



Identificando Oportunidades de Eficiencia Energética en Medellín



ANALISIS RESULTADOS BENCHMARKING E INICIATIVAS APLICABLES A LA CIUDAD DE MEDELLIN

ANALISIS BENCHMARKING SECTOR TRANSPORTE

Consumo de Energía en el Transporte Publico

Este indicador representa el consumo energético en MJ por cada kilometro que un pasajero viaja en transporte publico. Es importante resaltar que en este sector no se pudo encontrar todos los datos requeridos por lo tanto fue necesario hacer aproximaciones en algunos casos. El transporte publico en Medellín esta representado por la flota de buses públicos (propiedad privada), el Metroplus (Bus de rápido transito), el Metrocable (Góndola elevada que sirve como transporte de las personas que viven en la zona montañosa de Medellín)

El tipo de combustible o energía utilizado por cada uno de estos modos se presenta a continuación:

- Flota de buses: ACPM
- Metroplus: Gas Natural
- Metro: Energía Eléctrica
- Metrocable: Energía Eléctrica
- Próximamente el Tranvía: Energía Eléctrica

El Consumo de Energía en el Transporte Publico es un poco mas alto que el promedio de todas las ciudades. El alto consumo de combustibles no eficientes como ACPM en la ciudad puede ser la explicación a esta situación. Ver Figura 1

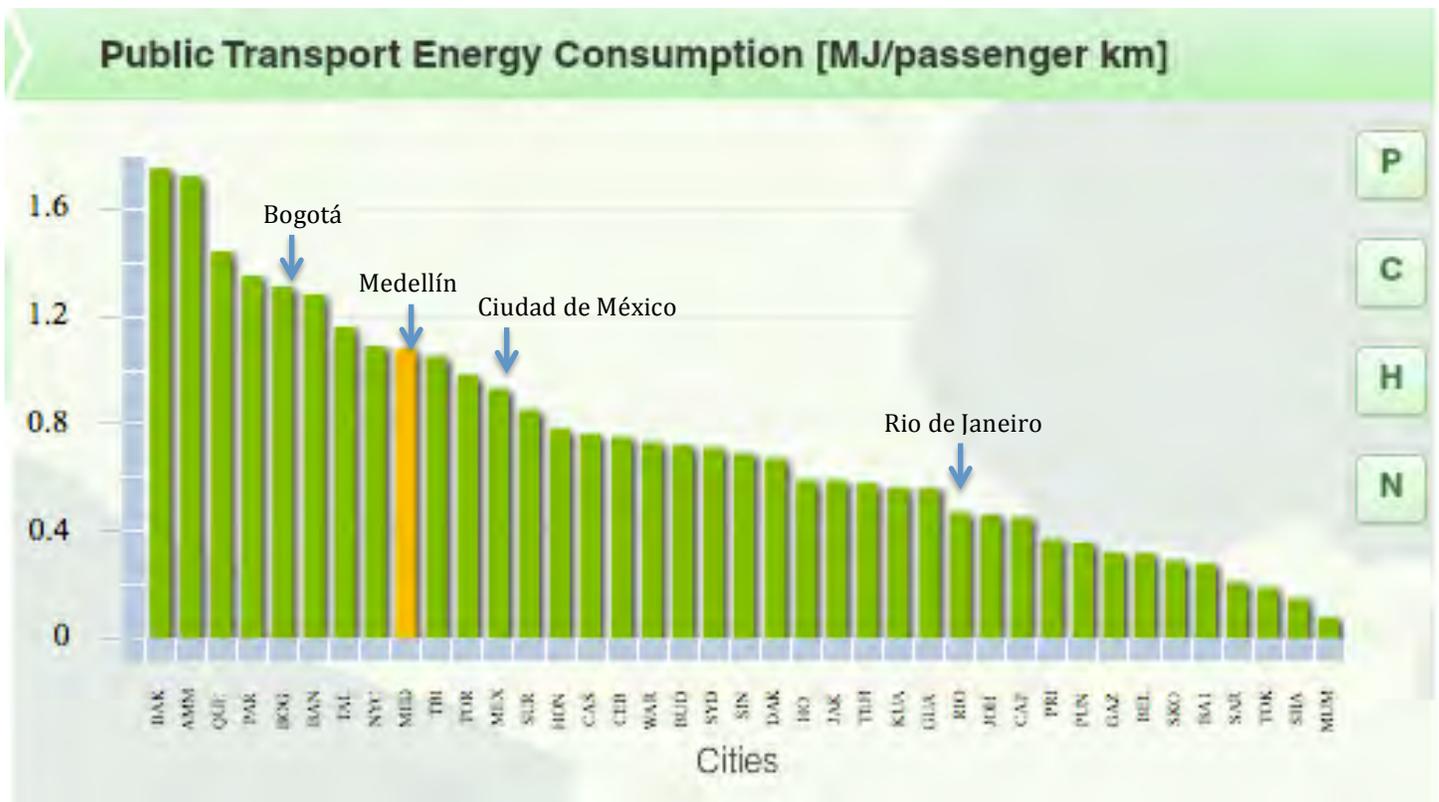
Resultados Benchmarking

- El consumo promedio de todas las ciudades es 0.73 MJ/pasajero km
- El consumo de Medellín fue 1.0 MJ/pasajero km, un poco menor que el promedio
- El Consumo de Bogotá es 23% superior (1.3110 MJ/pasajero km)
- Sídney y Rio de Janeiro tienen un mejor desempeño que Medellín

Observaciones

- Sobreoferta de buses en la ciudad. Existen mas de 3000 buses en operación.
- El 98.8% de los buses trabajan con ACPM.
- El consumo de ACPM representa el 41% del consumo energético total de la ciudad.
- Los buses son el medio de transporte publico mas popular, realiza el 29% de los viajes en la ciudad.
- El Metro, Metroplus y Metrocable representan tan solo cerca del 9% de los viajes totales en la ciudad según encuesta Origen - Destino.

Figura 1: Consumo de Energía en el Transporte Publico



Fuente: Resultados Benchmarking TRACE

Mejoramiento Continuo

- Medidas de incremento de la capacidad del Metro, Metroplus y Metrocable están en proceso.
- Uso de energías mas limpias como la eléctrica para el funcionamiento del Metro y Metrocable y Gas Natural para el Metroplus
- Nuevos proyectos como el tranvía en desarrollo con energías limpias.
- Sistemas inteligentes manejo del trafico como cámaras, avisos iluminados con mensajes en tiempo real del estado del transito entre otros.

Consumo de Energía en el Transporte Privado

Este indicador comprende el consumo energético por cada Km que una persona recorre en transporte privado. Dentro de el transporte publico se ha considerado los automóviles, los taxis y las motocicletas.

Medellín es una Ciudad con baja utilización de motorizados según Siemens. Esto podría explicar el buen desempeño de la ciudad en el consumo de energía para transporte privado. Ver desempeño de la ciudad de Medellín en la figura 2.

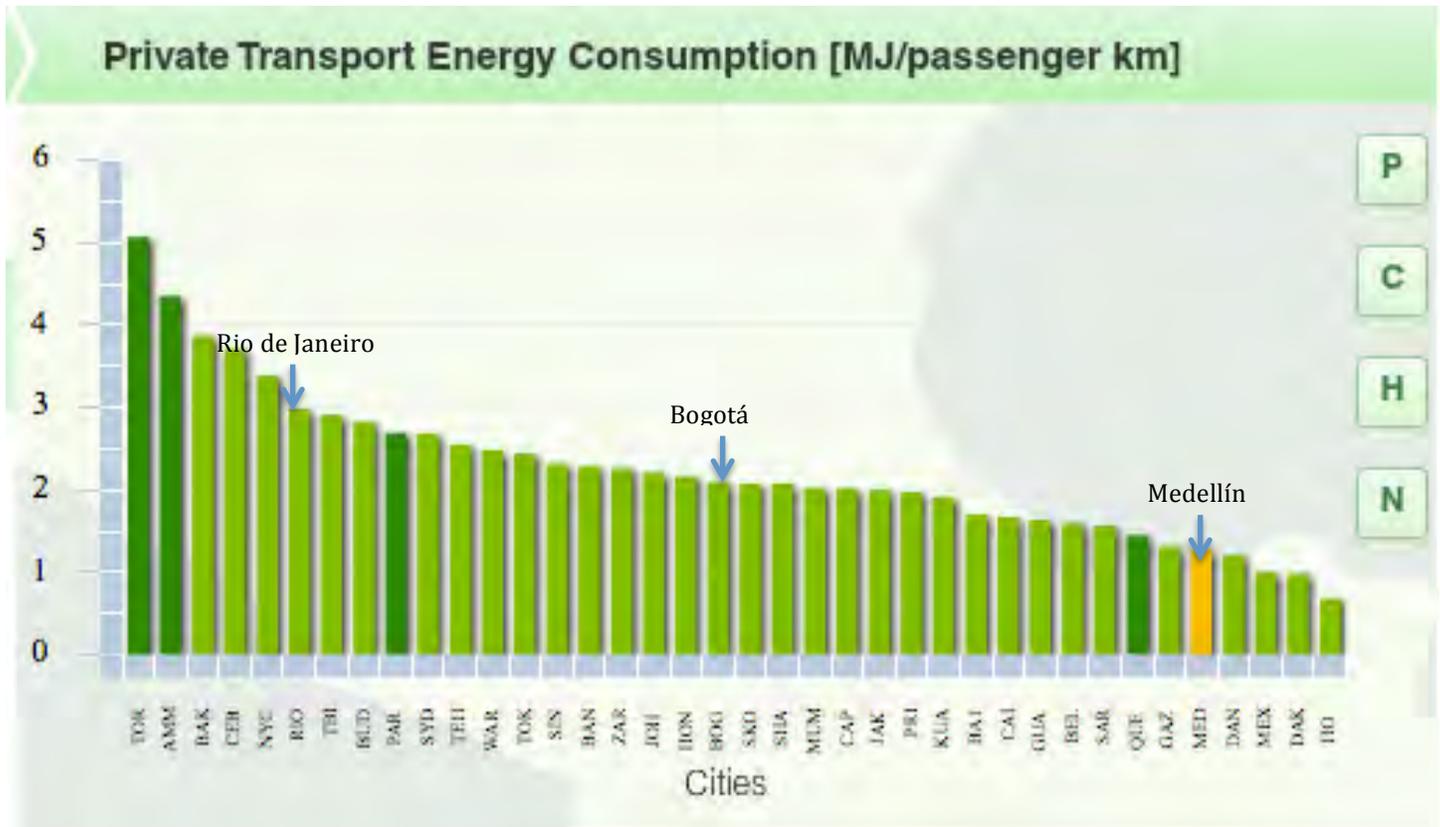
Resultados Benchmarking

- El consumo de energía de Medellín es 1.3 MJ/pasajero km
- El consumo energético en Bogotá es 38% mayor.
- El consumo energético en Rio de Janeiro es 56% mayor.

