

APEESD 2012

**2012 Asian Pacific Conference on
Energy, Environment and Sustainable Development**

Abstract

November 12-13, 2012, Kuala Lumpur, Malaysia

An abstract graphic at the bottom of the page consists of several overlapping, flowing blue waves. The waves are rendered with a soft, ethereal quality, featuring gradients of light and dark blue. They appear to be moving from the bottom left towards the right, creating a sense of dynamic energy and fluidity. The overall effect is clean and modern, complementing the conference's focus on sustainable development.

Table of Contents

Utilization of Steelmaking and Hot-Rolling Mill Waste <i>Lian Chen</i>	1
Optimization Research of the Comprehensive Coke Rate of Blast Furnace Based on the Operational Characteristic of Auxiliary Materials <i>Hua Zhang, Zhaohui Feng, Yanhong Wang</i>	1
Health Risk Assessment of Polycyclic Aromatic Hydrocarbons (PAHS) in the Pearl River Delta <i>Hui Zhang, Jiajia Zhao, Aimin Song, Mingwei Song</i>	1
Research on Application Mechanism of Vanadium Extraction Tailings by Cleaner Production <i>Wang Jian, Chen Lian, Jiang Long-kui, Yi Liang-gang, Huang sheng quan, Zhang Yong-Jun</i>	1
The Economic Comparisons and Introduction to China of the Kyoto Mechanisms <i>Sufeng Wang, Yu Bai</i>	1
Variation Characteristics of Reactive Plumes in the Process of Extinguishing Diesel Flame By Water Mist <i>Liang Wang, Shichuan Su</i>	2
Environmental Pollution and Protection of Oil & Gas Production and Utilization in China <i>Xiaolong Yang, Mingming Sun</i>	2
Heavy Metal Element Sedimentary Record Adjacent to the Pingtan Island <i>Hu Yi, Chen Jian, Xu Jiang</i>	2
The Water Pollution Control Planning Research in Lingyuan Stream Segment of Daling River <i>Jun Pan, Hongxue Li, Changhong Li</i>	2
Grid-Connected Micro-Inverter Systems Based on Mode Selector <i>Ling meng, Sha jin, Huang chen, Lv quanya</i>	3
Development and Sensitivity Analysis of Model for Aeration Chamber in Water-Circulating Aerator <i>Xin Sun, Feifei Duan, Tinglin Huang, Mengdan Zhang</i>	3
Analysis on the Water Salinity Change and Future Trends in the Bosten Lake <i>Honghua Zhou, Weihong Li, Hong Chi, Aihong Fu</i>	3
Analysis of Water Quality Change before and After the Wenchuan Earthquake <i>Feng Qian, Bo Hu, Jingjun Liu, XIONG Ming-biao, HU Heng</i>	3
Analysis of the River Flow and Sediment Concentration Change Before and After Wenchuan Earthquake <i>Feng Qian, Bo Hu, Jingjun Liu, XIONG Ming-biao, HU Heng</i>	3
1-Octadecanol/SiO₂ Hybrid Form-Stable Phase Change Materials for Thermal Energy Storage <i>Bingtao Tang, Xixi Zheng, Meige Qiu, Chao Jia, Shufen Zhang</i>	4
Debris Flow Warning System Design by Diao Zhongba on the Basis of GIS <i>Xueping Li, Yunan Li</i>	4
Metabolic Characteristic Analysis of an Oil Field Wastewater Degrading Strain Chelatococcus G5 <i>Xinyuan Liu, Can Wang, Min Ji</i>	4
Study on Recycling and Disposal of Waste Fluorescent Lamps <i>LI TianHua, XIANG DeQing</i>	4
Estimation of Biogas Production from Shrimp Pond Sediment Using the Artificial Intelligence <i>Srisertpol J, Srinakorn P, Kheawnak A, Chamniprasart K</i>	5
Resonance Rayleigh Scattering Spectral Method For Trace Fe³⁺ Using 1, 4-Dithiothreitol-Modified Nanogold As Probe <i>Guiqing Wen, Liangqin Wu, Zhiliang Jiang</i>	5
Research on Evaluation System of New Energy Vehicles Based on AHP <i>Li Su-hua</i>	5
A Comprehensive Study on Ground Source Heat Pump Applicability <i>Jiufa Chen, Long Gao, Junwei Chen, Yibo Chen, Baojiang Xu, Jian Xiong</i>	5
Hydrogen: Technologies, Policies and Challenges <i>Zhang Jun, Ji Lucheng, Jin Bo</i>	6
Mesoporous Thin Films: Thermoelectric Application <i>Min-Hee Hong, Chang-Sun Park, Yong-June Choi, Hong Sup Lee, Hyung-Ho Park</i>	6
Optimization of Economy Shift Schedule for Automated Mechanical Transmission in A Parallel Hybrid Electric Vehicle <i>Zhentong Liu, Hongwen He, Weiqing Li</i>	6
Photopatterning Based on a Chemically Amplified Mechanism Nano-Sheet Films <i>Tiesheng Li, Xiaohang He, Keke Zou, Wenjian Xu, Ynagjie Wu, Tokuji Miyashita</i>	6
Design Optimization of Ss-AlN Cermet Solar Selective Coatings <i>Xinyue Liu, Runsheng Tang</i>	7

Explore Impacts of Urban Compactness on Energy Consumption <i>Hsueh-Sheng Chang, Tzu-Ling Chen, Chi-Fei Wang</i>	7
Industrial Wastewater Reclamation for Sustainable Development – Integration of Membrane Bio-Reactor Process <i>C. H. Ni, J. C.T. Lin</i>	7
Research on the Residential Environment Construction of Healthy City <i>Dongzhou.Wang</i>	7
Stabilization of Large-Scale Wind Power Generation by Combination of Pumped Storage Generation with Archimedean Screw <i>Soichiro Uehara, Katsutoshi Nishijima, Masaki Mitobe, Ma Jinghao, Zhai Yazhou, Gon Shaoyan, and Akira Sugawara</i>	8
Determination of Airborne Quantity and Consequence Analysis of 1, 3-Butadiene Release from a Petrochemical Plant Pipeline <i>Mousa Jabbari, Sayed. M. Hossein. Sajjadi, Reza Gholamnia</i>	8
Fuzzy Controlled Energy Saving Solution for Large-Scale Belt Conveying Systems <i>PANG Yusong, LODEWIJKS Gabriel, SCHOTT Dingena</i>	8
The Role of Vernacular Architecture in Design of Green Sidewalk (Case Study: Iran, Shushtar) <i>Mohammadjavad Mahdavejad, Abdolkarim Ghaedi, Mohammadhossein Ghasempourabadi, Hojat Ghaedi</i>	8
Effects of Soil Amendment Fertilizer on Cotton Growth and Yield <i>Du Jian, Du Xuan, Li Yumei, Jian Jinshi, Du Can</i>	8
Performance Optimization of Building Integrated-Mounted Wind Turbine <i>Marco Milanese, Arturo de Risi, Domenico Laforgia</i>	9
The Influences of Industry Development on the Urban Environment in Beijing, China <i>Kaiyong Wang, Yu Deng</i>	9
Biomass Exploitation in Efficient ORC Systems <i>Pietro Paolo Morrone, Angelo Algieri</i>	9
Performance Analysis of Induction Machines with Unconventional Winding Configurations <i>Mbika Muteba, Adisa A. Jimoh, Dan V. Nicolae</i>	9
Research on Camera-Oriented Smart Car and Intelligent Control <i>Zheng Ma, Guanbo Wang</i>	10
Synthesis and Properties of the Composite DSD Acid-Triazine Structure Containing Long-Chain Quaternary Ammonium Fluorescent Brighteners <i>Mingyang WANG, Maosheng WAN, Chengbo CAO</i>	10
Evaluation of Formaldehyde Emission from Particleboard Using the Large Chamber and Desiccator Method <i>Zeli Que, Lingfei Ma, Feibin Wang, Takeshi Furuno</i>	10
The Research of Induction Motor Vector Control System Based on Fuzzy Self-Adaptive Pi Complex Control Algorithm <i>Wang Wei, Sun Xia, Li Baoyin</i>	10
The Pure Electric Vehicle Dynamic Performance Simulation <i>Zhang zhi, Guo Minrui, Zheng Pei</i>	10
Performance Analysis and Simulation of Automotive Air Conditioning Systems <i>Zhang zhi, Du Peng, Zheng Pei</i>	11
Design and Implementation of System Integration Method for Power Distribution and Consumption <i>Jianbin Ye</i>	11
Simulation on Maximum Wind Energy Capturing of DFIG <i>Haihui Song, De Tian</i>	11
Security Authentication For Smart Substation Communication Based On Iec 62351 <i>Lu Chen, Yufei Wang, Tao Zhang</i>	11
Research on Recycling Technology of Vanadium Extracting Waste <i>Longkui Jiang, Xiangfei Zou</i>	11
Finite Element Modal Analysis for Steam Turbine Blade Based on ANSYS <i>Lu Wang, Shunqiang Ye, Rui Meng</i>	12
Characterization and Identification of Inorganic Water-Soluble Ions in Pm_{2.5} <i>Wei Dai, Jiaqi Gao, Bo Wang, Feng Ouyang</i>	12
Feasibility Study on the Concentration of Miscible Liquid in Aeration Tank Used by CAF Process <i>Xiaotao GUAN, Fengping HU, Linyuan WANG</i>	12
The KSF of Led Business Development in Taiwan with E Company as Case Study <i>Ming-Lang Wang, Han-Kun Chen</i>	12
Supply Chain Contract Arrangements of Carbon Abatement with Consumer Preferences <i>Na Ma, Gaoxiang Lou</i>	12
AZO Dyes Biodegradation Based on Silicone Membrane-Aerated Bioreactor <i>Jing Wang, Hong Lu, Guangfei Liu</i>	13

