coupled with three already identified fuel approaches in the field and under development today reduce carbon emissions greater than cold climate electric heat pumps using a future grid projected electricity from low emissions advanced combined cycle combustion turbines.

[36] "Energy, Cost and CO2e Analyses of Reversible, Hybrid and Heating- Only LF-AHP in the Northeast", Christopher Keinath, PhD, Thomas Butcher, PhD and Michael Garrabrant, PE, ASHRAE, June 2018

futurefuel

Richard Sweetser
NORA Sr. Advisor on Research

NORA Board of Director's Meeting

September 24, 2018

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understanding the viability of advanced biofuels and combustion technologies to deliver zero net carbon combustion in the future

and

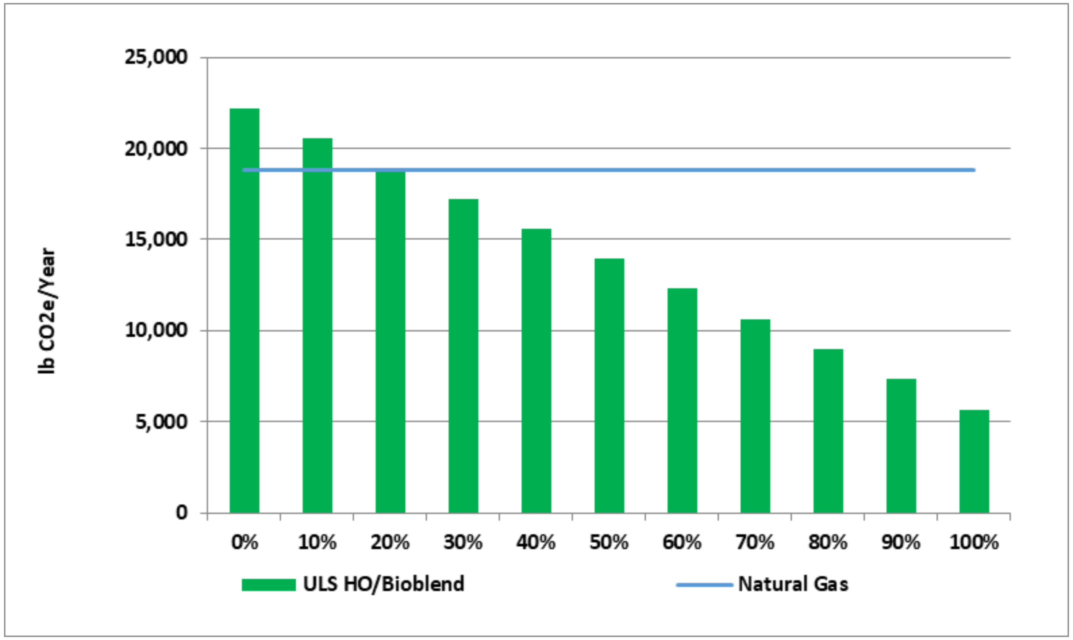
examining advanced biofuels as an alternative to electric heat pumps and other fossil fuel combustion in tomorrow's homes

Recent Fuel-Switching Studies

	Does not evaluate biodiesel	Does not evaluate advanced biofuels	Does not evaluate thermal liquid-fueled heat pumps	Does not cost grid upgrades required for 80% renewables	Does not evaluate low ambient comfort
ACEEE’s July 2018 report	●	●	●	●	●
RMI’s - The Economics of Electrifying Buildings	●	●	●	●	●
nationalgrid’s 80 x50 Pathway brochure	●	●	●	●	●

Comparing Liquid Biofuels with Natural Gas

For Boston, the GHG emissions of a typical replacement residential oil boiler using a B20 blend are equivalent to the emissions from a typical replacement natural gas boiler based on 100-year atmospheric lifetime calculations without considering induced land use change impacts. Blends up to B100 have been used in the field today, with B20 blend being quite typical.