Observaciones

- De acuerdo a Siemens, Medellín tiene un índice muy bajo de carros y motos: **0.07 vehículos por persona**. El promedio actual en ciudades similares en Latino América es 0.3.
- Sin embargo, la anterior afirmación no es absoluta porque el parque automotor mantiene una tendencia creciente cada año.

Figura 2: Consumo de Energía en el Transporte Privado.



Fuente: Resultados Benchmarking TRACE

Mejoramiento Continuo

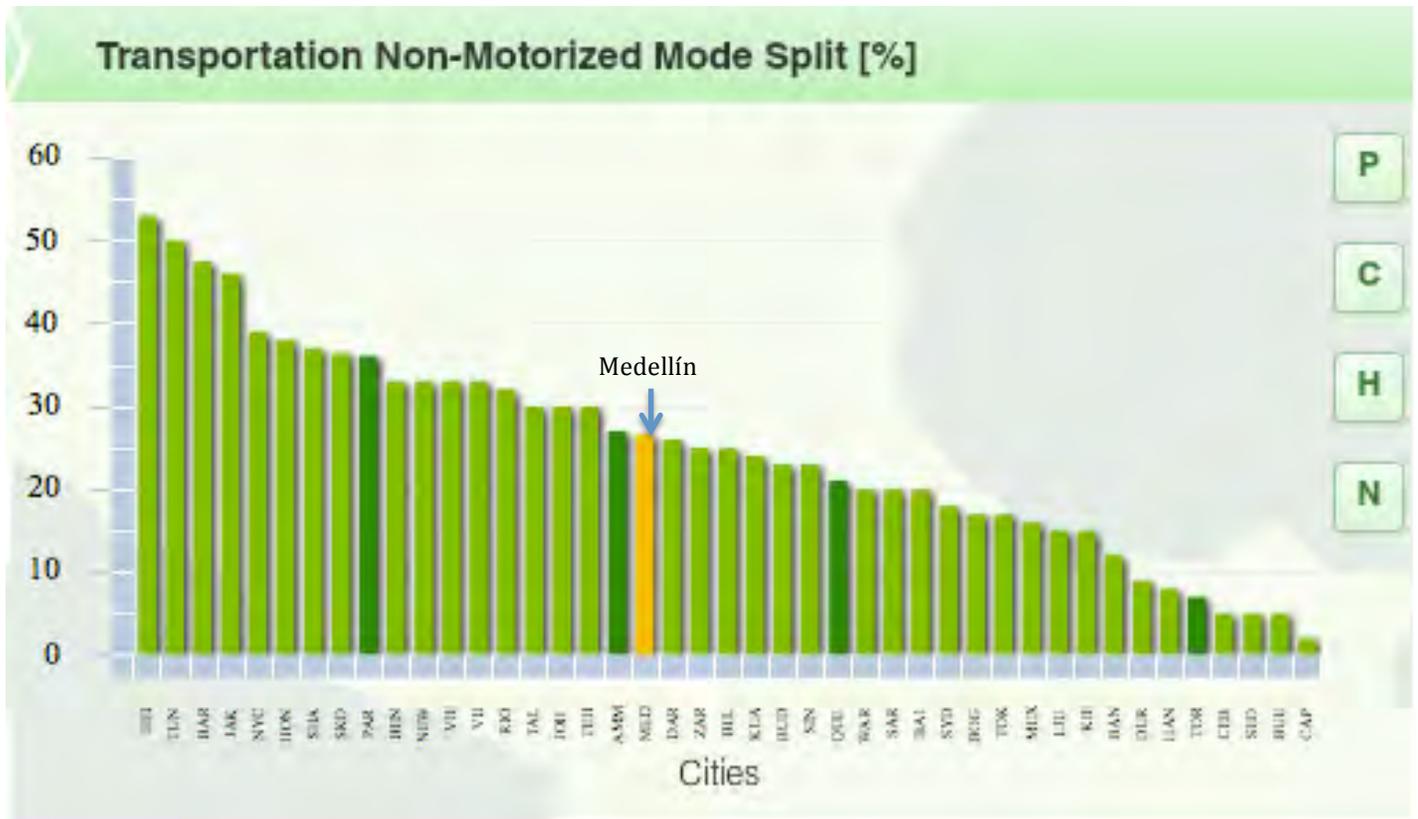
- Sistemas inteligentes de manejo del trafico con cámaras, tableros iluminados con mensajes sobre trafico en tiempo real entre otros.
- Restricción de parqueo en calles publicas y asignación de Celdas permitidas con cobro de tarifas altas.
- Medidas de restricción por emisiones de gases en vigencia.

Porcentaje de Viajes que se realizan con No-Motorizados

Este indicador representa el porcentaje de viajes en que las personas usan medios de transporte no motorizados. En Medellín el 26.1% de los viajes se generan caminando, solo el 0.5% de los viajes se realizan en bicicleta. A pesar de que el modo caminar parece ser muy popular, es importante saber que esos viajes se hacen regularmente para distancias muy cortas donde un medio motorizado no se necesita.

Las cifras expuestas anteriormente, permiten concluir que el desempeño de Medellín no es bueno en relación con este indicador. Aunque el modo “caminata” es alto en Medellín, un porcentaje de viajes en bicicletas tan bajo (0.5%) denota que hacen falta mas promoción de este medio de transporte en la ciudad. Ver Resultados benchmarking en la figura 3.

Figura 3: Porcentaje de Viajes en No-Motorizados



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- El Porcentaje total de transporte no motorizado es de 26.6%
- El 26.1% de viajes se hacen caminando.
- El 0.5% de los viajes se hacen en bicicleta

Observaciones

- A pesar de que el modo caminar parece ser muy popular en la Ciudad, es importante resaltar que estos viajes representan generalmente pequeñas distancias donde un motorizado no es necesario.
- La geografía montañosa de la ciudad no favorece el desarrollo de ciclo rutas masivamente.

Mejoramiento Continuo

- La ciudad acaba de terminar exitosamente un proyecto piloto donde se construyo una ciclo ruta con préstamo gratis de bicicletas que conecto una estación de metro con una universidad de la ciudad.

ANALISIS INICIATIVAS

1. Restricción de las Emisiones de Vehículos

La secretaria de Transporte de Medellín desde hace varios adelanta medidas para el control de emisiones de gases en vehículos. La estrategia para este control consiste en hacer operativos en vía pública para verificar si el vehículo se encuentra dentro de los límites permisibles de emisiones establecidos en la norma (Resolución 910 de 2008). Cuando un vehículo no cumple esta regulación es sancionado con 30 salarios mínimos.

Esta iniciativa podría ser fortalecida en la ciudad si por ejemplo como en el caso de Londres, se utiliza la tecnología existente como cámaras de tráfico para tomar fotos de las placas de los carros y comparar estas con la base de datos de los vehículos registrados como que cumplen la regulación de emisiones de gases. Cuando una placa obtenida por una foto no se encuentra en la base de datos quiere decir que no cumple la regulación. Ver Anexo 1 para conocer la iniciativa.

Otra de las estrategias que la ciudad implemento para reducir las emisiones de gases consistió en pacto que firmó la Administración Municipal y Ecopetrol para mejorar la calidad del combustible distribuido en Medellín.

2. Optimización de Flujo de Tráfico

La medida mas popular utilizada en Medellín para regular el tráfico es el Pico y Placa, esta restringe el uso de vehículos en las horas pico una vez por semana según las placas. Si bien esta medida logro reducir el tráfico en los primeros años de implementación, en los últimos años el tráfico en Medellín ha empeorado especialmente en las horas pico.

Medellín implemento un sistema inteligente de movilidad compuesto por varias herramientas tecnológicas como medida para regular el tráfico, algunas de las tecnologías aun se encuentran en etapa de implementación o planeación. Las tecnologías son las siguientes:

- Cámaras de fotodeteccion para captar infracciones.
- Paneles informativos en las vías para comunicar en tiempo real y de forma oportuna el estado de las vías. Esta iniciativa ayuda a los conductores a tomar decisiones inteligentes sobre las vías sobre las que manejan.
- Optimización de semáforos para el eficiente flujo vehicular, esta optimización permite reducir los tiempos de viajes en la ciudad , actualmente el tiempo promedio de viaje en la ciudad es 39 min.
- Gestión de Flota mediante el monitoreo de los buses con GPS y otras tecnologías. Esto garantizara que los buses respeten los limites de velocidad y paradas en sitios autorizados.
- Circuito cerrado de televisión compuesto por cámaras de ultima tecnología ubicadas en puntos estratégicos de la ciudad. La información sobre las vías recolectada por estas cámaras permite que en el centro de control se hagan estudios de comportamiento vehicular y así tomar decisiones inteligentes sobre como reducir la congestión.
- Software gestor dirigido por el centro de control de transito que integra todos los componentes del sistema y permite facilitar el monitoreo y control de las vías en todo momento.
- Web 2.0 que consiste en la utilización de redes sociales como Twitter o Facebook para informar en tiempo real sobre el estado de las vías y permitirle al ciudadano interactuar en temas de movilidad.

Si bien algunas medidas de evaluación del tráfico como el tiempo promedio de viajes en motorizados (39 min) y la velocidad promedio en la ciudad (34 km/h) han venido incrementándose en los últimos años dando cuenta de un empeoramiento del tráfico en la ciudad, es importante reconocer que algunas de las iniciativas como por ejemplo el sistema inteligente de movilidad han sido recientemente implementadas y los beneficios se evidenciarán más adelante.

Las iniciativas nombradas anteriormente demuestran que hay un compromiso de la ciudad pero mejorar el flujo del tráfico, es por esto que se recomienda explorar otras iniciativas exitosas para la reducción del tráfico en la ciudad como por ejemplo: Cargo por congestión, carriles reversibles, pares viales, carpooling entre otros. Ver anexo 2,3 y 4

3. Transporte No-Motorizados

Hasta la fecha la iniciativa más sobresaliente en la ciudad de Medellín sobre este tema, consistió en la construcción de una cicloruta con un trayecto que comienza en una estación de metro y va hasta una de las Universidades en Medellín. En la estación de metro se instalaron estaciones de préstamo de bicicletas totalmente gratis para los estudiantes que usen este medio para llegar a su universidad. La idea es expandir esta iniciativa en las zonas de Medellín que sean adecuadas para la construcción de ciclorutas.