Effect of Mechanical Aeration on Nitrogen and Microbial Activity in Sediment-Water Interface from Urban Lake <i>Jianjun Chen, Shaoyong Lu, Zaiyi Liao, Shichao Ai, Minsheng Huang</i>	13
Effects of Simulated Acid Rain on Soil Chemical Properties of Potting Yellow Cinnamon Soil under Quercus Variabilis <i>Xiaoqin Liang, Renqing Wang, Wenjuan Ding, Yujie Luo, Jian Liu</i>	13
The Relationship between Ecosystem Health and Ecological Safety <i>Ying Song, Ruiying Chang, Zhengda Yu, Renqing Wang, Jian Liu</i>	13
Corona Detection System on Insulators VIA Acoustic Emissions <i>Rennó Marco Antônio Martins, Bonaldi Erik Leandro, Oliveira Levy Ely Lacerda, Silva Jonas Guedes Borges, LAMBERT-TORRES Germano</i>	14
Charging and Discharging Equalization with Improved Switching Matrix for Series-Connected Battery Pack In EV <i>Yajun Rong, Chunyu Hua, Wenbin Tang</i>	14
Analysis and Evaluation of Heavy Metal Pollution of Surface Soil in Baicheng City <i>Gang Wang</i>	14
Design and Simulation of Stand-Alone Wind-Solar Hybrid Generating System <i>Gang Wang</i>	14
Experiment Study on Microwave Strengthened Fenton Process Oxidation of Organophosphorus Pesticide Wastewater <i>Ya Feng Li, Jing Xin Wang, Yan Zhang</i>	14
Variability of Soil Erosion under Different Topographical and Vegetation Conditions in Upper Min River Watershed <i>Zhiyong Liu, Xin Zhang, Ping Zhou, Dan Wei</i>	15
Indoor Air Quality Audit and Grey Incidence Analysis of An Air-Conditioned Institutional Library In The Subtropics <i>Li-ru Liu, Jun Wu, Xiao-xia Wang, Zhi-sheng Li, Tian Cheng</i>	15
Study on a Combination Drying Technique of Shrimp <i>Yaxiang Bai, Yucai Hu, Qiang Huang</i>	15
Characteristics and Causes of Air Pollution in Lanzhou, China <i>Yu-xia Ma</i>	15
Analysis and Experimentation of Multi-S Rotors for Vertical Wind Turbine Applications <i>E.M. ElBeheiry, W.A. El-Askary</i>	16
Risk Analysis of Smart Terminals in Mobile Application of Power System and the Protection Solution Design <i>ZhiPeng Shao, ShiDa Lu, Mu Chen</i>	16
Explore the Self-Governance on Nuclear Safety Emergency- A Case Study of the 3rd Nuclear Power Plant <i>Yi-Chun Lin, Yung-Nane Yang</i>	16
Physicochemical Modeling of Hypergene Mineralization Processes in the Solnechnaya Reclamation Plant Tailing Dump (Khabarovsk Region) in the Temperature Range from -5 To +45 °c <i>Alyona Kostina, PhD, Prof Valentina Zvereva, Konstantin Frolov, AntonPyatakov, Anastasia Lysenko</i>	16
The Reliability Evaluation Methods of the Wind Farm <i>Huan Wang, Lei Pan</i>	17
Resonance Rayleigh Scattering Spectral Determination of Vitamin C By Nanogold Catalysis <i>Guiqing Wen, Zhiliang Jiang</i>	17
A Design Scheme of Energy Management System for Low-Carbon Community in Smart Grid Environment <i>Shuanghu Wang, Yongyi Wu</i>	17
Analysis of Shock Effect Generated by Vehicles on Human Body under Hvac Transmission Lines <i>Ma Aiqing, Chen Lei</i>	17
Research on the Equivalent Circuit Modeling of Oil-Paper Insulation of Transformer by Analyzing the Dielectric Spectra <i>YongQing Liu, JinDing Cai, YanXue Guo</i>	17
Estimation of Effect of Technogenic Discharges on Hydrosphere in Dalnegorsk District of the Far East <i>V.P. Zvereva, L.T. Krupskaya, E.N.Salyukova</i>	18
The Carbon Emission Quantification of the Low Carbon Road Maintenance Technology in China <i>Ke Zhou, Yim Wong, Xijuan Xu, Charence Chiang, Huicong Zhang</i>	18
Research of Setting Main Circuit Parameters of Independent Photovoltaic Power System <i>Fei Zhang, Jiao Fu, Hua Jia</i>	18
The Propagation Characteristics of Partial Discharge Signals in Enclose Busbar <i>Fei Zhang, Jiao Fu</i>	18