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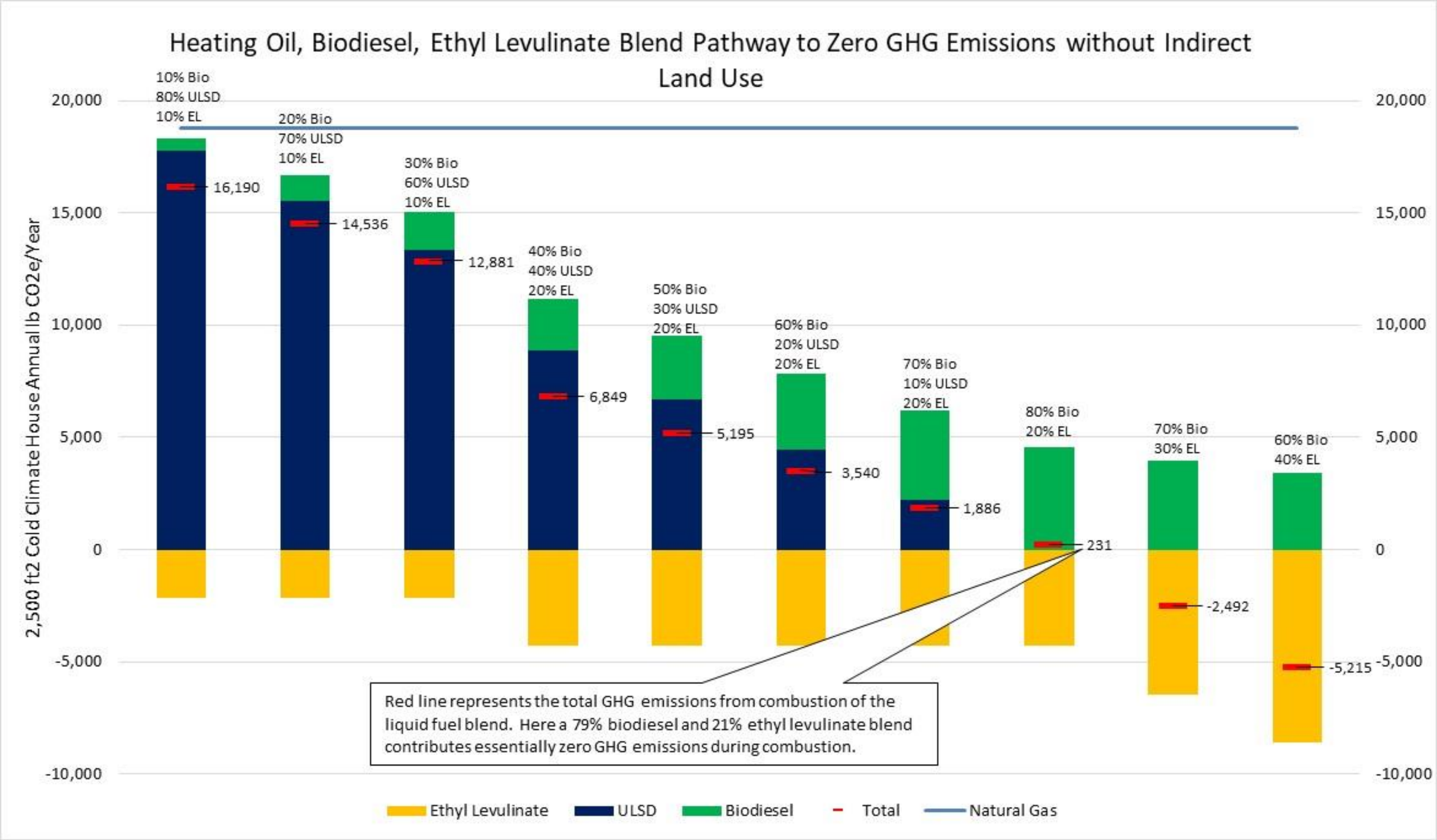
Comparing Liquid Biofuels with Natural Gas



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Beneficial Electrification

Meaning: Eventually all energy is delivered by a renewably supplied (solar, wind, hydro and batteries) electric grid.

Favored by the environmental community: which advocates no more development of fossil fuel infrastructure and fuel switching.

However, policy-driven electrification would increase the average residential household cost – largely because intermittent renewables and batteries would substantially increase the electric infrastructure. A vastly oversized grid and a dramatic increase in production will be necessary to ensure that the electric operating system does not collapse during a sustained freeze when demand is high and heat pump efficiency is low or fails to provide heat.

Decarbonized Power Systems

Decarbonized power systems dominated by variable renewables such as wind and solar energy are physically larger, requiring much greater total installed capacity.

a. A scenario for decarbonizing the European power system by 2050 - total installed capacity in this scenario is <u>4.2-times larger</u> than the peak demand.

b. 100% renewable electricity scenario for Australia features total capacity roughly <u>3-times</u> the peak demand in the system.

c. Another study concludes that total installed capacity is <u>3.5 to 5.5 times larger</u> for wind and solar-dominated power systems than more balanced systems.

d. Total U.S. generating capacity is projected to be roughly <u>2-times</u> today's installed capacity in a set of <u>80% renewable electricity scenarios</u>.