Es importante que la Ciudad siga desarrollando proyectos como el nombrado anteriormente para incentivar el uso de la bicicleta en la ciudad y que se logre aumentar el porcentaje de viajes en este modo. Como se señaló anteriormente, este indicador fue del 0.5% en el año 2012 según la encuesta de origen-destino. Se recomienda revisar Anexo 5 que contiene casos éxitos de implementación de este tipo de iniciativas.

4. Utilizar Incentivos Fiscales para Mejorar la Eficiencia del Transporte Privado

Esta iniciativa consiste en un programa de “chatarrización” de vehículos demasiado viejos. Esta iniciativa contribuye a la reducción de emisiones de gases. El Anexo 6 explica algunos casos exitosos en otros países.

Resumen Iniciativas

- Control de emisión de gases en vehículos
- Utilizar incentivos fiscales para mejorar la eficiencia del transporte privado.
- Incentivar el uso de modos no motorizados y desarrollar la infraestructura.
- Medidas para regular el tráfico: Carpooling, Cobro por Congestión, Carriles Reversibles y los Pares Viales

A continuación se hace un análisis de los beneficios estimados suponiendo beneficios entre el 10% y 15% con la aplicación de las intervenciones apropiadas. Los beneficios son estimados para 1 y 10 años en tres categorías: Ahorro en combustible, ahorro financiero y emisiones de CO₂ evitadas. Ver figura 4.

Figura 4: Beneficios Estimados

Beneficios Estimados		
Indicador	Anual	10 Años
Ahorro en Combustible	54 a 81 millones de litros	541 a 812 millones de litros
Ahorro Financiero	US\$ 71 a 107 Millones	US\$ 713 a 1.070 Millones
Emisiones de CO2 evitadas	130.000 a 195.000 tCO2	1,3 a 1,9 Millones de tCO2

*Suponiendo ahorros de un 10% a 15% con la aplicación de las intervenciones apropiadas

ANALISIS BECHMARKING SECTOR RESIDUOS

El sector de residuos es operado por las Empresas Varias de Medellín E.S.P. Esta es una empresa industrial y comercial del estado encargada de la recolección y disposición de los residuos y otras actividades complementarias en el municipio de Medellín. Las actividades relacionadas con el tratamiento de residuos y reciclaje son gestionadas o manejadas por la secretaria de medio ambiente, empresas privadas y recicladores informales. Esta empresa recientemente se acaba de unir como una filial mas de EPM.

Generación de Residuos per Cápita

Entre las ciudades con similar índice de desarrollo humano, Medellín es la segunda que genera menos residuos per cápita. Ver figura 5.

Resultados Benchmarking

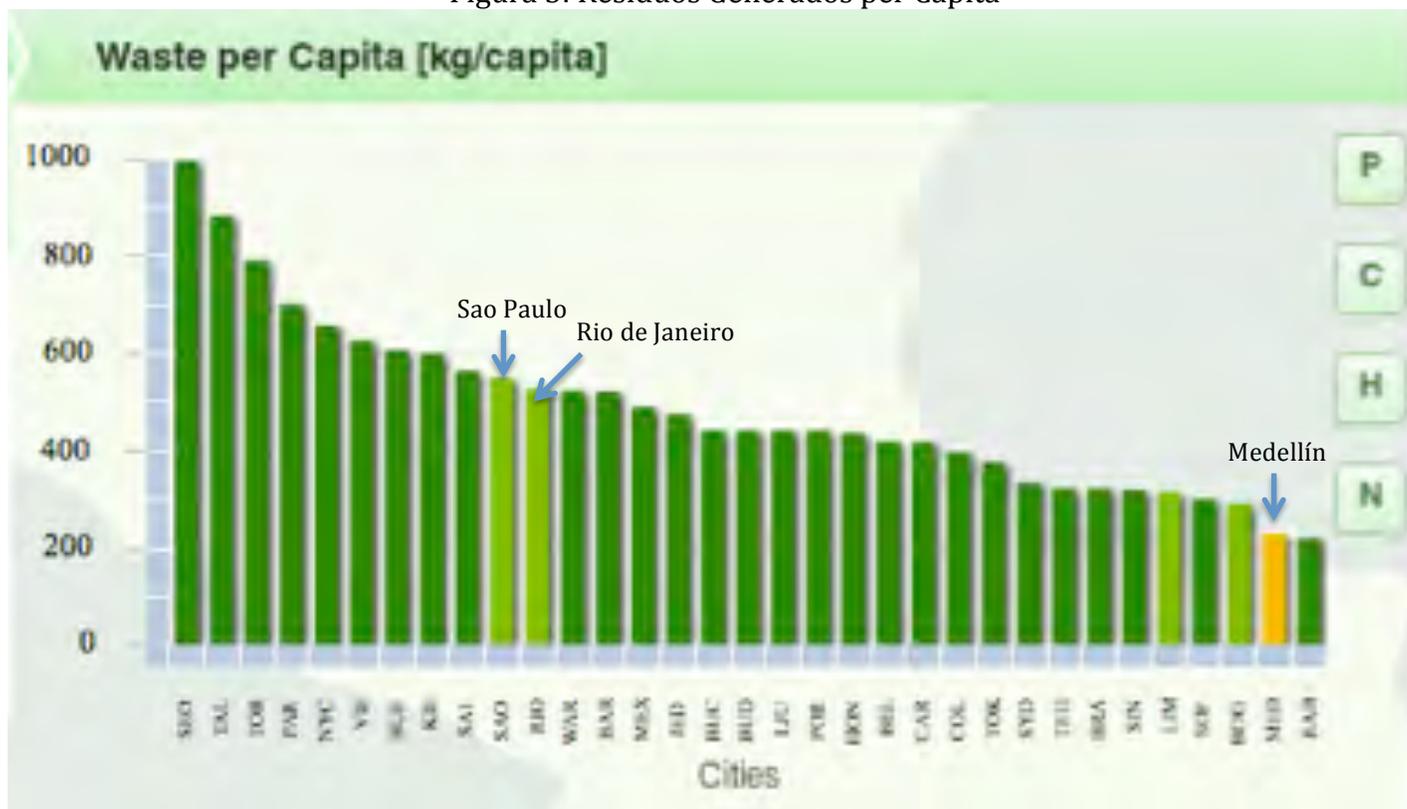
- Medellín es la Ciudad que genera menos residuos entre las ciudades en TRACE de Latino América.
- Rio de Janeiro y Sao Paulo generan el doble de residuos de lo que genera Medellín

Observaciones

- Medellín tiene muy desempeño sobresaliente en la captación y disposición de residuos. En ambos casos 97.86%.
- El sector de residuos podría fortalecer su operación si adoptaran practicas innovadoras como estaciones de transferencia y plantas de tratamiento con nuevas tecnologías.

En el pasado se ha estudiado la posibilidad de generar energía a partir de los residuos, pero aun no se han generado proyectos pilotos.

Figura 5: Residuos Generados per Cápita



Fuente: Resultados Benchmarking TRACE

Porcentaje de Residuos Sólidos Reciclados

Medellín tiene oportunidades de mejorar el porcentaje de residuos reciclados. Actualmente solo el 12% se recicla. Ver figura 6.

Resultados Benchmarking

- Medellín es una de las ciudades que menos recicla en comparación con otras ciudades, sin embargo, su porcentaje de reciclaje es mayor que muchas ciudades en Colombia y Latinoamérica (Ciudad de México, Bogotá, Cali)

Observaciones

- No existe la cultura de reciclaje en la fuente.
- 30% de los residuos podrían ser aprovechados.
- Recuperación informal predomina, representa 54%.
- No existen rutas selectivas de recolección de materiales.
- Se estima que en promedio cada recuperador gestiona 73 Kg/día, lo que implica que los recuperados desvían alrededor de 8.400 ton/mes.
- Si los recuperadores cesaran su actividad, las EEVVM requerirían de al menos 25 vehículos compactadores mas (Alrededor de 520 millones de pesos)

Figura 6: Porcentaje de Residuos Sólidos Reciclados



Fuente: Resultados Benchmarking TRACE

Mejoramiento Continuo

- La secretaria de Medio Ambiente anticipó que en Naranjal (Barrio) la Alcaldía hará un edificio piloto con varias cabinas para separar residuos desde la fuente.
- Se hacen varias campanas de promoción del reciclaje en la fuente.
- Capacitaciones sobre gestión de residuos a recicladores informales.

ANALISIS INICIATIVAS

1. Programas de Modernización de la Flota y Mantenimiento.

Las Empresas varias de Medellín cuenta actualmente con una flota de 154 vehículos recolectores. Aproximadamente el 36% de esa flota es de modelos entre el año 1982 y 2000, es decir son vehículos con casi 14 años o mas de antigüedad. En estos momentos la empresa se encuentra en el proceso de comprar nuevos vehículos, entre 37 y 47 vehículos nuevos a gas para el primer trimestre del año 2014. La flota actual trabaja con ACPM, gasolina corriente y extra. Los planes pilotos que se han hecho con los nuevos vehículos han arrojado ahorros de hasta 37% en combustibles. Se recomienda a la ciudad revisar los casos sobre esta iniciativa en otros países ver el [Anexo 7](#). Estas experiencias pueden ayudar fortalecer el plan de modernización de la flota en la empresa y a la vez un plan de mantenimiento en el resto de la flota.

2. Planeación de la Infraestructura de Residuos, instalaciones de transferencia y clasificación.

La Empresas Varía de Medellín E.S.P no tiene una planta de reciclaje, o de separación ni una tercera frecuencia de ruta selectiva. La empresa simplemente recolecta y dispone. La separación y tratamiento de basuras lo hacen entes privados y recolectores informales. La Secretaria de Medio Ambiente tiene solo 2 centros de acopio urbanos y 5 rurales, en la ciudad existen cerca de 260 plantas de tratamiento de residuos privados.

El rol de la alcaldía en estas plantas de tratamiento o unidades productivas como también se les llama es básicamente fortalecer y dar apoyo en temas de salud ocupacional, delimitación y PGIRS. Actualmente la secretaria de ambiente esta en la tarea de fortalecer 120 unidades productivas. Con los recolectores informales, la estrategia de la alcaldía es mantener los precios del material reciclado altos. Esto lo hace comprando material reciclado en las plantas de su propiedad a precios altos. Con esto la alcaldía incentiva un pago justo a los recicladores informales, de igual forma se les da dotación.