Retention and Removal Efficiency of Riparian Wetlands on Non-Point Source Pollutants <i>Jin Xu, Ligang Xu, Lei Dong</i>	19
Stripping Photo-Resist with Rf Dielectric Barrier Atmospheric Pressure Plasma <i>Shaoxia Jia, Lingli Zhao, Jinghua Yang, Chen Zhang, Shougou Wang</i>	19
A Multiplex Data Acquisition System Applied In High Voltage Transmission Line Based on Electronic Transformers <i>Tao Song</i>	19
A Reactive Power Generator Based on Voltage Source Inverter <i>Tao Song</i>	19
The Method for Torque Distribution of In-Wheel Motor Driving Vehicle Aiming to Save Energy <i>Huanhuan Zhang, Guoping Yang</i>	20
Thermogravimetric Analysis of Different Biomass Materials and the Primary Biomass Components <i>Yabo Li, Xuning Zhang, Leiqiang Zhao, Qiang Lu, Changqing Dong</i>	20
Wind Tunnel Experimental Study of Wind Turbine Airfoil Aerodynamic Characteristics <i>Xinzi Tang, Xu Zhang, Ruitao Peng, Xiongwei Liu</i>	20
The Long-Term Dynamics in Crude Oil Prices <i>Baoming Qiao, Si Zhang, Hao Jin</i>	20
Effect of Thermal Conductivity of the Soil Cover on the Air Temperature Dynamics under Natural Conditions and at Anthropogenic Loads <i>Kholoden E.E., Morina O.M., Lobanov S.A.</i>	21
Removal of Caramel Pigment from Sauce Wastewater by Electrocoagulation Process Using Aluminum Electrodes <i>Xiaolong Li, Taotao Li, Fengqin Zhang</i>	21
The Research of Mine Environmental Quality Early Warning <i>Yunzhang RAO, Huiyue YANG</i>	21
Study on the Recycling of Waste Old Ship-Wood <i>Zhongfeng Zhang, Kai Huang, Jingshu Gao</i>	21
Analysis and Assessment of the Environment in the Area of Abandoned Coal Mines in Primorsky Region <i>Derbentseva Alla, Krupskaya Ludmila, Arefieva Olga, Nazarkina Alina, Orlov Alexey, Morin Vitaly, Volobueve Nadezhda</i>	21
Sustainability through Optimization: The Future of Watershed Management <i>Thambirajah Saravanapavan, Guoshun Zhang, Mark Voorhees</i>	22
Study on Risk Analysis and Control of Oil Tank Based on Environmental Safety <i>Qidong Yong, Yang Chen, Yao Wang</i>	22
The Effect of Polyacrylamide on Floc Structure of Typical Systems <i>Pengkang Jin, Yongning Feng, Jie Xu, Xianbao Wang</i>	22
The Development and Optimal Allocation of Water Resources in Zhidan Country Energy Chemical Industrial Park <i>Pengkang Jin, Lei Zhang, Xianbao Wang, Yongning Feng</i>	22
Evaluation of the Implementation of Cleaner Production among Enterprises in Qingdao, China <i>Lu Xing, Lei Shi, Ruicong Wang, Xiaochen Sun, Le Tian</i>	23
Micro-Morphology and Micro-Area Chemical Characteristics of the Nickel-Carrying Minerals in the Garnierite <i>FU Wei, HUANG Xiao-Rong, CHEN Hong-Yi, NIU Hu-Jie, YANG Meng-Li</i>	23
The Study of Cavity Making Using Directional-Butted Wells Technology <i>Deyi Jiang, Liang Yi, Jie Chen, Xiang Jiang, Song Ren, Huaifu Qiu</i>	23
The Research of Led Lights Model Based on Road Lighting in Mesopic Vision <i>Fangzhou Zhu, Weihai Yuan, Huamei Xu, Yuefeng Yuan</i>	23
Thermal and Mechanical Characteristics of Thermal Barrier Coatings in Cyclic Thermal Fatigue Systems <i>Kang-Hyeon Lee, Sang-Won Myoung, Min-Sik Kim, Seoung-Soo Lee, Eun-Hee Kim, Yeon-Gil Jung, Ungyu Paik</i>	24
Performance Enhancement of Phase Change Thermal Energy Storage Unit Using Fin and Copper Foam <i>Yongqi Xie, Jun Song, Pengtao Chi, Jianzu Yu</i>	24
Design and Simulation Analysis of Doubly Fed Induction Generator Wind Turbines <i>Peng Cheng, Fengyan Li, Jihui Li</i>	24
Stability Evaluation for Polymer Electrolyte Membrane Electrolyzer <i>Hong Gun KIM, Hee Jae SHIN, Yun Ju CHA, Sun Ho KO, Hyun Woo KIM, Lee Ku KWAC</i>	24
The Numerical Calculation of Highway Slope Stability Under The Influence Of Rainfall <i>Yu Chen, Huiyun Duan, Chengtao Zhou</i>	25
Energy Storage: A Key Factor for Large-Scale Utilization of Renewable Energy <i>Chen Ying Jian</i>	25
Effects of Environmental Factors on Phosphorus Release In Sediment from Baihua Lake, China <i>Mei Jin, Jiwei Hu, Xianfei Huang, Liya Fu, Jin Luo, Miao Jia, Chun Liu, Wei Shen</i>	25

A Complete Optimal Control Solution for Permanent Magnet Synchronous Motors <i>Marian Gaiceanu, Emil Rosu</i>	25
Research on the Control Strategy of Dfig Grid Side Converter under Unbalanced Grid Voltage Conditions <i>Fei Song, Dan Zhu, Kan Tang, Xuejing Liu</i>	26
Effect of Top Coat Thickness on Thermal Stability in Thermal Barrier Coatings <i>Tae-Sik Jang, Sang-Won Myoung, Hyun-Sung Kim, Zhe-Lu, Geun-Ho Cho, Je-Hyun Lee, Yeon-Gil Jung</i>	26
Research on the Electrical Model of a Capacitive Soil Moisture Sensor <i>Yan Xu, Weidong Yi, Kowen Jwo</i>	26
Two-Dimensional Modelling and Simulation of Crystalline Silicon N⁺Pp⁺ Solar Cell <i>S. Tobbeche, M. N. Kateb</i>	26
On The Control of the Collector Field Outlet Temperature of Shiraz 250 KW Solar Power Plant <i>Mostafa Zamani Mohi Abadi, Seyed Mohammad Hessem Mohammadi, Seyed Ali Akbar Safavi, Seyed Vahid Naghavi</i>	27
Investigating of Correlation BETWEEN Modis Satellite Data AND Ground Data Related To Aerosols AND Modeling Aerosols Using Neural Networks Over Shiraz <i>Alireza Dehghani, Ali Akbar Safavi, Mohammad Jafar Nazemossadat, Seyed Mohammad Hessem Mohammadi</i>	27
Calculation Model of Peak Power Load Shifting Of Electric Thermal Storage Air-Conditioning System <i>He Wang, Dezhi Li, Renwu Xu, Hong Ji</i>	27
Implementation of Secure GOOSE Protocol Using HSM <i>Jincheol Kim, Youngeok Kim, Taehun Kim</i>	27
Characteristics of TVOC, Aldehydes and Ketones Emitted From Fiber Dryer in Manufacturing of HDF Made from Poplar and Pine <i>Shan Huang, Peiguo Zhou, Zhigang Lu, Guizhen Zhang, Wenbin Sang, Handong Zhou, Tao Ding</i>	28
Environmental Practices as Requirements for Supplier Evaluation and Selection in the Automotive Supply Chain <i>R.M. Vanalle, L.B. Santos</i>	28
Integrated Assessment of Carbon Dioxide Emissions for A Large-Scale Iron and Steel Corporation in China <i>Aijun Li, Yinxue Cao</i>	28
Numerical Simulation on Self-Priming Spray and Conventional Spray Characteristics <i>Zhongfei Ma, Zhen Zhang, Zhilin Ge</i>	28
Effect and Control of Suspended Solids at the Blast Furnaces <i>Ayo Samuel Afolabi, Kazeem Oladele Sanusi, Ambali Saka Abdulkareem, Oluwaseyi Samson Bada</i>	28
Effect of Flotation Parameters on Recovery of South Africa Nickel Sulphide Ore <i>Ayo Samuel Afolabi, Ambali Saka Abdulkareem, Edison Muzenda</i>	29
Investigation of the Treatment of Wastewater Using Activated Sludge Process <i>Ayo Samuel Afolabi, Oluwagbenga Johnson, Ambali Saka Abdulkareem, Bada Samson Oluwaseyi</i>	29
Modeling and Simulation of Wear in PTFE Lip Seals <i>Jianwei Sun, Liqin Wang, Le Gu</i>	29
Improve the Condition of the Energy Consumption of the Refinery Based on the Exergy Theory <i>Jia Mou, Song Xiaozhong</i>	29
Thermal Analysis of Recycled Gypsum from Construction and Demolition Waste <i>Gladis Camarini, Sayonara M. M. Pinheiro, Katia Tannous</i>	30
Ibis Model-Based Simulation Study on Variation of Ecological Carbon Sink Potential in Shenzhen City <i>Weiling Liu, Linbo Zhang, Bin Gong</i>	30
The Architectural Applications and Design Methods of Gluebam <i>Xiaohu Liu, Dan Xiong, Wei Mu, Han Liu</i>	30
Study on Indicators System for Construction of Ecological Demonstration Province in Guangxi <i>Hao Cheng, Yongchun Huang, Jianhua Xiong</i>	30
Research on Leachate Treatment Process Selection of Guangxi Municipal Solid Waste Plant <i>Hao Cheng, Ming La, Jianhua Xiong</i>	30
Experimental Analysis of CO₂ Concentration <i>Xiaodong Zhang, Chengduan Wang, Junjie Jin, Yunzhong Li</i>	31
The Research and Design of Intelligent Community Energy Management System <i>Yufeng Yang, Yangyang Xi</i>	31
Wind Erosion At a Saline Playa Environment, Ebinur Lake, Xinjiang, China—A Case Study on The Source of Saline Dust Storm <i>Dongwei Liu, Jilili Abuduwalli</i>	31
Construction Waste Recycling Technology Management Based on Circular Economic Theory <i>Jianglin Wu, Yanbing DENG</i>	31
Analysis of the Crushing Effect about Ultrasound on E. Coli and B. Subtilis <i>XinYing Wang, YongTao Liu, Min Hui, JiFei Xu</i>	32

