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Summary

Transportation - Measurement and Modeling of Energy Use and Emissions; Energy and Environment Consulting; Technology and Business Development; Onroad and Nonroad/Offroad Vehicles; Alternative Fuels and Electric Vehicles; Air Pollution and Air Quality; Data Analysis and Quality Assurance Methods; U.S. EPA's MOVES model; Computer-Based Data Acquisition and Measurement Systems; LabVIEW Programming.

Education

2015 - Ph.D. in Civil Engineering, North Carolina State University (NCSU), USA

Dissertation ([Link](#)): *Evaluation of Activity, Fuel Use, and Emissions of Heavy-Duty Diesel and Compressed Natural Gas Vehicles*. Advisor: Dr. H. Christopher Frey, Glenn E. Futrell Distinguished University Professor

2011 - M.S. in Environmental Engineering, NCSU, USA

Thesis ([Link](#)): *Methods for Quality Assurance of Portable Emissions Measurement System Data and Methods for Field Comparison of Alternative Fuels*. Advisor: Dr. H. Christopher Frey

2001 - B.E. in Instrumentation Engineering, S. L. Institute of Engineering and Technology, India

Professional Experience

2015-Present: Fellow, ORISE Research Program, *National Vehicle and Fuel Emissions Laboratory (NVFEL)*, *United States Environmental Protection Agency (U.S. EPA)*

2008-2014: Graduate Research Assistant, *NCSU, USA*

2001-2008: Various Positions, *Quantum Age Tech Solutions Pvt. Ltd. (QATSPL), India*

2005-2008: General Manager, Engineering Solutions

2003-2005: Assistant General Manager, Engineering Solutions

2001-2003: Systems Engineer

Professional Voluntary Service

Chair: On- & Off-Road Mobile Sources Technical Coordinating Committee of the A&WMA. Vice-Chair for the same committee for 2015-2017.

Journal Reviewer: (1) Atmospheric Environment; (2) Transportation Research Part D: Transport and Environment; (3) Journal of the A&WMA; (4) Transportation Research Record, Journal of the Transportation Research Board (TRB) of the National Academies; (5) Resources, Conservation & Recycling; (6) SAE Technical Papers; (7) Journal of Infrastructure Systems; (8) International Journal of Sustainable Transportation

Member: (1) Emissions Measurement & Testing Committee (EMTC) of the Truck & Engine Manufacturers Association (EMA); (2) TRB; (3) A&WMA; (4) Society of Automotive Engineers (SAE); (5) American Society of Mechanical Engineers (ASME); (6) American Society for Testing and Materials (ASTM)

Highlights – U.S. EPA (2015–Present)

Related to the MOTO Vehicle Emission Simulator (MOVES, [link](#)) model, MOVES_CTL_NPRM version. The rates updates cover running exhaust CO₂, THC, CO, NO_x, and PM_{2.5} for MY 2010–2060, unless noted otherwise.

- Late MY diesel heavy-duty vehicles (HDVs) – improved energy and emissions rates for MY 2016–2060; added 2 million seconds of the latest heavy-duty in-use testing (HDIUT) data from 74 HDVs to the previous dataset; proposed for inclusion in *MOVES3*, the next public release version of the model
- Effect of intake humidity on NO_x emissions – updated the equations and coefficients for all fuel and vehicle types and all model years; Proposed for inclusion in *MOVES3*
- Diesel HDVs rates update – based on 8 million seconds of quality-assured HDIUT data from 291 vehicles; previous rates based on pre-DPF and pre-SCR vehicles; led to large increase in running exhaust NO_x inventory; critical to establishing benefits from a rulemaking to reduce NO_x emissions from HDVs
- Gasoline HDVs rates update – analyzed current gasoline technology real-world in-use data; previous rates based on pre-2000 gasoline vehicles
- Natural Gas(NG) HDVs rates update – analyzed current NG technology real-world in-use data; previous rates based on early 2000 model-year gasoline and NG vehicles
- Glider HDVs – conducted analysis to establish that MY 2000 diesel HDV emission rates are representative of new glider vehicles
- Revised the fixed mass factor (f_{scale}) for all MY 2010–2060 HDVs – fundamental change in the MOVES model that improved its ability to distinguish between low-/medium-/high-load operation
- CH₄/THC ratio for MY 2010–2060 diesel HDVs – updated based on literature review; significant effect on pollutants, such as formaldehyde, chained to non-methane HCs

Assessment of HDV emissions regulation and technology; Cleaner Trucks Initiative (CTI, [link](#))