Es importante resaltar que ninguna de las iniciativas ya adoptadas por la alcaldía esta enfocada a mejorar la eficiencia energética de la infraestructura de residuos. Aunque la mayoría del mercado de tratamiento y reciclaje es manejado en organizaciones privadas, el apoyo del municipio además de enfocarse salud ocupacional, pgirs, etc puede evolucionar al punto de entrenar, informar concientizar o hasta financiar proyectos de eficiencia energética en las unidades productivas. Ver especialmente caso de Londres e Italia en el [Anexo 8 y 9](#).

3. Estaciones de Transferencia

El municipio todavía no cuenta con estaciones de transferencia, pero se tiene planeado tener una en el año 2015. El estudio de la forma en que se ejecutara apenas esta iniciando, pero según personal de las empresa operadora de residuos, la idea es implementar trato-camiones a gas (estos transportan la cantidad de residuos que pueden transportar 3 recolectores). [El anexo 10](#) muestra varias experiencias que pueden ser tenidas en cuenta por la ciudad en la planeación de ejecución de esta iniciativa.

4. Otras iniciativas de captura de gas en los rellenos y programas de basura a energía.

EMVARIAS tiene un sistema de chimeneas en las diferentes zonas del relleno que extraen el gas y lo quema. EPM hizo un estudio con este sistema para evaluar la posibilidad de producir gas vehicular o gas para meterlo en la red de gas natural. La evaluación financiera del proyecto arrojo resultados negativos ya que es un proyecto muy costoso y la energía en Colombia es muy económica. En la actualidad se están buscando recursos internacionales para realizar una prueba piloto. Puede ser útil para la ciudad estudiar casos exitosos de implementación de estas iniciativas que le sirvan de modelo para iniciar el estudio mas profundo de esta iniciativa para Medellín. [Ver Anexo 11 y 12](#) .

Resumen Iniciativas

- Programas de Modernización de la Flota y Mantenimiento.
- Planeación de la Infraestructura de Residuos, instalaciones de transferencia y clasificación.
- Estaciones de Transferencia
- Otras iniciativas de captura de gas en los rellenos y programas de basura a energía.
- Educación sobre el reciclaje en la fuente.

A continuación se hace un análisis de los beneficios estimados suponiendo ahorros entre el 20% y 30% con la aplicación de las intervenciones energéticas apropiadas. Los beneficios son estimados para 1 y 10 años en tres categorías: Ahorro en combustible, ahorro financiero y emisiones de CO2 evitadas. Ver figura 7.

Figura 7: Beneficios estimados

Beneficios Estimados		
Indicador	Anual	10 Años
Ahorro en Combustible	854 mil a 1.3 millones de litros	8,5 a 12,8 millones de litros
Ahorro Financiero	US\$ 1,1 a 1,7 Millones	US\$ 11,3 a 16,9 Millones
Emisiones de CO2 evitadas	2.052 a 3.077 tCO2	20.500 a 30.700 tCO2

*Suponiendo ahorros de un 20% a 30% con la aplicación de las intervenciones apropiadas

SECTOR AGUA, ENERGIA Y ALUMBRADO PUBLICO

Estos tres sectores, todos manejados por las Empresas Públicas de Medellín tuvieron resultados muy positivos en el benchmarking, muchas de las iniciativas sugeridas por TRACE ya han sido adoptadas por las empresas en estos tres diferentes sectores. *Las iniciativas aquí expuestas son producto de las entrevistas hechas a los funcionarios de estas tres dependencias en EPM.*

Empresas Públicas de Medellín

Las Empresas Públicas de Medellín (EPM) es una empresa comercial e industrial propiedad de la Alcaldía de Medellín, fundada en 1920. Presta los servicios de energía eléctrica, agua potable saneamiento y gas por red en los lugares donde tiene presencia. La reputación de EPM es muy favorable tanto en Antioquia donde están la mayor proporción de sus clientes como en todo el país. Encuestas y evaluaciones nacionales e internacionales muestran el liderazgo de esta compañía en temas que van desde su gestión operativa hasta social.

El grupo EPM es reconocido por su desempeño económico como la tercera empresa del país en generar más utilidades y laboralmente como la cuarta mejor empresa para trabajar. Por su gestión social en EPM resaltan además de iniciativas enfocadas al apoyo de colegios y bibliotecas, programas sociales de gran impacto social como lo son la energía y agua prepago y programas de financiamiento social. El programa de energía prepago fue diseñado con el fin de adaptarse a la capacidad económica del cliente y esta estrategia resultó en un gran éxito; la meta era conectar 33 mil usuarios en contadores prepagos en un lapso de 5 años, pero en 4 años EPM logró conectar 130 mil superando las expectativas de proyecto. Esta iniciativa se convirtió en una mejor opción frente a la ilegalidad y el no pago de servicios y contribuyó a un uso más racional de la energía.

Frente al éxito de Energía Prepago, EPM decidió expandir la iniciativa con el programa piloto de Agua Prepago el cual justo finalizó este año con resultados positivos y pruebas de las bondades del sistema.

Además una vez este sistema muestra su aporte a la cultura del ahorro y uso racional del agua. Actualmente EPM se encuentra esperando el marco regulatorio del sistema para poder masificarlo. Por otro lado, EPM cuenta con varios programas de financiamiento social para los mas pobres, uno de los mas exitosos ha sido la habilitación de viviendas que es un crédito hasta por 10 años que busca financiar las conexiones a los servicios públicos de las familias con pocos recursos.

Las Empresas Publicas de Medellín EPM se ha logrado ganar la confianza y credibilidad de sus clientes; según la evaluación de medición de políticas y mecanismos de transparencia promovido por la corporación de transparencia de Colombia, la calificación de EPM en el tema de transparencia fue de 86 puntos mientras la calificación del sector de energía y gas fue 78 puntos. Por otro lado la medición del indicador global de Satisfacción del cliente en el año 2012 fue de 84.4%, mostrando esto que el desempeño de EPM para la prestación de servicios públicos es sobresaliente.

Finalmente y para ratificar el liderazgo y buen desempeño de EPM, una evaluación internacional “*Dow Jones Sustainability Index*” usada por las empresas que cotizan en la bolsa, califico a EPM con 69 puntos en electricidad y 72 puntos en agua de 100 puntos posibles. El líder en a evaluación obtuvo 84 puntos en cada modalidad.

Estas y algunas otras acciones en las que no profundizaremos en este informe, explican el éxito de compañía y porque esta juega un rol trascendental en desarrollo económico y social del departamento de Antioquia.

ANALISIS BENCHMARKING SECTOR AGUAS

La empresa operadora de el sistema de agua potable y alcantarillado es EPM. El servicio de agua potable se hace en dos pasos fundamentales: la producción de agua potable que comprende tanto la captación y potabilización y la distribución de agua potable en la red primaria y secundaria. El servicio de agua potable implica las actividades recolección y transporte de aguas residuales y el tratamiento del agua residencial. Debido a que Medellín es una ciudad montañosa las actividades necesarias para prestar estos dos servicios públicos implican el bombeo de agua.

Consumo de agua per Cápita

Medellín es una de las ciudades con menor consumo de agua per cápita por día. Ver figura 8

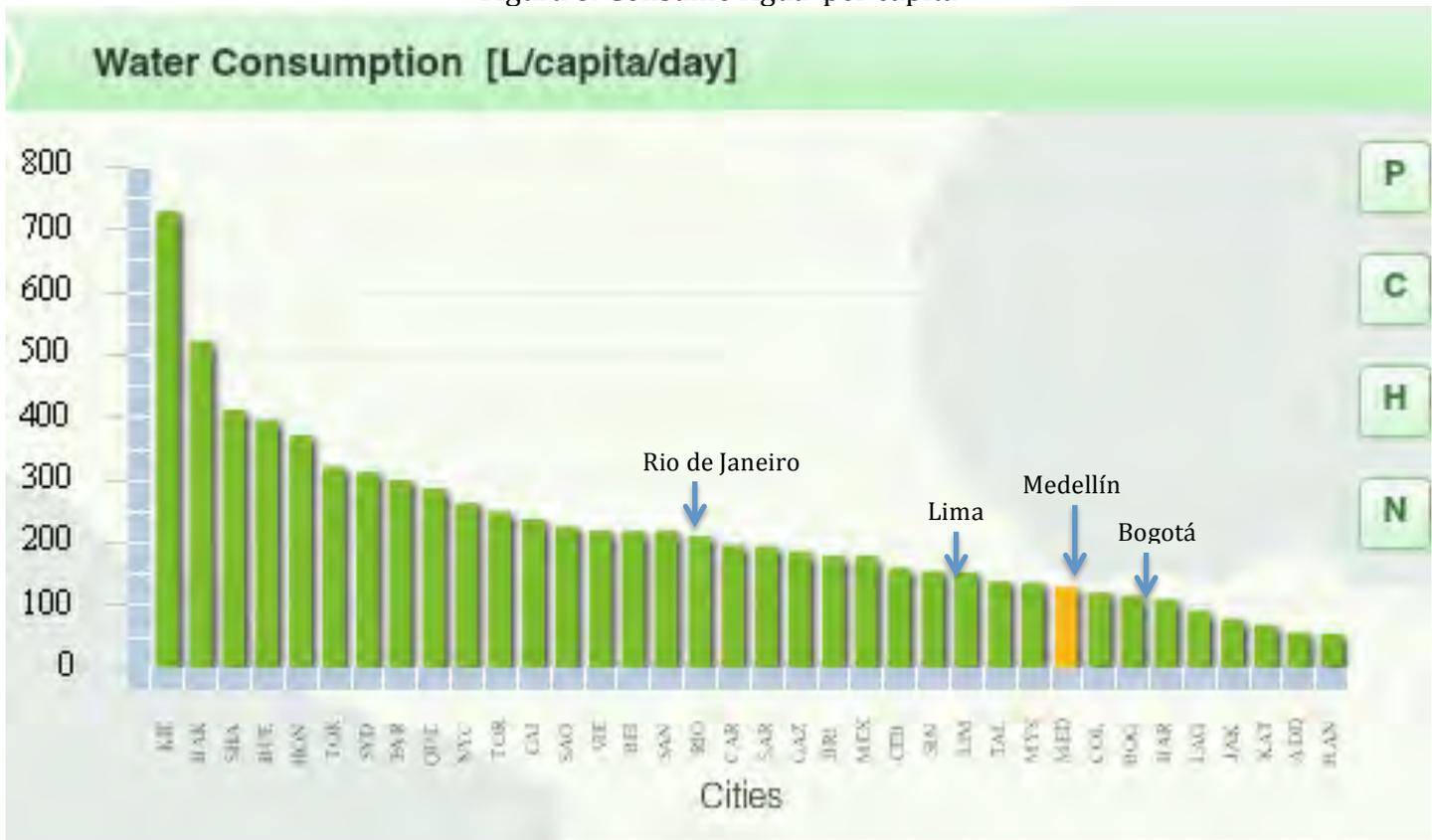
Resultados Benchmarking

- El consumo total de agua es 129 litros/cápita/día
- Comparando Medellín con otras ciudades en Latino América, solo Bogotá tiene menor consumo (114.3 litros/cápita/día)
- Buenos Aires, rio de Janeiro y Lima tienen consumos mas elevados (395,2 y 151 litros/cápita/día) respectivamente.