Greater required installed capacity and the lower energy-density of wind and solar resources also significantly increase the land use consequences of power systems dominated by variable renewable resources.

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Cost of Policy-Driven Electrification

Policy-driven electrification would increase the average residential household energy-related costs (amortized appliance and electric system upgrade costs and utility bill payments) of affected households by between $750 and $910 per year, or about 38 percent to 46 percent.

Widespread residential electrification will lead to increases in peak electric demand and could shift the U.S. electric grid from summer peaking to winter peaking in every region of the country, resulting in the need for new investments in the electric grid including generation capacity, transmission capacity, and distribution capacity.

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Cost Impacts from Electrification Policies

Power Generation Costs: The capital cost of new electric generating capacity needed to supply the increased electricity demand.

Transmission Costs: The cost of new electric transmission infrastructure required to serve the increased load and generation.

The latter two costs are often neglected by most studies that promote the concept of beneficial electrification. The reason generally stated is that electric heat pump high efficiency and future energy efficiency programs will essentially reduce electric demand. Note the cost of these future energy efficiency programs is never calculated. Therefore, additional electric capacity (generation, transmission and distribution capacity) "fuel-switching" for a fossil fuel to electricity must be added.

Thermal Heat Pump (THP)

Thermal Heat Pumps: an exciting new technology, in late stage development, is the air-sourced thermally-driven heat pump. This technology would, in today's world, deliver heating at a source coefficient of performance (COP) of about 1.3. Thermal heat pumps, when fully developed can be integrated with existing and new home furnaces and boilers. And their coefficient of performance and delivered air temperature would not drop precipitously during cold weather like electric heat pumps.

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Economic Comparison THP v CCEHP

Baseline Heating / Cooling System	Radiator Based Boiler, 14 SEER Minisplit AC			Forced Air System with Condensing Furnace, 14 SEER Central AC			
Replacement Technology	Hybrid THP/14 SEER AC	Heating only THP and 14 SEER AC	18SEER- 12 HSPF CCEHP with Boiler backup	Hybrid THP/14 SEER AC	Heating only THP and 14 SEER AC	18SEER- 12 HSPF CCEHP with Furnace backup	18SEER- 12 HSPF CCEHP with Resistance backup
Location	**Payback Period, Years**						
Portland, ME	0.8	3.6	8.6	4.7	4.8	9.5	5
Hartford, CT	0.7	3.4	9.8	4.3	4.4	12	7.6
NYC, NY	0.9	3.9	Never	5	5.1	Never[15]	Never[15]
Albany, NY	0.6	2.9	7.8	3.8	3.8	9.3	5.2
Concord, NH	0.7	3.3	14	4.2	4.3	20.9	Never[15]
Burlington, VT	0.6	3	15.5	3.9	3.9	Never[15]	Never[15]
Worcester, MA	0.7	3.2	10	4.1	4.1	13	7.3
Location	**15 Year Total Cost, USD**						
Portland, ME	$33,625	$35,575	$36,728	$31,250	$31,300	$31,833	$28,876
Hartford, CT	$36,889	$38,839	$42,729	$34,435	$34,485	$38,063	$36,433
NYC, NY	$37,240	$39,190	$49,964	$35,061	$35,111	$45,703	$42,441
Albany, NY	$39,081	$41,031	$43,119	$36,444	$36,494	$38,444	$36,231
Concord, NH	$39,365	$41,315	$49,640	$36,710	$36,760	$44,585	$46,941
Burlington, VT	$43,153	$45,103	$55,576	$40,244	$40,294	$50,106	$56,924
Worcester, MA	$37,405	$39,355	$44,226	$34,913	$34,963	$39,809	$37,087

Source: "Energy, Cost and CO2e Savings Analyses of Reversible, Hybrid and Heating-Only Liquid Fuel Fired Absorption Heat Pumps in the Northeastern United States", ASHRAE Summer Meeting, Christopher Keinath, PhD, Thomas Butcher, PhD, Michael Garrabrant, PE, June 2018

Residential Energy Supply and Usage Trajectories Impact Attributes

	efficiency[1]	economic impact[2]	environmental impact	heating comfort
Natural Gas	●	●	●	●
Electricity	●	●	●	●
ULSD[3]	●	●	●	●
B100	●	●	●	●
Tri-Mix[4]	●	●	●	●

[1] Electric heat-pump source-based COP of 1.09, thermal heat pump source-based COP of 1.3

[2] Economic impact refers to the cost of transitioning from a home with one energy source to another e.g. from liquid-fueled furnace to electric heat pump including any infrastructure costs to support the transition e.g. transmission and distribution capacity upgrades or battery storage for internment renewable power sources.