- Evaluated real-world emissions reduction from HD 2007/2010 standard and technologies such as SCR; led briefing to present findings to the Office Director of the Office of Transportation & Air Quality; analysis used in CTI's Regulatory Impact Analysis of the Notice of Proposed Rulemaking (NPRM)
- Led the development of the What-If Analysis Inventory Tool (WAIT) – takes user-defined HD gasoline, diesel, and CNG base emission rates, and useful life and warranty standards to produce national emissions inventory; significant time and effort savings compared to running the MOVES model; trained the CTI team on using WAIT to develop control cases for the NPRM
- Developed estimates of emissions contribution from tampering & mal-maintenance and vehicle operation under idle, low-/medium-/high-load for baseline and control options; graphics used in the briefing to the EPA Administrator to select control options for the NPRM
- Contributed to various rulemaking discussions and analysis related to certification standards, compliance methods, in-use testing, generation/use of credits, on-board diagnostics, benefit-cost, and air quality modeling

Highlights – Graduate Research (2008–2014)

- Developed PEMS Quality Assurance Software (PQAS) – GUI-based platform used at Dr. Chris Frey's vehicle emissions laboratory at NCSU since 2010; features include data quality-assurance, time alignment, road-grade estimation, exhaust flow rate calculations, and generation of modal emissions rates. See Appendix F of Ph.D. dissertation for screenshots of the software.
- Unofficial lab technician – maintained portable emissions measurement system (PEMS) equipment and trained over a dozen colleagues on PEMS-based measurement and data analysis.
- Conducted over 500 hours of portable emissions measurement system (PEMS) based real-world in-use data collection covering a variety of vehicles, fuels, and duty cycles:

Solo

- Refuse trucks – 24 vehicles (18 diesels from MYs 2003-2012 having EGR, DOC, DPF, or SCR and 6 CNG from MY 2012-2013 with TWC); largest study on refuse trucks to date
- Combination Long-haul trucks – five vehicles, MY 1999–2010, with EGR, DOC, DPF, SCR, using ULSD (baseline) and B20 with/without fuel additive
- Earthmoving equipment – three wheel-loaders, MY 2007–2008, using ULSD, B20, B35

Major contribution

- Over-snow vehicles – five snow-coaches (two MY 2011 diesel with DPF and SCR, three gasoline from MYs 2002, 2008, and 2011) and three snow-mobiles (gasoline MY 2008-2012) at Yellowstone National Park

Significant contribution

- Light-duty vehicles – eight student-owned passenger vehicles, MY 1998-2008; part of a larger campaign conducted over many years

Minor contribution

- PHEV – energy use (charge sustaining/depleting) and emissions from a MY 2013 plug-in hybrid Toyota Prius; developed software for operating mode transition matrix
- Locomotives – engine dynamometer measurements; developed software for notch-based modal analysis; assisted with PEMS installation and maintenance during over-the-rail tests.

Highlights – Private Industry (2001–2008)

2005 to 2008: **General Manager, Engineering Solutions, QATSPL, India**

Responsibilities: Technology development and management, project supervision, customer feedback and relationship management, and business development.

- Led a team that developed the pre-processor and post-processor for Tire Noise Simulation Software. Implemented high-speed parsing and packaging of multi-million-point arrays. Software allows tire noise estimates at the design stage, thereby significantly cutting prototyping cost, meet noise regulations, and provide competitive advantage by reducing design cycle duration.
- Led a team that developed software to implement Design of Experiments (DOE) based waveform analysis approach for locating defects in tire building process by using data from tire uniformity machine.
- Supervised design and development of software for gear “health” monitoring system for detection, identification and quantification of gear defects such as eccentricity, misalignment, backlash, broken tooth, and imbalance. This product won an award at the National Instruments India annual user conference in 2005.
- Conducted Failure Mode and Effects Analysis (FMEA) studies, for a pharmaceutical company, which involved a diverse group of stakeholders such as design, quality, production, finance, and marketing.
- Expanded business in overseas markets, specifically, sold the tire noise simulation software and coordinated software supply and technical support for a tire manufacturer in Malaysia.
- Negotiated exclusive India representation for bolted joint analysis software from a Lancashire, UK based company.

2003 to 2005: **Assistant General Manager, Engineering Solutions, QATSPL, India**

Responsibilities: Manage project requirements including review of system specifications with customers, estimating project timelines and costs, technical development, and project delivery.

- Led a team in the development of Tire Extruded Rubber Offline Profilometer. Specs: PXI (PCI eXtensions for Instrumentation) bus architecture, dual laser non-contact measurement, real-time SQL Server data storage, 25-micron accuracy along gauge, and 10-micron accuracy along length. The product helped improve accuracy of extrusion die, reduce rubber waste, and reduce tire rejection at tire building stage. Product was delivered at 50% cost of similar imported system and achieved a return on investment in six months.
- Formulated a software coding model that improved hardware resource utilization, lean and efficient programming, and maintainable project structures.
- Established practices to bring fresh software development recruits to full productivity on live projects.
- Negotiated India representation for contact pressure imaging systems from a leading technology company based in Alberta, Canada.