Observaciones

- Existen programas educativos en escuelas sobre el buen uso del agua
- Iniciativas de agua prepago en implementación.
- EPM acaba de finalizar exitosamente el plan piloto de agua prepago con resultados positivos. Esta iniciativa incentiva el uso racional del agua.

Figura 8: Consumo Agua per cápita



Fuente: Resultados Benchmarking TRACE

Densidad de Producción de Agua Potable.

EPM cuenta con 11 plantas de producción de agua potable, con una capacidad de potabilización de 17.25 m³/s y una producción neta de 9.20m³/s.

La densidad de producción de agua potable es relativamente alta en Medellín, una de las posibles causas puede estar relacionada con la geografía de la ciudad que implica bombeo de agua para el transporte de esta. Ver desempeño de Medellín en la figura 9.

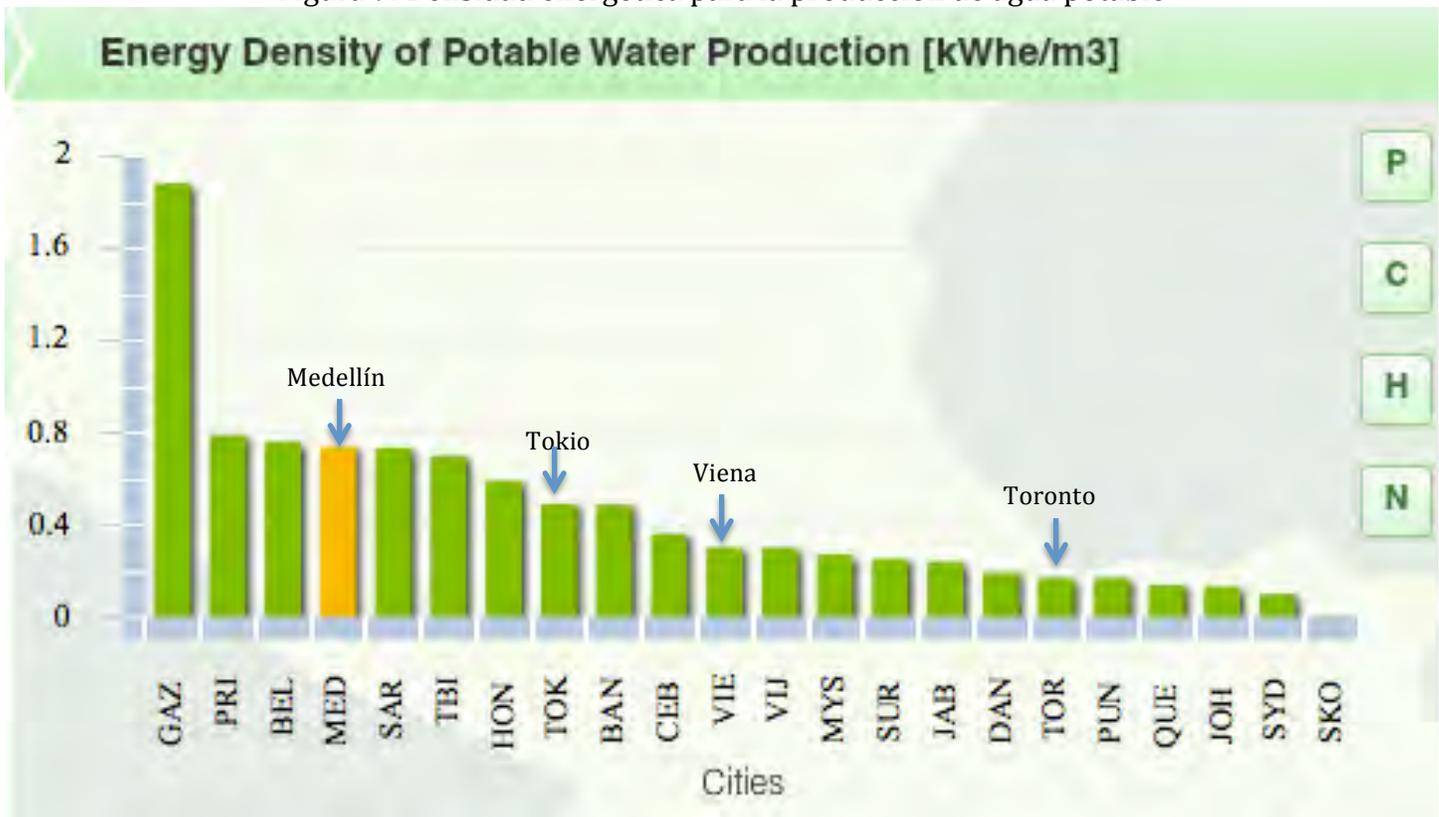
Resultados Benchmarking

- La densidad de energía para la producción de agua potable en Medellín es 0.73 Kwh/m³
- Medellín es la tercera ciudad con mayor densidad de energía para la producción de agua potable.
- La energía necesaria para producir un m³ de agua potable es menor en ciudades como Tokio, Viena y Toronto

Resultados Benchmarking

- La densidad de energía para la producción de agua potable en Medellín es 0.73 Kwh/m³
- Medellín es la tercera ciudad con mayor densidad de energía para la producción de agua potable.
- La energía necesaria para producir un m³ de agua potable es menor en ciudades como Tokio, Viena y Toronto

Figura 9: Densidad energética para la producción de agua potable



Fuente: Resultados Benchmarking TRACE

Observaciones

- Medellín es una ciudad montañosa, en algunas zonas el transporte se puede realizar por gravedad, en otras zonas debe ser por bombeo.
- En la actualidad se viene adelantando estudios para la utilización de las fuentes alternativas de agua, aún no se tiene datos de factibilidad financiera, pero esto podría implicar fuentes mas cercanas a los lugares de suministro.
- Para este indicador no existe ninguna ciudad en Latinoamérica con la que se pueda comparar el desempeño de Medellín.
- El costo de la energía en Medellín es uno de los mas bajos comparados con el resto de las ciudades en la base de datos de TRACE.

Densidad de Tratamiento de Aguas Residuales

EPM cuenta con una planta de tratamiento de agua residual con capacidad de tratamiento de 1.8 m³/s y tratamiento neto de 1.36m³/s

La energía consumida para tratar aguas residuales es alta comparada con el resto de la ciudades en TRACE. Ver figura 10

Figura 10: Densidad Energética para el tratamiento de Aguas Residuales



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- La densidad de energía para el tratamiento de aguas residuales es 0.4Kwh/m3.
- Toronto y Sídney tienen mejor desempeño energético en el tratamiento de aguas residuales que Medellín.
- Se necesita bombear el agua en las zonas montañosas generando más consumo energético.

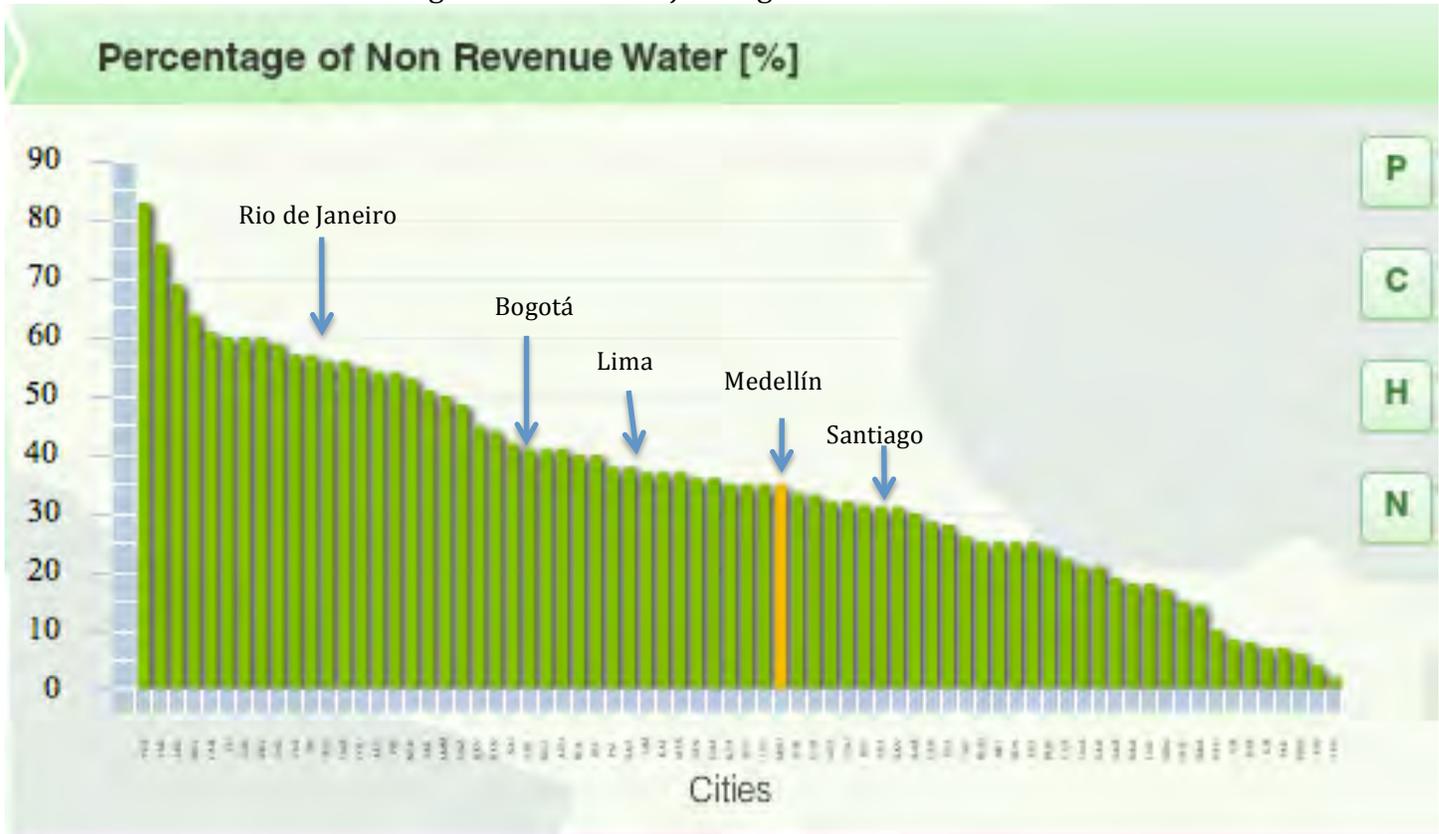
Observaciones

- Existe un programa de aprovechamiento del biogás producido en el proceso de digestión anaeróbica de lodos que subsidia el 30% de las necesidades de energía eléctrica de la PTAR San Fernando.
- Para este indicador no existe ninguna ciudad en Latinoamérica con la que se pueda comparar el desempeño de Medellín.
- El costo de la energía en Medellín es uno de los más bajos comparados con el resto de las ciudades en la base de datos de TRACE.