[3] ULSD - < 15 ppm sulfur diesel

[4] 1/3 ULSD, 1/3 B100 and 1/3 Ethyl Levulinate

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Pathway to Low Carbon Fuels

The yellow cells indicate liquid fuel pathways to no carbon combustion.

	2018	2025	2030	2035		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
Standard Boiler, 14 SEER Minisplit AC	0%	14%	29%	71%	95%	95%
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Percent Reduction in CO_2e Annual Emissions from Heating and Cooling a Single-Family Home (Hydronic-Cold Air)

	2018	**2025**	**2030**	**2035**		
	ULSD	B20	B40	B100	ULSD40, B50 & EL10	1/3 ULSD, 1/3 B100 & 1/3 EL
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Percent Reduction in CO_2e Annual Emissions from Heating and Cooling a Single-Family Home (Hot-Cold Air)

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Our View

The capability of the oil heating industry to innovate and meet state's decarbonization agenda has not been adequately recognized. It is not furnaces or boilers that produce carbon emissions, it's the fuel they run on. Therefore, it is premature for policy makers to consider regulating against oil heating when all liquid fuel furnaces and boilers could be run on a low carbon alternative fuel <u>before</u> 2035."

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Communications & Education

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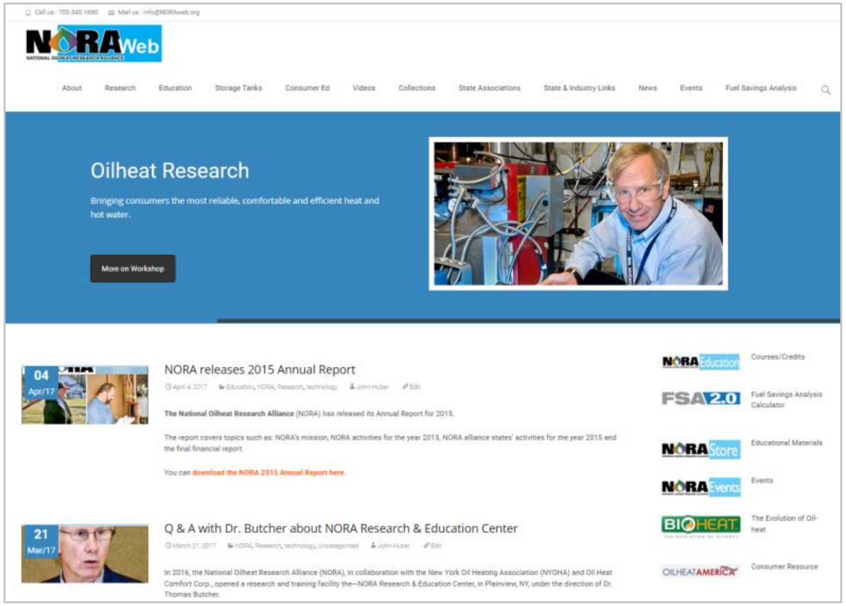

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Press Releases (past 12 Months)

1.5 per month (avg.) exceeds goal of 1 per month

- Each release sent to 4,500 recipients (average)
- 30% open rate – high
- Seen more that 17,00 times
- Include:
    - Technical bulletins and reports
    - Interviews
    - Education updates
    - Surveys
    - News

Example: FSA 2.1, Tech Workshop, Annual Report, NORA Classes at EEE

NORA NEWS
NATIONAL OILHEAT RESEARCH ALLIANCE

For Immediate Release
April 18, 2018
Contact: DFarrell@NORAweb.org

NORA Education at the Eastern Energy Expo

The National Oilheat Research Alliance is offering multiple opportunities to earn Gold, Silver and Bronze certification continuing education credits (CEUs) at this year's Eastern Energy Expo.