2001 to 2003: **Systems Engineer, QATSPL, India**

Responsibilities: Development of customized analog and digital data acquisition systems for PC based control.

- Implemented real-time data encapsulation and data storage schemes for high speed and long duration computer-controlled data acquisition systems.
- Designed and developed an automotive clutch Bearing Endurance Testing System. Integrated a third-party test rig with off-the-shelf electronics and custom software code. Post-processing of measurement data and statistical analysis helped the customer find out design robustness and identify causes of typical failure modes.
- Designed and developed a race dimensional measurement system for bearings. Recycled sensors and power supply from the existing manual measurement setup. Implemented software-based noise filtering routines to handle high sensitivity and micron level precision measurements. The system allowed the user to archive full test data and perform statistical analysis. Achieved over 25% reduction in the testing time over existing system.
- Established a business channel with a noise and vibration control company based in Illinois, USA to assist a leading research organization in India get dynamic material property characterization of their composite materials as per SAE J-1637 (Oberst Bar) standard.

Skills – Software and Hardware

- LabVIEW for data analysis and data acquisition, including Advanced Signal Processing, Report Generation, Database Connectivity, and Noise & Vibration Toolkits
- Machine controlled data acquisition on PXI, PCI, Serial, USB, and wireless platforms
- Operation, calibration, and maintenance of portable emissions measurement systems (PEMS)
- Advanced literature search & review skills; Zotero for citation and bibliography management
- ArcGIS 10.1 – Analysis of geospatial information

Patents

1. Miller, D. W.; Hynd, W. J.; **Sandhu, G. S.**; Burnette, A. D.; Ropkins, Karl. *Particulate Matter/Number Synchronization Measurement Device*. U.S. Patent No. US 10,190,945, issued January 29, 2019. [Link](#).
2. Ropkins, K.; Miller, D. W.; Hynd, J. W.; Miller, J.; Pfister, C.; Burnette, A. D.; **Sandhu, G. S.** *Particulate Calibration and Generation Simulator for Particle Measurement and Number*. U.S. Provisional Patent, Application No. 15/748,797, PCT/US2016/045018, filed August 1, 2016. [Link](#).

Publications

Refereed Journal Papers

1. (*Under Review at Science of the Total Environment*) **Sandhu, G. S.**; Frey, H. C.; Bartelt-Hunt, S.; and Jones, E. Real-world Activity, Fuel Use, and Emissions of Heavy-Duty Compressed Natural Gas Refuse Trucks. Submitted January 31, 2020.
2. **Sandhu, G. S.**; Frey, H. C.; Bartelt-Hunt, S.; and Jones, E. Real-World Activity, Fuel Use, and Emissions of Diesel Side-Loader Refuse Trucks. *Atmospheric Environment*, 129: 98–104, 2016. [Link](#).
3. **Sandhu, G. S.**; Frey, H. C.; Bartelt-Hunt, S.; and Jones, E. In-Use Activity, Fuel Use, and Emissions of Heavy-Duty Diesel Roll-off Refuse Trucks. *Journal of the Air & Waste Management Association*, 65 (3): 306–323, 2015. [Link](#).
4. **Sandhu, G. S.**; Frey, H. C.; Bartelt-Hunt, S.; Jones, E. In-Use Measurement of the Activity, Fuel Use, and Emissions of Front-Loader Refuse Trucks. *Atmospheric Environment*, 92: 557–565, 2014. [Link](#).
5. Hu, J.; Frey, H. C.; **Sandhu, G. S.**; Graver, B. M.; Bishop, G. A.; Schuchmann, B. G.; Ray, J. D. Method for Modeling Driving Cycles, Fuel Use, and Emissions for Over Snow Vehicles. *Environmental Science & Technology*, 48 (14): 8258–8265, 2014. [Link](#).
6. **Sandhu, G.S.**; Frey H.C. Effects of Errors on Vehicle Emission Rates from Portable Emissions Measurement Systems. *Transportation Research Record: Journal of the Transportation Research Board of the National Academies*, 2340: 10-19, 2013. [Link](#).

7. Boroujeni, B.Y.; Frey, H.C.; **Sandhu, G.S.** Road Grade Measurement Using In-Vehicle, Stand-Alone GPS with Barometric Altimeter. *Journal of Transportation Engineering of the American Society of Civil Engineers*, 139 (6): 605–611, 2013. [Link](#).
8. **Sandhu, G.S.**; Frey H.C. Real-World Measurement and Evaluation of Duty Cycles, Fuels, and Emission Control Technologies of Heavy-Duty Trucks. *Transportation Research Record: Journal of the Transportation Research Board of the National Academies*, 2270: 180-187, 2012. [Link](#).