Porcentaje de Agua no Contabilizada

El porcentaje de agua no contabilizada es alto en la ciudad de Medellín (34.87%), sin embargo mucho menor que otras ciudades en Latinoamérica. Ver figura 11.

Figura 11: Porcentaje de agua no Contabilizada



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- El porcentaje de agua no contabilizada en la ciudad es de 34.87%
- Comparando Medellín con otras ciudades en Latino América, esta tiene mejor desempeño que la mayoría de las ciudades excepto por Santiago en Chile.

Observaciones

- Se estima que por fugas se pierde el 16% del agua.
- 18.87% corresponden a otras pérdidas ya sean de mantenimiento del sistema o fraudes en el sistema.
- EPM acaba de finalizar exitosamente el plan piloto de agua prepago con resultados positivos. Esta iniciativa desincentiva los fraudes en el sistema.

ANALISIS INICIATIVAS

1. Mejorar la eficiencia de Motores y Bombas

Estado actual con relación a la iniciativa

- Los sistemas de bombeo tanto del proceso de captación como el de distribución primaria y los instalados en las diferentes plantas de potabilización y tratamiento de aguas residuales fueron

adquiridos con especificaciones según los parámetros de diseño realizados para cada caso en particular.

- La capacidad de bombeo nominal instalada para el proceso de Captación es de 45,640 m³/h, mientras que la capacidad de bombeo utilizada es de 8,903 m³/h. De igual forma en el proceso de Distribución Primaria la capacidad es de 22.873 m³/h y 7.580 m³/h respectivamente.
- Varios programas de modernización de bombas y motores se han hecho en el pasado y se han planeado otras actualizaciones para el año 2014.
- Desde hace cinco años EPM viene trabajando en un proyecto de gestión energética el cual involucra una auditoria energética en cada sistema de bombeo y también anualmente se realizan pruebas de eficiencia de los sistemas de bombeo.
- EPM cuenta con un plan de mantenimiento muy efectivo que ha logrado alargar la vida útil de las bombas de 20 a 30 años.
- En los motores se tienen lineamientos de no rebobinar un motor mas de 2 veces, también se les realiza una serie de pruebas dinámicas y estáticas que dan información de la condición de estos equipos. Toda esta información luego se cruza con la de las auditorias energéticas y se determina la necesidad de reposición o no de los motores, teniendo en cuenta además también el retorno sobre la inversión y la criticidad del sistema.

Los resultados del benchmarking muestran que la densidad de energía de producción de agua potable y tratamiento de aguas residuales es alta comparada con los países en la base de datos de TRACE. Sin embargo es importante tener en cuenta que este indicador solo estaba disponible para una proporción pequeña de ciudades, esto quiere decir que el desempeño de Medellín podría ser mejor comparado con otras ciudades si sus datos estuvieran disponibles.

Otro factor importante a tener en cuenta es la geografía de Medellín versus el resto de las ciudades en la base de datos. Medellín es una ciudad montañosa por lo tanto los procesos de tratamiento de aguas residuales y de potabilización siempre consumirán mas energía que en ciudades no montañosas. Un estudio mas profundo sobre las causas del alto uso de energía e la potabilización y tratamiento podría ser necesario.

A pesar de que algunas iniciativas emprendidas en Medellín para mejorar la eficiencia de motores y bombas van de la mano con algunos de los casos expuestos en el Anexo 13. Se recomienda revisar el resto de los casos expuestos, estas experiencias exitosas enriquecerán la experiencia de Medellín. Ver Anexo 13.

2. Programa de Reutilización de Lodos

Estado actual con relación a la iniciativa

- EPM tiene experiencia en programas de aprovechamiento de lodos. Actualmente la estabilización de los lodos subsidia el 30% de las necesidades de energía eléctrica de la PTAR San Fernando, a través de motogeneradores que aprovechan el biogás producido en el proceso de Digestión Anaeróbica de Lodos. Se considera que soluciones alternativas de energía como enriquecimiento del biogás y la codigestión de lodos tienen especial potencial en Medellín.

- En otra forma de aprovechamiento del lodo, actualmente este es tratado con digestión anaerobia y deshidratado a través de centrífugas, hasta el mes de junio de 2013 se aplicaron los Biosólidos directamente al suelo como fertilizantes en pasturas para ganado lechero y se utilizaron como materia prima para procesos de compostaje ya que cumplen con la norma EPA 503 para biosólidos clase B.

EPM ha incursionado en el aprovechamiento de lodos en los últimos años, se recomienda analizar las recomendaciones sobre el programa de reutilización de lodos en [Anexo 14](#), ya que este contiene las experiencias de varios países que podrá contribuir a fortalecerán la aplicación de Medellín.

3. Programa de detección activa de fugas y manejo de la presión.

Estado actual con relación a la iniciativa

El desempeño de la Ciudad de Medellín en cuanto al porcentaje de agua no contabilizada esta por encima del promedio de las ciudades en la base de datos de TRACE, las siguientes iniciativas adoptadas por EPM dan razón de este desempeño positivo:

- EPM tiene implementado un método basado en el seguimiento a los consumos mínimos nocturnos que se distribuyen en los diferentes sectores hidráulicos del sistema distribución y se acompaña de una estrategia de localización de fugas no visibles por medio de la utilización de equipos acústicos de detección tales como geófonos electrónicos. Esta estrategia permite realizar el control de fugas a costos bajos.
- Cuenta además con cámaras de televisión para la inspección de las redes de alcantarillado, con equipos de inspección de fugas en redes de acueducto. Se cuenta con un sistema de monitoreo y control remoto de la operación de la red primaria (SCADA)
- Finalmente, realiza el control de la presión en las redes del acueducto mediante la instalación de válvulas reguladoras de presión que permiten tener la presión en un rango que garantice la prolongación de la vida útil de las redes, reduciendo el riesgo de presencia de daños por altas presiones o por variaciones altas de ésta. Se puede obtener un nivel mínimo de fugas si se suministra el servicio a los usuarios bajo unos parámetros mínimos y máximos de presión de 15 mca (metro, columna, agua) en horas de máximo consumo y de 60 mca en horas de mínimo consumo en combinación con una estrategia de sectorización se obtiene un nivel económico de fugas.

En el [Anexo 15](#) se puede estudiar otros casos exitosos sobre programas de detección de fugas y manejo de presión en otros países.

ANALISIS BENCHMARKING SECTOR ALUMBRADO PUBLICO

A diferencia de otros municipios, la infraestructura de alumbrado publico de Medellín no es del municipio, aproximadamente 99% pertenece a EPM quien es una entidad descentralizada 100% oficial. EMP tiene un contrato permanente para la prestación de servicio de alumbrado publico de Medellín. Existen unos indicadores asociados donde el municipio ejerce control sobre lo que pasa en EPM y tiene un interventoría contratada. La financiación para alumbrado publico se obtiene en un 90 - 95% de lo que recauda del impuesto y el 5% sale del presupuesto del municipio.

Electricidad Consumida por Km de Camino Iluminado

Los estándares de iluminación altos de Colombia y el hecho que Medellín es una de las Ciudades mejor iluminadas del país, pueden estar generando un consumo de electricidad por Km de vía un poco superior al del promedio de las ciudades. Ver figura 12.

Figura 12: Electricidad Consumida por Km de Camino Iluminado



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- El consumo eléctrico en Medellín es 25.025,2 kwh/km.
- El consumo promedio de todas las ciudades es 22.230,02 kwh/km
- El consumo eléctrico por alumbrado publico es un poco superior al promedio de la ciudades

Observaciones

- 97% Lámparas HPS → Mayor eficiencia y menor potencia.
- 0.025% Lámparas Led
- Medellín es una de las ciudades mejor iluminadas en Colombia

Mejoramiento Continuo

- Pilotos exitosos con lámparas Led
- 1000 luminarias LED de 40W reemplazaran luminarias de 70W con fuente e Sodio de alta presión (HPS)
- 2014 se tiene proyectado telegestionar 3000 luminarias.

ANALISIS INICIATIVAS

Estado actual con relación a la iniciativa

1. Programa Integrados de Alumbrado Publico.

Existe un control de inventario de todas las luminarias y lámparas en uso, todas estas además están graficas y georeferenciadas.

2. Auditorias del alumbrado publico y programas de modernización.

El municipio contrata una interventoría que vigila constantemente la calidad de la iluminación. Por medio de esta se identifican las zonas que no están iluminadas y se hacen las respectivas solicitudes de Iluminación. EMP envía mensualmente el inventario de luminarias y el tipo para que la empresa interventora valide la información. Existen además dentro de las visitas de mantenimiento, visitas de revisiones de sectores oscuros que son ingresadas a un programa para mejorar la iluminación.

La sección de alumbrado de EPM opera bajo la filosofía de iniciativas “Calidad de iluminación y no precio”. Es por esto que siempre se están buscando formas de iluminar mas eficientemente. Algunas de iniciativas adoptadas en el pasado son:

- Compra de luminarias con una mejor repartición fotovoltaica. Las luminarias anteriores daban un espaciamiento de 30 metros, las nuevas luminarias 56 metros. Se necesita solo una iluminaria para iluminar lo mismo que dos anteriormente o mejor.
- Se incursiono en nuevas tecnologías como son las luminarias LED. Hace dos años se comenzó una prueba piloto para evaluar el potencial y en Septiembre de 2013 se adjudico una licitación para comprar 1000 luminarias LED de reemplazo de sodio 70. Con esta decisión se baja de 81 vatios que consume una luminaria de 70 sodio a 40 vatios que consume una LED. La idea es ir incrementando las lámparas LED cada año.
- Telegestion. Permite apoyar el tema de mantenimiento con posibilidades de disminucion del alumbrado que en horas de baja circulación de vehículos, se puede bajar la clasificación de la vía y bajar el nivel lumínico. La telegestion también permite identificar luminarias que puedan estar prendidas en el día despilfarrando energía. Las pruebas piloto para la implementación de esta tecnología ya finalizaron con resultados positivos, 1500 elementos de estos ya fueron ordenados para ser instalados en todo el corredor del rio.