The Numerical Simulation Study of a Flocculation Reactor <i>Lai Yanping, Zhao Jianhai</i>	32
Estimation Method for Spatial Capacity of Sea Areas Reclamation <i>Zhang Minghui, Chen Changping, Suo Anning</i>	32
Changes of Value of Ecosystem Services and Its Driving Forces In The Lower Reaches of the Tarim River <i>Huang Xiang, Li Weihong, Ma Jianxin</i>	32
The Effect of Ferric Ion and Copper Ion on Extracellular Polymeric Substances <i>Liyun Ge, Huanhuan Deng, Dexiang Gao, Hongwu Wang</i>	32
Photodegradation of Two Antibiotics Involved With Fe (Iii) and Marine Algae <i>Liyun Ge, Yonggang Huang, Dexiang Gao, Huanhuan Deng</i>	33
Comparison of Extraction Methods for Quantifying Extracellular Polymers of Marine Algae <i>Liyun Ge, Yonggang Huang, Dexiang Gao, Huanhuan Deng</i>	33
Rapid in Vitro Propagation of Bioenergy Crop Miscanthus Sacchariflorus <i>Hai Peng Guo, Ruo Xuan Shao, Chun Tao Hong, Heng Kang Hu, Bing Song Zheng, Qi Xiang Zhang</i>	33
The Effect of Doping Ce and Fe on the Mn/Tio2 Catalyst for Low Temperature No Selective Catalytic Reduction with NH₃ <i>Shiye Feng, Pan Gao, Changqing Dong, Qiang Lu</i>	33
A Review of Foreign Researches on Energy and Environment Field: Based on the Research Perspective of CGE Model <i>Wei Liang, Huiying Zhang</i>	34
Research on Influencing Mechanism of Industrial Carbon Emissions in Hebei Province <i>Weiyang Yu, Huining Zhao</i>	34
Study on Control Factors and Genetic Model of Karst in the Ordovician of Tahe Oilfield <i>Ying Li, Shouyu Xu</i>	34
The Design of Arc Fault Circuit Interrupter Based on Wavelet Transformation <i>Xiang Xinjian, Lin Zhang</i>	34
The Effect of Electrode Parameters on Lead-Acid Battery Performance <i>Vahid Esfahanian, Pooyan Kheirkhah, Hassan Bahramian, Amir Babak Ansari, Goodarz Ahmadi</i>	34
The Study of Hierarchical Control Method for Micro-Grid Control <i>Yongyi Wu, Shuanghu Wang</i>	35
Design of Three-Phase Voltage Source PWM Rectifier Using Feed-Forward Compensation <i>Zhu Qi, Shi Jing-bo</i>	35
Impact Analysis to Building Energy Consumption of Daylighting Combined Lighting Control <i>Xiaolei Li, Huan Li, Jianping Gao</i>	35
Research on the Classification of Coupling Relationship among the Ecological Environment, Natural Disasters and Regional Poverty In Inner Mongolia Autonomous Region <i>Alateng Tuya, Buren Jirigala, BaoYin</i>	35
Study on Early Warning Mechanism of Water Resources Security <i>Mingqi Chang, Yanli Fan</i>	35
Optimization of Drive Unit through Load Measurement <i>Jan Nečas, Tomáš Mlčák, Jiří Zegzulka, Roman Hrbáč</i>	36
Study on Determination of Best Window-Wall Ratio of Office Building in Cold Area <i>Zhihua Zhou, Shan Hu, Tao Du</i>	36
Application of Life Cycle Assessment in Agricultural Circular Economy <i>Xiaoxian Zhang, Fang Ma, Li Wang</i>	36
Degradation of 2-Chlorophenol Using a Pd/Mwnts Gas Diffusion Electrode in the Divided Cell <i>Zhipeng Zeng, Hui Wang, Zhaoyong Bian, Lei Pang</i>	36
Ashing Temperature'S Impact on the Characteristics OF Biomass Ash <i>Wenni Li, Qinghai Li, Yanguo Zhang, Aihong Meng</i>	37
A Simulation Training System of Multi-Effect Seawater Desalination <i>Weiqing Li, Yong Wu</i>	37
Study Platform for Ac Transmission System of High-Speed Train <i>Xiaochun Fang, Zhongping Yang, Fei Lin, Jinfei Qin</i>	37
Study on the Advanced Treatment Technology for Wastewater Containing both Zn²⁺ and Cd²⁺ <i>Guozhong Huang, Dengkun Li, Xuemin Miao, Junfeng Wang, Lijie Bao</i>	37
Design on Pulse Acquisition Circuits of Intelligent Distribution Network Digital Terminal <i>Yu Zhang, Guobao Zhang</i>	38
A New Calculation Method of Environmental Similarity <i>XiaomanXU, JunxianKe, DangKun</i>	38
Research on the Corn Stalk Composite Solvent Liquefaction <i>Li Xiangyu, Zou Yigang, Wu Junhua, Pang Jiuyin, Shi Junyou, Ma Chunan</i>	38

The Inevitability Research on the Adjustment of Industrial Structure to Achieve Sustainable Development of the Resource-Based Cities <i>Jun Chen, Fubin Cai, Biyun Xiao</i>	38
The Impact of Green Tide on the Phytoplankton Community in Yellow Sea <i>SONG Xiukai, SHI Yajun, LIU Aiyong, XING Hongyan, JIANG Huichao, WANG Wenjie, ZHANG Limin</i>	38
Quantitative Study of Elements Migration during the Wall Rock Alteration Process for Gejiu Copper-Polymetallic Deposit inside Rock <i>Xiaohu Deng, Shouyu Chen, Shili Liao</i>	39
Coordinated Control Strategies between Photovoltaic Power Plant in Mw Level and the Power Grid <i>Kangning Wang, Chaoying Yang, Jinhao Wang, Lin Liu</i>	39
Non-Uniform Electrokinetic Removal of Heavy Metals from Contaminated Soil with Permeable Reactive Composite Electrodes <i>Fang LIU</i>	39
Vibration Control Based on Shift Mass of Propulsion Motor for Watercraft <i>Hui Wu, Tiger Sun</i>	40
Fault Current Limitation (FCL) and Voltage Dip Improvement Thanks to Distributed Static Series Compensator (DSSC) <i>Salman Badkubi</i>	40
A New Real Time Forecasting Model for Wind Power <i>Xu Song, Chen Shoulun</i>	40
Three-Phase AC Variable Frequency Speed Adjustment Controller Based on FPGA <i>Changzhi Lv, Ting Gao, Guozhi Xin, Yuanyuan Zhou</i>	40
Fly System of Green Infrastructure for Coping with Climate Change <i>Goeun Choei, Jeongeun Bae, Sangmin Shin, Heekyung Park</i>	40
Ecological Effects of Mining Exploitation and Typical Technology of Ecological Restoration <i>Saiming Yang</i>	41
Modeling of Wellbore Overall Heat Transfer in Circulation <i>Huifang Song, Ruihe Wang, Hongjian Ni</i>	41
Intra-Day and Day-Ahead Wind Farm Output Forecasting Using Neural Network Ensembles <i>Alain Fuser, Jack Copper</i>	41
Review of the Treatment of Water Containing Arsenic <i>Yun-nen Chen, Li-chao Ding, Chun-hua Liu</i>	41
Role of Green Coverings in Mitigating Heat Island Effects: an Analysis of Physical Models <i>Giorgia Peri, Gianfranco Rizzo, Gianluca Scaccianoce, Giancarlo Sorrentino</i>	41
The Study on the Battery Modeling Through the Mathematical Modeling Techniques of High-Power Lithium-Polymer Battery for HEV <i>DongWoo Seo, JaKyung Koo, ILSong Kim</i>	42
Environmental Implications of Traffic Flow Delays: A Model for Urban Streets <i>Ferdinando Corriere, Giorgia Peri, Vincenzo La Rocca, Gianfranco Rizzo</i>	42
Characterization of Biodiesel from Vegetable Oil Using Comprehensive Two-Dimensional Gas Chromatography <i>Ferdinando Corriere, Giorgia Peri, Vincenzo La Rocca</i>	42
Research on Adaptive Current Protection of Wind Farm <i>Fengting Li, Changsheng Su</i>	42
A New Approach to Analyzing Gas Mixtures Based on Improved BP Neural Network Algorithm <i>Teng Li, Xiaomei Yuan, Shiliang Yang, Xinhui Zhang</i>	42
Study of Magnetics Performance of Inset Permanent Magnet Synchronous Machine (Inset - Pmsm) Using Finite Element Method <i>Jeeng-Min Ling, Tajuddin Nur</i>	43
Investigation the Performance of Axial Channel Rotor in Inset Permanent Magnet Synchronous Machine <i>Jeeng-Min Ling, Tajuddin Nur</i>	43
The Security Strategy for Chinese Petroleum Industry <i>Shibao Dong, Xuanmin Li, Meng Su</i>	43
Flocculation and Sedimentation of Bauxite Flotation Tailings <i>Haiyun Xie, Likun Gao, Shuming He, Dianwen Liu, Xiong Tong</i>	43
Investigation of the Thermal Flow Field and Recirculation of A Direct Air-Cooled Condenser For A Large Power Plant <i>Wanli Zhao, Qiuyan Li, Linghua Wang</i>	43
Energy Efficiency of Major Energy Consuming Countries <i>Xin-qiang Wei, Bao-sheng Zhang</i>	44
Prediction Model Establishment of the Opening Angle of a Ball Valve <i>Zhanrong Feng, Lixia Wang, Zhengquan Li</i>	44