The Expo, to be held at the Foxwoods Casino Resort, Mashantucket, CT, May 20-23, offers a wide array of technical education classes, including more than 20 offering NORA CEUs. Additionally, three NORA Gold courses will be presented: *Advanced Steam*, *Advanced Controls* and *Advanced Venting*.

Courses carry from one to six CEUs each.

The NORA certification course requires 20 CEUs to upgrade from Bronze to Silver and 24 CEUs to keep Silver and Gold current.

The classes are included in the Eastern Energy Expo's *Full Conference Registration* package as well as the *Technical Track Only* registrations.

In addition to the CEU courses, NORA will be presenting two additional programs, *What's new with NORA Education, Training & New Technology* and *Oilheat-Bioheat-Future/How do We Move Forward.*

A NORA Board of Directors meeting will held on Tuesday, May 22 at noon.

Registration for EEE and the NORA courses is at www.EasternEnergyExpo.com

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NORA Board Meeting
2018 Education Report

NATIONAL OILHEAT RESEARCH ALLIANCE Education

Online CEU Classes

- Working with manufacturer's to add classes to the library.

Online Testing

- Vast majority of current SCHOOL tests.

- Computer labs @ school.

- Keeps them honest.

- Faster, simpler grading.

NORA Education
NATIONAL OILHEAT RESEARCH ALLIANCE

Online Testing

- Also available for areas where classes and proctors are unavailable.
- Offered on a case by case basis.

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Bronze Program

Revising program?? to:

- Make test more appropriate for entry level.
- Discontinue automatic move up to Silver.
- Expand the number of opportunities – additional schools and company sponsored programs.

NORA NATIONAL OILHEAT RESEARCH ALLIANCE Education

Gold Program

NORA Education
NATIONAL OILHEAT RESEARCH ALLIANCE

Gold Program

- Taught by Bob O'Brien and Rich Simons. @ EEE.
- Modifications 95% complete.

- Taught by Rich Michael @ EEE.
- Modifications complete.

Gold Program

Going forward:

- Need help from associations to increase scheduling.
- OESP involved.
- Recognize alternatives – steam, hydronics, airflow, tank, efficiency and venting.
- Expand topics – Combustion…..

NORA Education
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Gold Program

Scheduling "Train the Trainer" programs in steam, airflow and tanks to help make the classes more accessible.

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NORA Education

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Education portal

- Upgraded user experience
- Upgraded administrative experience
- Upgraded speed
- Improved accuracy of records
- Automated tracking and renewal of certifications
- Continued Source for education materials
- June 2018 launch