3. Auditorias de Señales de Trafico y Programas de Modernización.

Todas las señales están inventariadas y georeferenciadas. Toda la red semafórica de la ciudad funcionan con lámparas Led, 18.122 en total. Antes, estos tenían lámparas halógenas e incandescentes.

4. Programa de sincronización de la Iluminación.

Esta es una tecnología que se esta pensado introducir prontamente en el sistema de iluminación. Sin embargo actualmente cada puto lumínico cuenta con un dispositivo que se llama fotocontrol automatico, este censa cuando la iluminación baja en la noche y prende la luminaria y cuando mejora la iluminación en la mañana la apaga. Cuando se daña el equipo la luminaria permanece encendida garantizando la

seguridad. El programa de telegestión que está siendo implementado podrá detectar fallas inmediatamente en estos aparatos y atenderlos rápidamente evitando así el desperdicio de energía con luces prendidas de día.

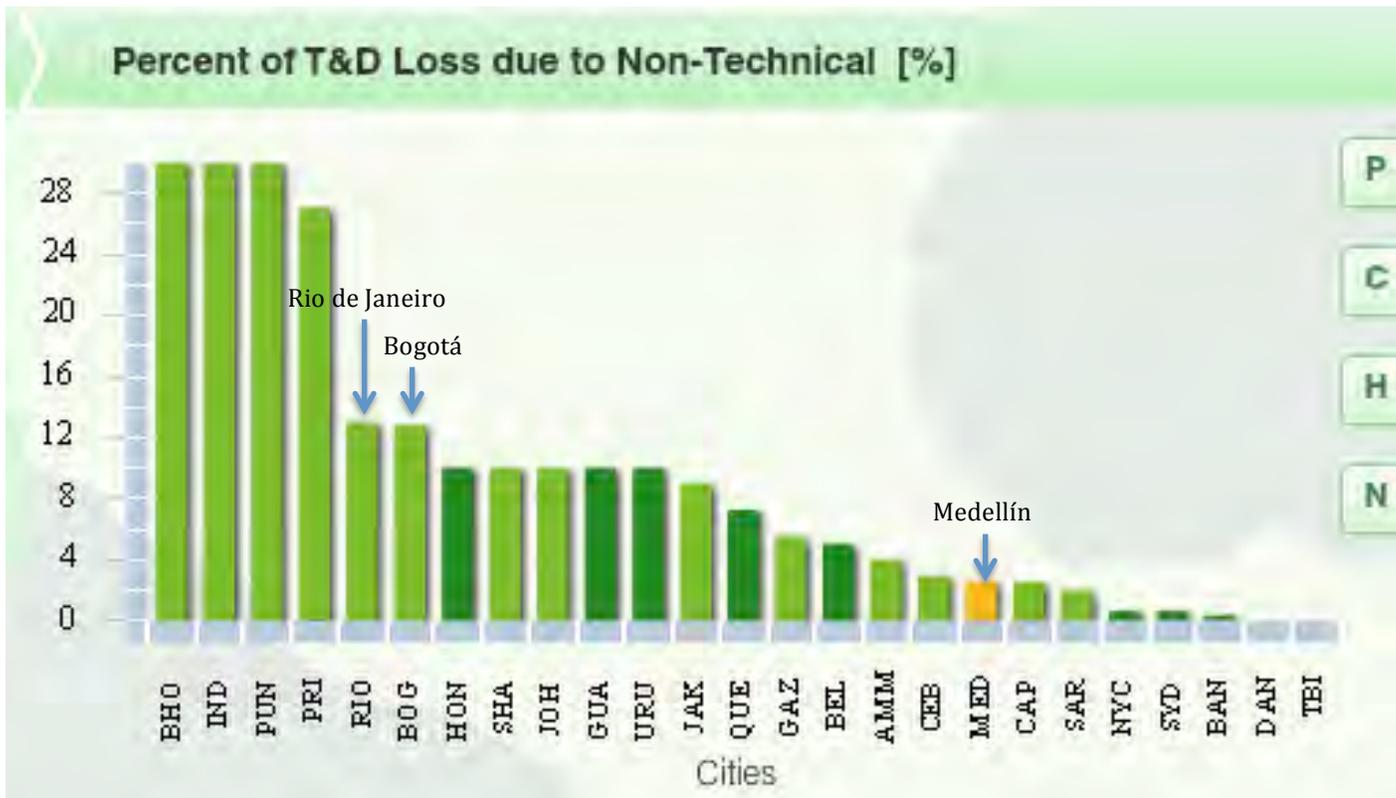
ANÁLISIS BENCHMARKING SECTOR ENERGÍA

EPM cuenta con una capacidad de generación de energía de 3249.3 MW, mediante 27 plantas; 25 de generación hidráulica, 1 eólica y 1 térmica. En transmisión y distribución de la energía eléctrica, EPM cuenta con una capacidad de transformación de 5190 MVA a través de 127 subestaciones.

Porcentaje de Pérdidas no Técnicas

Medellín tiene niveles bajos de pérdidas de transmisión y distribución, 7.24% en total. De este total solo el 2.55% corresponde a pérdidas no técnicas. Este bajo porcentaje de pérdidas no técnicas puede ser una consecuencia positiva de la iniciativa de Energía prepago en la Ciudad. Ver resultados benchmarking en la figura 13.

Figura 13: Porcentaje de Pérdidas no Técnicas



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- Medellín tiene un porcentaje bajo de pérdidas totales por T&D. Cuando se compara con ciudades con similar índice de desarrollo, su desempeño se puede clasificar como promedio.
- Rio y Bogotá tienen índices de pérdidas totales muy superiores a Medellín (30% y 20% respectivamente)

Observaciones

- EPM tiene implementado programas de energía prepago que desestimulan las conexiones ilegales.

ANALISIS INICIATIVAS

Programa de Reducción de Pérdidas No Técnicas

Entre 1998 y 2003, EPM implementó programas de reducción de pérdidas de energía en el departamento de Antioquia, tanto en el mercado metropolitano como en el mercado regional, por un valor aproximado de 165 millones de dólares, logrando reducir el índice de pérdidas consolidado del departamento, del 15.3% al 9.2%. Del 2004 y hasta la fecha, EPM destina anualmente 15 millones de dólares aproximadamente, para el control y el mantenimiento de este indicador. Con programas de control de pérdidas cada vez más eficientes, ha logrado disminuir el índice de pérdidas en este periodo, de 9,2% a 7.86%. Tanto en la etapa de reducción como en la de control de pérdidas, EPM ha implementado una gestión integral para la mitigación de la problemática, realizando acciones técnicas, comerciales, administrativas y financieras, entre otras. Entre las más importantes se destacan la implementación del Sistema Integrado Domiciliario, lo cual consistió en disminuir la vulnerabilidad de la red con el uso de cable trenzado para la red secundaria, cable concéntrico antifraude para la acometida, cajas porta borneras y cajas herméticas para los medidores. Así mismo se destaca la implementación de la medida prepago, inicialmente como solución para los venteros ambulantes y posteriormente para los estratos bajos del sector residencial con riesgo de falta de capacidad de pago.

Programa de Modernización de Transformadores.

EPM tiene registro de todos sus transformadores y constantemente hace verificaciones y mantenimiento de ellos. Para los Equipos de Distribución Energía que son desmontados por remodelación de la Red, por algún proyecto en especial, o por que han fallado en su operación, EPM realiza los respectivos diagnósticos para determinar si el activo se debe reparar, mantener o dar de baja debido al cumplimiento de su ciclo operativo. Adicionalmente, en los casos en que se debe realizar reparación o mantenimiento de los equipos, se realiza una interventoría completa a todo el proceso, la información asociada, es registrada en las bases de datos de los Negocios.

Existe además una Base de datos (GDE) en donde se registra los datos técnicos de los transformadores, en ella se indica si el transformador cumple las normas técnicas Colombianas respectivas. Las normas mencionadas establecen los requisitos mínimos que deben cumplir los transformadores desde el punto de vista de pérdidas de corto Circuito y Vacío como medio de control de la eficiencia energética de estos equipos.

Programa de Corrección del factor de potencia.

EPM monitorea el sistema de forma permanente revisando el sistema con equipos para la medición de la calidad de la potencia, entre los cuales se monitorea la variable del factor de potencia. Este sistema se tiene a nivel de las subestaciones y da la información para los circuitos y los transformadores de potencia. El sistema de calidad de la potencia mencionado tiene información a nivel de las barras de tensión en subestaciones niveles 2,3 y 4.

Además del sistema de monitoreo de calidad de la potencia, el sistema SCADA conserva el registro del factor de potencia de los circuitos de las líneas de interconexión y de los transformadores de potencia.

ANALISIS BENCHMARKING SECTOR EDIFICIOS PUBLICOS

La administración de los edificios públicos es altamente descentralizada, resultando esto en una carencia de datos para analizar el sector. Por ejemplo la oficina a cargo de este sector no tiene una lista de los edificios propiedad del municipio con una relación de sus áreas, consumos de energía o renovaciones. De igual forma no se pudo obtener datos sobre la cantidad de dinero que paga el municipio por la energía consumida en los edificios públicos. Debido a la escasez de datos, la estrategia en el sector fue elegir un edificio representativo como ejemplo o muestra del desempeño energético del sector.

Consumo Eléctrico en Edificios Municipales

El edificio seleccionado fue el “CAM” en este se encuentra la Alcaldía de Medellín y el Consejo Municipal de Medellín. Ver resultados benchmarking en la figura 14

Figura 14: Consumo Eléctrico en Edificios Municipales



Fuente: Resultados Benchmarking TRACE

Resultados Benchmarking

- Se tomo como muestra un edificio representativo en la Ciudad: “El CAM”
- El consumo eléctrico en este edificio es de 177kwh/m2. El promedio de todas las ciudades es 166.8kwh/m2

- La iluminación y los computadores representan el 52% del consumo
- El sistema de aire acondicionado y los ascensores representan el 48% del consumo

Observaciones

- Existen pocas iniciativas enfocadas en la eficiencia energética.
- No existe agencia encargada de la consolidación y análisis de datos sobre consumo energético.
- Sistema de aire acondicionado en el edificio analizado es ineficiente. Modernización planeada para el año 2014.
- La Empresa de Desarrollo Urbano hace muchos de sus proyectos teniendo en cuenta iniciativas de eficiencia energética. Los proyectos de la EDU pueden servir de modelo en la ciudad.
- La EDU esta construyendo actualmente un edificio con certificación LEEDS.