Dynamic Response of a Semi-Submersible Floating Offshore Wind Turbine in Storm Condition <i>Haitao Wu, Jin Jiang, Jing Zhao, Xiaorong Ye</i>	44
Evaluation on Circular Economy Development in Provincial Region——Based on Eco-Efficiency Perspective <i>CUI Mu-hua</i>	44
Study on Fire Safety Planning in Chinese Petrochemical Industry Parks <i>Hanbin Wan, Yinxia Yun</i>	44
Research the Structural Feature of Jibei Mining Area to Control the Gas Bearing <i>Haiyan Liu, Zengxue Li, Dawei Lv, Dongdong Wang, Wenfeng Ning</i>	45
Green Construction Partner Selection <i>Han-bing Tang</i>	45
The Study of Heavy Metal Pollution Characteristics in Soil of Typical Urban-Industrial Wasteland <i>Su Chen, Lei Chao, Lina Sun, Tieheng Sun</i>	45
Study of Failure Rate Model for a Large-Scale Water Supply Network in Southern China Based on Different Diameters <i>Pengjun Yu, Jinxu Nie, Gang Xu, Zhihong Long, Zhihong Wang, Yu Tu, Bin Li, Xiaomei He, Yuli Chen</i>	45
Characterization of Zsm-5 during Conversion of Glucose to Levulinic Acid <i>Ying Liu, Lu Lin, Xiaoyu Sui, Junping Zhuang, Chunsheng Pang</i>	46
The Study on the Inhibiting Effect of Denitrifying Bacteria on Sulfate-Reducing Process <i>Yan Li, Xuan Zhang, Lihui Zhou, Jianke Ren, Nan Zhao</i>	46
Analysis of Energy Demand and Smart Grid Policy-Making Issues of China <i>Shengxia Cai</i>	46
Design Study of Small PB-Bi Cooled Non-Refueling Nuclear Power Reactors (SPINNORs) <i>Zaki Su'ud</i>	46
Optimum Design of Interior Permanent Magnet Motor for Automotive Cooling Device <i>Ju-Seong Yu, Han-Wook Cho</i>	47
Study of CO₂ Emissions Decrease in Metallurgy Industry of Czech Republic <i>Simona Jursová, Pavlína Pustějovská, Jaroslav Frantík, Veronika Sassmanová</i>	47
Analysis and Study on Microgrid Planning Based IEEE 1547 <i>Xiuqiong Huang, Dawei Yang, Jianhua Yang, Yunfeng Tang, Rengang Yang, Jing Zhang, Bin Feng</i>	47
The Use of Ft-Ir for the Determination of Liquid Products Properties after the Tyres Thermal Degradation <i>Veronika Sassmanová, Zuzana Poláčková, Jaroslav Frantík, Stanislav Honus, Dagmar Juchelková</i>	47
Experimental Determination of Energy Demand and Spatio-Temporal Course of Pyrolysis for Various Materials <i>Stanislav Honus, Ondřej Němček, Jaroslav Frantík, Veronika Sassmanová, Dagmar Juchelková</i>	47
Comparison of Numeric Methods that Simulate Energy Transfer by Radiation <i>Stanislav Honus, Dagmar Juchelková</i>	48
Application and Efficiency Verification of Classical and Unconventional Sorbents Which Serve For Capture of Heavy Metals during Coal Combustion in Experimental Fluid Device <i>Ondřej Němček, Stanislav Honus, Dagmar Juchelková</i>	48
Optimization of Small Long Life Gas Cooled Fast Reactors with Natural Uranium as Fuel Cycle Input <i>Menik Ariani, Z. Su'ud, Fiber Monado, A. Waris, Khairurrijal, I. Arif., Ferhat A., H. Sekimoto</i>	48
Establishment and Practice of China's Corporate Environmental Supervisor System <i>Jing yi Tian, Ying huai Mao</i>	48
Advanced Refrigerating Plants Based on Transcritical Cycles Working with Carbon Dioxide for Commercial Refrigeration <i>Vincenzo La Rocca, Antonio Messineo, Massimo Morale, Antonella Dispenza, Domenico Panno</i>	49
Preliminary Study of the Geological Disaster Modeling in the Three-Dimensional Tunnel Project <i>Xiao Fang ZU, Wei Hua HUA, Jin LUO</i>	49
Gis-Based Alerting and Control System Design of Geological Disaster in Jiangxi Province <i>Xiao Fang ZU, Xian Gang LUO, Jin LUO</i>	49
Cause Analysis and Countermeasure Research on the Deterioration of Oasis Ecological Environment of Minqin County <i>Fanghong Li, Xuli Liang, Kang Chen</i>	50
Research on Environment Geology Information System Based on GIS <i>LUO Jin</i>	50

The Carbon Emission Quantification of the Low Carbon Road Maintenance Technology in China

Ke Zhou^{*1,a}, Yim Wong^{2,b}, Xijuan Xu^{3,c}, Charence Chiang^{4,d} and Huicong Zhang^{*5,e}

^{1,5}Renmin University of China, Law School. No. 59 Zhongguancun Street, Haidian District, Beijing, China.

^{2,4}8/F, Centre Point, 181-185 Gloucester Road, Wanchai, Hong Kong, China.

³Xian Institute of Highway Research. No. 39 South Road, Beilin District, Xi'an City, Shanxi Province, China.