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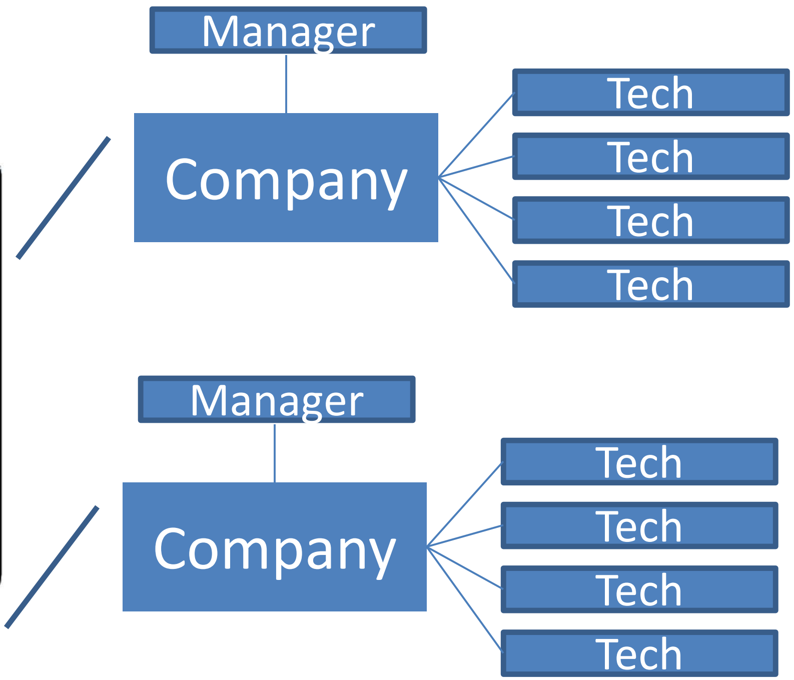
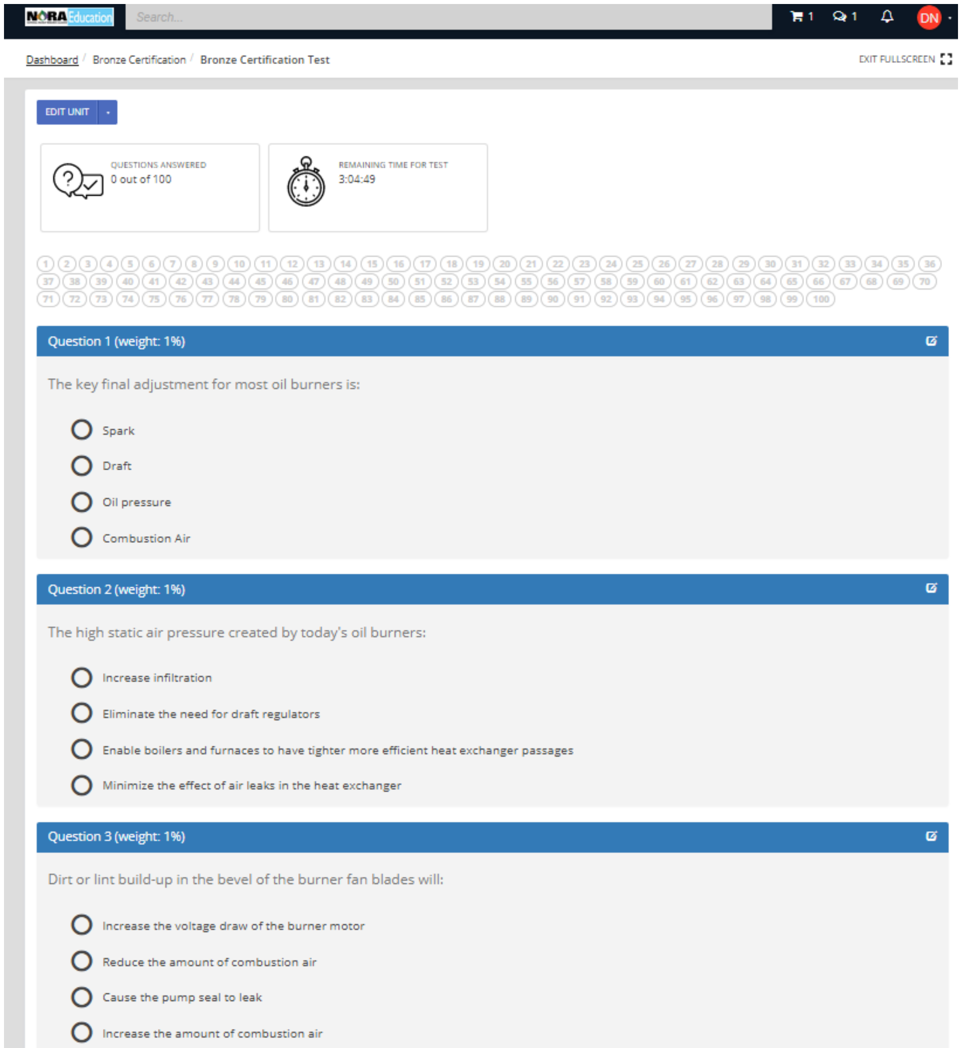


NORA member companies can track employee technicians' certifications and ongoing education.



Learning.NORAweb.org

- Online certification testing for Silver and Bronze.
- Transitioning schools from paper to online testing
- 140 online Bronze tests administered since June
- Instant results & certification

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NORA Communications

Regular Series of educational content “e-newsletters”

Geared for technical personnel

- Include service tips/help/updates
- Include NORA educational opportunities
- Include research updates

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Chairman	- Charlie Uglietto
First Vice-Chairman	- Peter Aziz
Second Vice-Chairman	- Kate Childs
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President	- John Huber

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John McCusker	Global
Ted Noonan	Noonan Energy
Tom Santa	Santa Energy
Steve Clark	Genessee Fuel
Peter Aziz	BantamWesson Fuels
Allison Heaney	Energy Conservation Group
Charles Uglietto	Cubby Oil
Michael Estes	Estes Oil Burner Service
Steve McCracken	Victory Fuels
Kate Childs	Tuxis-Ohrs Fuel
Matt Meehan	Mirabito Fuels
Matt Cota	Vermont Fuel Dealers Association