Select Presentations

1. **Sandhu, G. S.**; Sonntag, D. *Updates to MOVES Heavy Duty Running Exhaust Rates: Diesel, Gasoline, and Natural Gas*. MOVES Review Work Group, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Ann Arbor, Michigan, April 2019. [Link](#).
2. **Sandhu, G. S.**; Sonntag, D. B.; Sanchez, J. *Identifying Areas of High NO_x Operation in Heavy-Duty Vehicles*. 28th Annual Real World Emissions Workshop of the Coordinating Research Council, Garden Grove, California, March 2018. [Link](#).
3. **Sandhu, G. S.**; Sonntag, D. *Recommended Updates to MY 2010+ Heavy-Duty Vehicles - Fixed Mass Factor and Diesel Particulate Matter Rates*. MOVES Review Work Group, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Ann Arbor, Michigan, December 2017. [Link](#).
4. **Sandhu, G. S.**; Sonntag, D. B.; Sanchez, J. *In-Use Emission Rates for MY 2010+ Heavy-Duty Diesel Vehicles*. 27th Annual Real World Emissions Workshop of the Coordinating Research Council, Long Beach, California, March 2017. [Link](#).
5. **Sandhu, G. S.**; Sonntag, D. *Update to Running Exhaust Criteria Pollutant Emission Rates for Model Year 2010+ Heavy-Duty Diesel Vehicles*. MOVES Review Work Group, Office of Transportation and Air Quality, U.S. Environmental Protection Agency, Ann Arbor, Michigan, December 2016. [Link](#).
6. **Sandhu, G. S.**; Sonntag, D. B.; Hamady, F. *Effect of Driving Conditions on NO_x Emissions from 2010+ Heavy-Duty Vehicles*. 26th Annual Real World Emissions Workshop of the Coordinating Research Council, Newport Beach, California, March 2016. [Link](#).
7. Ropkins, K.; **Sandhu, G. S.**; Burnette, A. D. 2015. A Novel Multiplexed Sensor-Based Approach to Mobile Particle Mass and Number Measurement. 25th Annual Real World Emissions Workshop of the Coordinating Research Council, Long Beach, California, March 2015.
8. **Sandhu, G. S.**; Frey, H. C.; Bartelt-Hunt, S.; Jones, E. *Real-World Activity and Fuel Use of Diesel and CNG Refuse Trucks*. PEMS International Conference and Workshop, CE-CERT, University of California-Riverside, April 2014.
9. **Sandhu, G. S.**; Frey, H. C. *Energy Use and Emissions from Diesel and Biodiesel Blends for Earthmoving Equipment*. 106th Annual Conference & Exhibition of the Air & Waste Management Association, Chicago, Illinois, June 2013.
10. Frey, H.C.; **Sandhu, G.S.**; Sun, Y.; Lee, T.; Swidan, H.; Liu, B.; Babae, S. *Incorporating Vehicle Portable Emissions Measurement Systems into the Classroom*. 104th Annual Conference & Exhibition of the Air & Waste Management Association, Orlando, Florida, June 2011.

Select Technical Reports

1. Ray, J.D.; Bishop, G.; Schuchmann, B.G.; Frey, C.; **Sandhu, G.**; Graver, B. *Yellowstone Over-snow Vehicle Emission Tests – 2012: Summary Vehicle Data and Fleet Estimates for Modeling*. Natural Resource Technical Report NPS/NRSS/ARD/NRTR—2013/661; National Park Service, U.S. Department of the Interior in Denver, Colorado, January 2013. [Link](#).
2. Frey, H.C.; **Sandhu G.S.** *Comparison of Energy Use and Emissions for Three Wheel-Loaders Operated on Ultra Low Sulfur Diesel, B20 Biodiesel, and B35 Biodiesel*. Prepared by North Carolina State University for Greener by Design in New Brunswick, New Jersey, September 2012.
3. Frey, H.C.; **Sandhu, G.S.**; Graver, B.M.; Hu, J. *Measurement of Fuel Use and Emissions of Over-Snow Vehicles at Yellowstone National Park*. Prepared by North Carolina State University for Louis Berger Group in Denver, Colorado, September 2012.
4. Frey, H.C.; **Sandhu, G.S.** *Comparison of Fuel Use and Emissions of B-20 Fueled Combination Trucks with versus without a Fuel Additive*. Prepared by North Carolina State University for Hydrotex Partners Inc. in Farmers Branch, Texas, October 2011.