^ardzhouke@x263.net, Tel: 13240405110, ^bkwongccel@yahoo.com.cn, ^cxxj96_2005@sohu.com, ^dcharence@hotmail.com, ^echifengjirui@163.com, Tel: 18810348216

Key words: Low carbon economy; road maintenance; carbon emission measurement; law

Abstract. Low carbon road maintenance(hereinafter referred to as LCRM) technology is an important and essential part of the overall low carbon transportation policy in China. The large amount of carbon emission resulting from road maintenance needs to be determined with definitive methods and data to form a basis of measurement of the carbon emission of the road maintenance process. Various road surface maintenance technologies have different environmental impacts and dissimilar levels of carbon emission. When comparing the merits and drawbacks of the various maintenance technologies, not only factors such as the maintenance outcome, road surface quality, serviceable lifespan, costs and the impact on traffic and environment should be evaluated, but also other factors, such as carbon emission of the material used for the maintenance process, carbon emission of the machinery deployed and other amounts released during construction, have to be assessed and measured. This paper will allow for a comprehensive analysis that will help to choose the right road surface maintenance technology that produces the best road surface quality, the optimal economic benefit and the most favourable social and environmental outcome. LCRM protocol should be regulated and promoted by government legislation and through which adoption of the best practices would be encouraged.

Analysis on the necessity of LCRM

Transportation is a major source of air pollution due to the large amounts of fossil fuel consumption involved. Sulphur dioxide emission and other greenhouse gas emission are the major contributors[1]. Different modes of transportation could result in great differences in the amount of carbon emission. Statistics show that for the same transport load volume, the energy consumption ratio between rail, highway, and air transportation is 1.9:3:18.6[2]. Hence, highway and air both have high fuel consumption while rail consumes the least. Many scholars have proposed the establishment of a comprehensive policy that governs a sustainable transportation network, and such policy should also address the issue of rapidly escalating greenhouse gas emission from vehicle exhaust[3].

Presently in China, the average highway energy consumption is 5 to 10 times of rail consumption, while in the United States it is 3 times[4]. The impact on the environment is not simply related to emission per kilometre, but also related to the freight volume and the mode of transportation[5]. The World Bank study on 17 cities in China discovered that the increasing high carbon dioxide emission results mainly from the longer distances traveled, motorization and low loading ratio of vehicles[6]. In August 2004, Dr. M.Y. Fisekci, released a four-year research report

which sampled only 37 Chinese national highways, with a total length of about 3,000km, mostly 4 lanes to the China Highway Society. Among those highways, 90% are substandard. Without proper maintenance, the life span of these highway would be shortened by half and the national losses would exceed tens of billions RMB each year, enough money to construct two international-standard airports over a life span of 7 to 8 years[7].

Low carbon transportation addresses a broad and comprehensive subject encompassing all the links in transportation with regard to greenhouse gas emission. In reality, consumption of fossil fuel cannot be reduced until there is a discovery of large scale alternative energy sources. Therefore, the primary focus of development of low carbon transportation is reduction in conventional energy consumption, while alternative energy utilization is secondary. Compared to docks in shipping and airports in air traffic, road maintenance in highway transportation deserves even more attention. Transportation is made up of vehicles and infrastructure facilities. At present, the high-grade roads in China save over 20% petrol than standard roads[8] .

Road construction inevitably consumes energy, resulting in high carbon mission in the process. LCRM is an essential part of low carbon transportation, and therefore an important step to achieve low carbon transportation. The highway maintenance in China consumes 50 million tons of rocks now[9]. During the rehabilitation of the highway, traditional methods will create traffic congestion. The slow traffic will create huge quantities of carbon emission. Adding this to more emission from the refining of asphalt, milling and paving of the road surface, the total carbon dioxide emission from road maintenance is about 1.1 million tons yearly[10].

Strong and accurate technical data are crucial in the quantitative analysis of LCRM technologies, which will help to standardize the industry and allow for control and consolidation through government legislation.

Measurement of carbon emission in road maintenance

Scope and Standard. The testing and research of carbon emission during road construction and road utilization represent a systematic and extensive undertaking. The study involves many facets of the road building process where carbon emission in the procurement of the raw materials, machinery mobilization and construction processes will be tested, calculated and determined, arriving at a final total emission for the entire construction process. Parallel to this research, new environmentally friendly and energy efficient materials, technologies and applications can be assayed and compared in their emission levels.

Utilization of a highway requires regular maintenance of the road surface. Different pavement maintenance systems and techniques affect the environment and carbon emission in different ways. Consequently, the comparison of the merits of pavement maintenance techniques has to take into consideration not only factors such as surface results, surface functionality, effective longevity, impact on traffic and the environment, but also the carbon emission burden of the material used, carbon emission of the construction equipment deployed and the emission during the application process.

As a preliminary assessment of carbon emission in road construction and road maintenance, this paper will study the carbon emission during the construction and operational stages of the various techniques, comparing the currently available preventive asphalt maintenance methods in their impact on the environment (or greenhouse effect).

Classification of road maintenance technologies. Pavement preventative maintenance (PPM) for asphalt road surface refers to conservative road surface treatment that is applied before any structural damage to the road occurs. Its effect is to enhance the serviceability and longevity of the pavement and to reduce the cost of the regular service cycle. Actual experience shows that proper PPM is a cost effective and efficient technology that can delay damages and extend the serviceable life of the surface, and postpone major rehabilitation and rebuilding of the highway.

At present, PPM technology can be divided into these main categories: asphalt rejuvenation technology (ART), micro-surfacing technology (MST), hot ultra-thin surface milling and over laying technology (HUT), and fog seal technology (FST). In general:

1. ART is very effective in preventing early damage to the road surface and in reviving the functionality of the asphalt, turning the old asphalt road back to almost new asphalt road without the need to mill and pave.

2. MST is suitable for use in high grade highways as an early stage preventive measure. It can significantly improve the performance and longevity of the surface.

3. The advantages of HUT are high leveling accuracy, anti-skid characteristics and noise reduction features. Again, traffic can flow 1 to 2 hours after process completion.

4. FST is a commonly used PPM technique. It has been popular with high speed highways because of its low cost, quick application and good performance. Highway can be re-opened for traffic very quickly following application.

As this paper focuses on carbon emission quantification, hence it is not the authors will to discuss, compare and evaluate all the foregoing methods in terms of costs, reliability and life span in this paper. For carbon emission evaluation purposes, measurement of carbon dioxide emission during the application process and subsequent operational phase of these four technologies should produce a comparison of the environmental impact of these techniques, allowing for better compliance with the objectives of low carbon emission and environmental compatibility.

Currently there is no established method to measure the carbon emission during highway construction and maintenance. This study draws on the atmospheric carbon dioxide assaying technique to determine the carbon emission during the construction or application process and at various time intervals after resumption of traffic flow. We have chosen carbon dioxide measurement as an indicator of the level of carbon emission of these technologies. The sequential measurement following initial completion of construction or application will show the longer term impact of the different PPM techniques.

Assaying methodology for carbon emission of pavement preventive maintenance techniques. Volumetric titration is the method used. The principle is that the carbon dioxide in a sample of air of known volume is absorbed in a barium hydroxide solution of known concentration. The test required the following equipment and reagents were as follows: 1. Instruments: suction tube, air sampler, burette, iodine bottle; 2. Reagent: absorption (barium hydroxide) solution, oxalic acid standard solution, phenolphthalein indicator, butanol, pure nitrogen or air with CO₂ removed by soda lime tube.

The test was divided into two parts: laboratory samples and field test samples. The procedure was as follows:

1. In the laboratory, asphalt rutting boards measuring 300mm x 300mm x 50mm (thickness) were fabricated at a moulding temperature of 60 degrees C, and wheel pressure of 0.7MPa. The surface is then treated with either RejuvaSeal (an asphalt rejuvenating agent approved by the Shanghai Authority)[10] or fog seal according to the manufacturers' directions. For micro surfacing and ultra-thin hot wear surface milling and over laying, the surfaces were prepared and then treated with the materials following manufacturer's directions.

2. At the end of the application process, air samples were taken at time intervals of 0 min, 30 min, 1h, 2h, 4h, 6h, 12h, 1d, 5d, 10d, 30d, and 60d.

3. In the field, the sampling sites were spaced out by 20m and their locations marked for future sampling.

4. To collect CO₂ gas samples, a suction tube purged with pure nitrogen or de-carbonated air was used. The tube was filled with 50 ml of barium hydroxide solution. The suction tube opening was positioned 10 cm above the surface and 3L of sample air is collected at a flow of 0.3L/min.

5. At the end of collection, the suction tube opening was sealed to prevent contamination. The temperature and atmospheric pressure were recorded during sample collection. Sampling was done

under good weather conditions to minimize fluctuations in temperature, humidity and barometric pressure that may cause inaccuracy in the measurements.

The analytical process involved the following:

1. The sand core tube of the suction tube was removed after sample collection and stopper applied and let standing for 3h. This allowed for complete precipitation of the barium carbonate. 25ml of the supernatant fluid was extracted and placed in the isodiametric bottle. 2 drops of phenolphthalein indicator were added to the solution and standard oxalic acid from the burette was used to titrate against the sample until the pink of phenolphthalein faded.

2. For each batch of samples, a 25ml volume of unused barium hydroxide was titrated using the same reagents to establish a baseline value.

3. The concentration of carbon dioxide in the air was calculated using the following formula:

$$c = \frac{20 (V_2 - V_1)}{V_0}$$

C - CO₂ concentration in the air sample

V₂ - volume of oxalic acid used in titration of the test sample

V₁ - volume of oxalic acid used in titration of the blank barium hydroxide solution

V₀ - volume converted to standard temperature and pressure.

Parallel data were obtained for the four different PPM techniques to allow for scientific comparison.

4. The CO₂ concentration of the samples were calculated and compared to the standard CO₂ level in the atmosphere.

This analysis formed the basis of the evaluation of the impact of the different PPM technologies had on the environment. The data obtained in the field showed higher values because of vehicular exhaust, and had to be adjusted using the laboratory tests.

Analysis of PPM carbon emission results

Tests have been concluded based on the above mentioned methodology on the four pavement preventive maintenance treatments, both in the laboratory setting and in the field where asphalt surface treatment has been performed. The results are also compared to CO₂ concentration in air samples over ordinary asphalt pavements. The test results are contained in Table1 and Table2; the CO₂ concentrations at different time intervals following different application methods can be seen in Figure 1 and Figure 3, and the comparison of CO₂ concentration under different methods is presented in Figure 2 and Figure 4.

<i>Lab</i>	<i>CO₂ Volume, %</i>					
<i>Time</i>	<i>Air in Lab</i>	<i>ART</i>	<i>MST</i>	<i>HUT</i>	<i>FST</i>	<i>NAP</i>
0min	0.06	3.51	4.15	5.97	4.08	5.83
10min	0.06	2.98	3.86	5.73	3.54	5.64
30min	0.06	2.03	3.54	4.86	3.09	4.78
1h	0.06	1.55	3.05	3.78	2.86	3.67
2h	0.06	0.87	2.72	2.55	2.58	2.45
4h	0.06	0.43	2.21	1.05	2.03	0.95
12h	0.06	0.14	0.81	0.12	1.08	0.12
1d	0.06	0.11	0.53	0.06	0.87	0.06
5d	0.06	0.08	0.08	0.06	0.52	0.06
10d	0.06	0.06	0.06	0.06	0.43	0.06
30d	0.06	0.06	0.06	0.06	0.24	0.06

Table 1: Test results of CO₂ concentration of different preventive maintenance technologies in the laboratory where CO₂ concentration of the gas sample at a point 10 cm above test surface (percentage by volume)[10].

Note: NAP means normal asphalt paving

On-Site	CO ₂ Volume, %					
	On-Site Air	ART	MST	HUT	FST	NAP
0min	0.04	3.86	4.75	6.92	4.59	6.57
10min	0.04	2.04	4.19	6.45	4.02	6.02
30min	0.04	0.54	3.88	5.31	3.56	5.14
1h	0.04	0.04	3.42	3.55	2.57	3.22
2h	0.04	0.04	3.03	2.14	2.01	1.86
4h	0.04	0.04	2.51	0.36	0.98	0.21
6h	0.04	0.04	1.87	0.04	0.64	0.04
12h	0.04	0.04	0.47	0.04	0.59	0.04
1d	0.04	0.04	0.04	0.04	0.51	0.04
5d	0.04	0.04	0.04	0.04	0.36	0.04
10d	0.04	0.04	0.04	0.04	0.22	0.04
30d	0.04	0.04	0.04	0.04	0.18	0.04
60d	0.04	0.04	0.04	0.04	0.06	0.04

Table 2: Test results of CO₂ concentration of different preventive maintenance technologies on-site where CO₂ concentration of the gas sample at a point 10 cm above test surface (percentage by volume)[10].

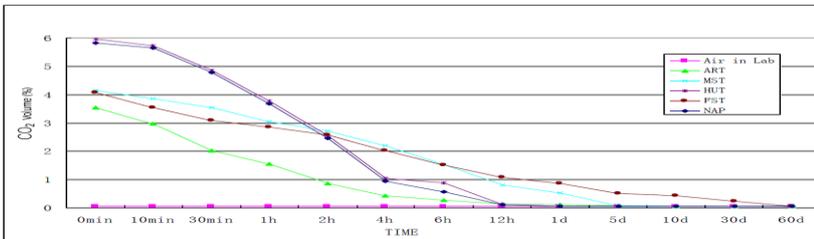


Fig 1: Change of the CO₂ concentration following time of different PPM in the laboratory[10].

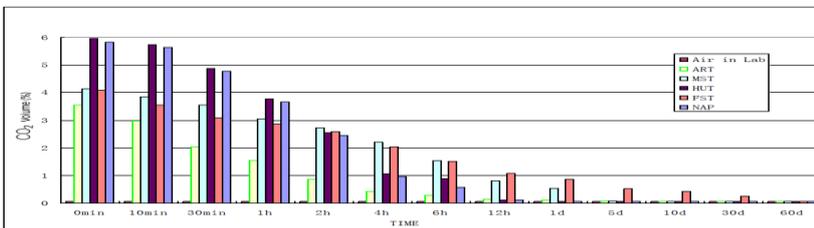


Fig. 2: Comparison of CO₂ concentration of different PPM in the laboratory[10].

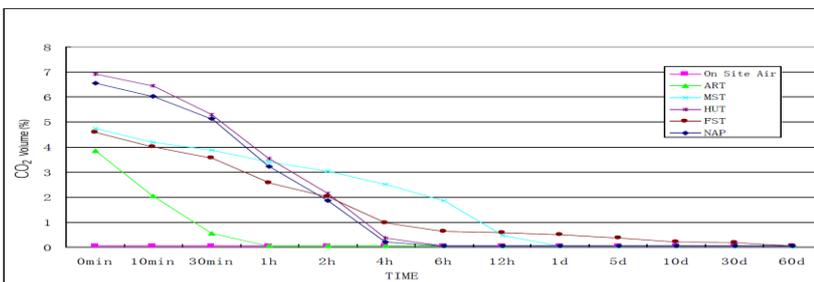


Fig. 3: Change of CO₂ concentration at different time intervals following PPM application on site[10].

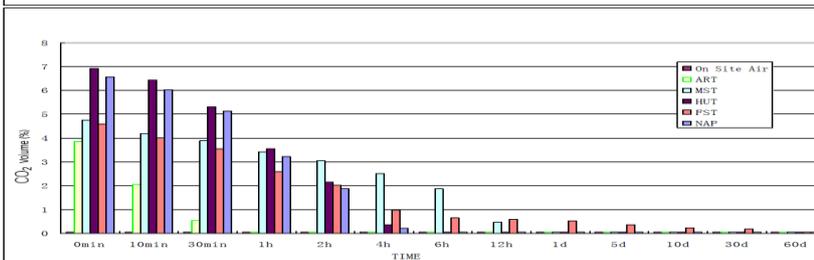


Fig. 4: Comparison of CO₂ concentration of different PPM on site[10].

Observations derived from the test results

The laboratory and field tests reveal the amount of CO₂ released during the application process of the different PPM technologies ranked highest for hot ultra-thin surface milling and over layering technology (HUT), followed by the normal asphalt pavement (NAP), micro-surfacing (MST), fog seal (FST) and asphalt rejuvenation technology (ART), all of which result in higher CO₂ concentration than ambient air.

Owing to the unique characteristics of the different material used, each PPM technology has its own pattern of change in CO₂ release. Mixtures that require heating have the greatest change in CO₂ release, such as HUT and NAP, where the CO₂ release greatly decreases as the material temperature drops. Usually, within 10min to 4h after application the CO₂ concentration drops from 5% - 7% to lower than 1%. As for rejuvenation material of ART, the mixture content is already environmentally friendly and therefore produces the least CO₂ emission. During the drying and downward penetration phase of rejuvenation, CO₂ concentration declines with time partly because the material does not contain harmful organic solvents. In an enclosed environment, the CO₂ level will decrease to below 1% within 2h, while in the open air field site CO₂ level can drop to below 0.5% within 30min. As for MST and FST the CO₂ emission during application will also decrease with time, but the speed of the decline is less rapid than rejuvenation or hot asphalt, requiring 12h before the concentration drops to 1%. This phenomenon could be due to the fact that both techniques utilize chemically reactive materials. In the drying and emulsion breakdown process chemical reactions may be occurring with the production of new substances and more CO₂ release. Laboratory and field tests both showed the same pattern of CO₂ changes.

Within the laboratory, ventilation is comparatively restricted and gases take longer to dissipate. For the rejuvenation material of ART, it takes CO₂ concentration in the laboratory 4h to drop from 3.55% to 0.43%. In the field where good ventilation is available, the same drop takes only 30min. This difference is even more obvious for heated asphalt mixtures of HUT. In the relatively closed environment of the laboratory, fresh asphalt (NPT) and HUT material need 6h to drop the CO₂ level from 6% to 0.6%, while in the well ventilated field condition CO₂ level can drop from 7% to 0.3% within 4h. Similar observation applies to MST and FST material, where CO₂ concentration takes 1d to 5d to drop down to 0.5% in the laboratory, but only 12h on site.

Fresh air contains 0.03% of carbon dioxide, which is the level compatible with human biological existence. If CO₂ concentration is too high because of poor ventilation or burning of fuel indoors, CO₂ toxicity could occur. There is no uniform international standard for CO₂ concentration in indoor air. Japan sets 0.15% of CO₂ concentration as the level where air exchange is required. Table 3 illustrates the effect of increasing CO₂ concentration on the human body.

<i>The content of CO₂ in the air/%</i>	<i>Symptoms</i>	<i>Table 3: The effect of CO₂ on the human body[10]</i>
2.5	No symptoms for hours	
3.0	Increased breathing without being aware	
4.0	Signs of agitation	
6.0	Hyperventilation	
8.0	Difficulty in breathing	
10.0	Confusion, leading to death	
20.0	Paralysis within seconds with heart stoppage	

Taking the above Table 3 information as guide, the upper limit of CO₂ content during the construction phase could be set at 6%, and the upper limit in the usage phase could be set at 0.5%. The various PPM technologies would evidently have different effects on the human body, and the timing of the re-opening of the road would have to fluctuate according to the speed of decline of CO₂ concentration. At the construction site, ART, MST and FST can all meet the upper limit requirement. NAP and HUT layering both require heated mixtures and the CO₂ concentration during construction is close to 7%, which may be harmful to the health of the workers. To meet the requirement of 0.5% limit at time of re-opening of the road, ART needs 30min after application, MST needs 12h and FST will require 1d. HUT layering and normal asphalt paving (NAP) both need 4h. From the point of human health considerations, the proper choice would be for a PPM material that produces the least CO₂.

This study did not conduct tests and research into the total amount of CO₂ produced at the construction and operational stages using different PPM technologies. However, we can make some reasonable estimate from Table 1 and 2, and from Figures 1 to 4. For example, in Figure 3 (Change of CO₂ concentration at different time intervals following PPM application on site) the area below the curve can indirectly reflect the total CO₂ emissions.

Preliminary Conclusions

Different pavement preventative maintenance technologies would produce different concentration and different total amount of CO₂. Mixture materials that require heating give out higher concentration as well as greater amount of CO₂. This is followed by methods that utilize reactive type of material like micro-surfacing (MST) and fog seal (FST). Asphalt rejuvenation technology (ART) gives out the least.

The drop in CO₂ concentration is quite fast in well ventilated surroundings, but for road sections within cities where ventilation is more stagnant, a PPM method with low CO₂ emission should be chosen to prevent high CO₂ accumulation that could be harmful to human health.

From the results of this study, one can deduce that in asphalt pavement preventative maintenance the technology of choice would be one that can be applied in ambient temperature and one that does not involve chemically reactive materials. This avoids the need for heated materials and ensures CO₂ level will remain low.

Ideas for future in depth research

This study is only a preliminary and exploratory study of CO₂ emissions from different preventative maintenance technologies currently used in highway construction. The CO₂ emission testing and evaluation during highway construction and operation involves all kinds of materials and machinery. Different construction techniques and maintenance methods also affect the testing and evaluation, making it a very large and complex undertaking. Further detail study is needed to analyse the various materials, machinery, and construction techniques in the highway construction process and road operating stages to determine the CO₂ emission under various conditions and over time. Such study can aid in the standardization of the testing and evaluation of CO₂ emission during the different phases of the construction and operation of the road. The main research emphasis in future would be as follows:

1. Include the composition and constitution processes, and calculate the unit CO₂ emission of each material.
2. Collect information on the machinery mobilized in the construction and maintenance processes; perform testing and calculate the CO₂ emission from each piece of equipment.

3. Collate the total requirement of the material, machinery and manpower needed in the road construction and maintenance processes, and calculate the CO₂ emission for each unit of highway construction or maintenance.

4. Develop computer software that calculates the CO₂ emission based on different road design and maintenance conditions.

5. Collect from China and overseas new low carbon and environmentally friendly materials, methods and technologies and evaluate their quantitative CO₂ emission levels.

6. Taking into consideration the available new materials, methods and technologies, compile a set of basic CO₂ emission standards for low carbon roads.

7. Using the CO₂ emission standards for low carbon roads, conduct a survey on planned or existing roads to evaluate their carbon emission level to determine if they meet the requirements for low carbon emission.

8. Investigate the factors that lead to noncompliance in road projects and implement improvement measures.

Last but not least, in China, related law must be established and reinforced. The authors will present their legal opinions in their next joint paper in the not very distance future.

References

[1]Philippe Sands QC , Principles of International Environmental Law, second ed. , Cambridge university Press, British, 2003.

[2] Information on <http://www.yueqikan.com/chengshiguishualw/15499.html>

[3] Yan, X. , Crookes, R. J., Energy demand and emissions from road transportation vehicles in China, J. Progress in Energy and Combustion Science, 6 (2010) 651 – 676.

[4] Information on http://www.caijing.com.cn/2009-08-30/110230918_1.html

[5] Schipper, L., Wei, S.N., Rapid Motorization in China: Environmental and Social Challenges, first ed. , World Resource Institute, Washington, DC, 2004.

[6] Darido, G., Torres-Montoya, M., Mehndiratta, S., Urban Transport and CO₂ Emissions: Some Evidence from Chinese Cities, first ed. , World Bank Discussion Paper, 2009.

[7]Information on http://www.crowncapital.com.hk/report_addinfo.php

[8]Jianwei Sun, Rongqin Zhao, Xianjin Huang, Zhigang Chen. Research on Carbon Emission Estimation and Factor Decomposition of China from 1995 to 2005, J. Journal of Natural Resources 25 (2010) 1284-1295.

[9]Information on <http://www.chuandong.com/about/index.asp>

[10] Sources are provided by the Marketing Group of Crown Capital Enterprise Ltd. of Hong Kong.

Acknowledgements

The authors are greatly in debt to Crown Capital Enterprise Ltd. of Hong Kong for their years of support in the research and study in the environmental issues by the Law School of Renmin University of China and Xian Institute of Highway Research of China. The authors are also grateful to Dr. Michael Lee, Ph.D. in Physiology and Oral Surgeon of University of Alberta, Canada and our colleagues Yuan Gao, LL.M., and Jiangyuan Fu, LL.M. of Renmin University of China for extending so much of their valuable time and effort in editing this paper.