Es importante para el sector que al menos se comiencen a tener bases de datos que contengan toda la información de consumos, áreas y modificaciones hechas en los Edificios Públicos. Esto es un buen punto de partida que permitirá tener información para analizar la situación actual hacer propuestas para el futuro. Se recomienda a la ciudad ver las iniciativas expuestas en los Anexos 16,17,18 esto podría ayudarles a identificar proyectos potenciales para desarrollar en este sector donde usualmente siempre hay mucha oportunidad de mejoramiento.

01 ENFORCEMENT OF VEHICLE EMISSIONS STANDARDS



DESCRIPTION

Enforcement of vehicle emissions standards not only improves local air quality, but also leads to lower fuel consumption. Vehicle emissions standards may be implemented through mandatory regular emissions checks for vehicles.

The higher the vehicle emission standard, the less fuel it is likely to consume and the higher the reductions in the emission of fine particles, nitrogen dioxide, ozone, CO2 and other pollutants. Lower emissions result in higher air quality and lower the risk of respiratory diseases associated with air pollution.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Technology based enforcement	The City Authority implements vehicle standards via mandatory vehicle registration using number plates, which are monitored with automatic number-plate recognition cameras. This approach works most effectively in discrete areas of the city with limited entry and exit points (to minimize capital costs). Whilst the initial capital costs may be high, operational costs are lower than manual enforcement, though it must also be supported by enforcement/sanction systems. Expansion of this approach to city-wide application is capital intensive although more effective than the manual approach (see Manual enforcement implementation activity below). Vehicles that have passed the test are entered onto a database linked to the automatic number plate recognition cameras.

Manual enforcement	The City Authority requires manual checks of vehicle emission standards, e.g. by traffic officers or wardens who collect non-compliance penalties, or by cordon officers who restrict entry into an emission standard area. This is done either by means of a system which uses categorized number plates, or by use of easily recognizable windscreen stickers displaying the permit or pass from emissions checks. A consideration for either approach should be whether the entire city should be designated for stringent emission standards, or whether there are particular areas that can easily be identified for the purpose. Note that this approach is less-likely to capture all emissions test evaders, and is also at risk from unscrupulous traffic officers or wardens. This intervention requires the establishment of a network of emission testing centers to award compliance certificates or permits. See Stockholm case study for further details.
Emissions centers	The City Authority regulates a network of emissions testing centers which are independently assessed and verified to undertake emissions tests. Sanctions for abuse or fraud should be severe to deter corruption. See Mexico City case study for further details.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

> 2 years

Co-Benefits

- Reduced carbon emissions
- Improved air quality
- Enhanced public health & safety
- Increased employment opportunities

CASE STUDIES

Low Emission Zone, London, UK

Source: Transport for London (2009). "Cleaner air for Greater London - The Low Emission Zone is now in operation", available online from <http://www.tfl.gov.uk/assets/downloads/LEZ/LEZ-information-leaflet.pdf>

The aim of the program is to improve air quality in the city by deterring the most polluting vehicles from driving in the area. The vehicles affected by the LEZ are older diesel-engined lorries, buses, coaches, large vans, minibuses and other heavy vehicles that are derived from lorries and vans. The Low Emission Zone (LEZ) is enforced using fixed and mobile cameras which read vehicles' registration number plates as they drive within the zone. This is then checked against a database of registered vehicles which meet the LEZ emissions standards, and which are exempt from the charge. If the vehicle does not meet required emission standards or does not qualify for an exemption, a daily charge has to be paid. A critical issue in the successful operation of LEZ schemes is the implementation of an effective enforcement program. If a vehicle driving within the zone is identified as not meeting the LEZ emissions standards and no daily charge has been paid, a Penalty Charge Notice is issued to the vehicle's registered keeper. The London Transport Authority works together with a European debt recovery agency and has established links with many European vehicle licensing agencies in order to even recover penalties against vehicles registered outside Great Britain.

Environmental zone, Stockholm, Sweden

Source: Transport & Travel Research (2006) Air Quality Impacts of Low Emission Zones available online from http://www.environmental-protection.org.uk/assets/library/documents/lez_aq_impacts.pdf

Environmental zones were created in central areas of the city which were particularly sensitive to emissions and noise. Based on vehicle age, the approach is simple: all vehicles over 3.5 tonnes that are older than 8 years old are banned, including buses. (Exceptions are made for vehicles between 8 and 12 years old if they are retrofitted with new engines). Enforcement is achieved through the police via spot checks as well as an informal arrangement between carriers. Identification of potential perpetrators happens by means of the vehicle number plate, with older vehicles being required to carry permits to prove they have been retrofitted with emission standard approved technology. The zone has resulted in older vehicles being replaced earlier than they otherwise would have been, yielding significant reductions in levels of key pollutants.

Inspection program, Mexico City, Mexico

Source: Kojima, M. and Bacon, R. (2001). "Emission Control", Public Policy for the private sector, Note number 238, available from <http://rru.worldbank.org/documents/publicpolicyjournal/238Kojim-831.pdf>

All motorists have to display a sticker showing that their vehicle has passed an emissions test every six months or risk a fine. In its earlier stages of deployment it suffered from high levels of evasion - an implementation problem common to similar programs in developing countries. However, as a result of operating through high-volume, test-only centers which are operated by the private sector, program performance has greatly improved. It is estimated that the program has achieved an energy savings potential of approx. 5%. Experiences recommend optimizing the number of centers relative to the volume of traffic to be tested, thereby reducing risk of tests becoming less rigorous as each centre relaxes their inspection protocols in order to attract more customers to increase their market share. Each lane which generates 10,000 per year had a capital cost of approx. USD 60,000.

TOOLS & GUIDANCE

Tools & Guidance

USAID (2004). "Vehicle Inspection and Maintenance Programs: International Experience and Best Practices" A document which consolidates the details of implementing a vehicle inspection and maintenance program, as well as provides an overview of lessons from a range of best practice international experiences. Available online from http://pdf.usaid.gov/pdf_docs/PNADB317.pdf

05 TRAFFIC FLOW OPTIMIZATION



DESCRIPTION

Traffic can be positively managed to ensure the most efficient operation of the transport system. Management techniques will seek to minimise distance travelled between origin and destination, ensure the efficient flow of traffic and encourage multiple occupancy vehicle travel.

Encourage the efficient use of vehicles and minimise journey lengths, reducing fuel use.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Flow optimisation	The City Authority changes driving patterns either by technical optimisation of traffic signalling, or by means of the provision of information. Real-time information can be provided by means of Variable Message Signing (VMS) or telecommunication where drivers are provided with route switching options, clear directional signing to destinations, and directions to nearest available car parks. This minimises journey length and reduces congestion. Messaging systems have also been used to counter crime by providing information on e.g. kidnappings and terrorist attacks. See Portland and Milton Keynes case studies for further details.

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Enhanced public health & safety

Regulatory	The City Authority establishes high-occupancy vehicle lanes (HOV), producing an incentive for car sharing. The pairing of users can be left to civic initiatives, or driven by city authorities either separately or in combination with its other initiatives (in the latter case initiatives can be communicated to users using the same platform). Achieving a minimum number of users is crucial, as insufficient use results in reduced available road space and increased congestion. The implementation of an effective enforcement and penalties system are equally important, as the lane will otherwise attract an unacceptably high level of non-HOVs, which also reduces effectiveness. See Madrid case study for further details.
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform traffic surveys of number of vehicles in circulation by using traffic counters.
- Determine mode share of people travelling in the area or city.

CASE STUDIES

Arterial 'green wave' traffic flow optimisation, Portland, USA

C40 Cities (2010). "Portland, USA: Optimizing traffic signal timing significantly reduces the consumption of fuel", available online from http://www.c40cities.org/bestpractices/transport/portland_traffic.jsp

The City Authority optimized traffic signal timing at 135 intersections on 16 of some of Portland's most congested thoroughfares. 'Optimization' of traffic signals consists of re-timing the traffic signals to improve their synchronization across a road traffic network. The cost of an intersection synchronization varied USD 1,000-3,000. The resulting reductions in the frequency by which vehicles accelerate and decelerate, as well as the reductions in the time vehicles spend with idling engines, yielded annual fuel savings of 1,750,000 gallons of gas. This is the equivalent of removing 30,000 passenger vehicles from the road for an entire year. The city went a further step by measuring and eliminating CO₂ through the purchase of carbon credits.

Variable Message Signs, Milton Keynes, UK

Department for Transport (2010). "Case Study: Milton Keynes Integrated Traffic Management", available online from <http://www.dft.gov.uk/itstoolkit/CaseStudies/milton-keynes-integrated-traffic-management.htm>

In order to achieve a more efficient usage of car parks and encourage shoppers into the central retail area of Milton Keynes, as well as reduce congestion caused by cars looking for parking, the city administration invested in Variable Message Signs which display the location and availability of parking spaces to road users. Installation costs were lowered by making use of existing ducted network in Milton Keynes used by the Police for CCTV. This created the added benefit of providing a large capacity network for future growth in data transmissions. The reduction in congestion and delays resulting from the system are estimated to save motorists and bus passengers in the central area more than GBP 3 million over a 10-year period.

High-Occupancy Vehicle lane, Madrid, Spain

Monzon, A. (1999) "Managing long term congestion in HOV lanes. Effect of 2+ vs 3+ limit on the Madrid N-VI corridor", paper presented at the European Transport Conference, Cambridge, Jan 1st 1999, available online from <http://www.etcproceedings.org/paper/download/2493>

High environmental standards, low housing density, and high motorization rates influenced the decision of implementing an HOV lane scheme on the median of the N-VI motorway into Madrid. The cut off limit for the lane is 2+ passengers and the facility is separated from the mix-flow lanes by a concrete barrier along the whole length of it. A successful design aspect is the reversible basis on which the system operates to match peak flows, serving the inbound trips during the morning peak, and the outbound trips during the evening peak. Rather than increase ridesharing, the lanes have attracted a growth in public transport mode share (40% in the period 0700-1000 in the year following implementation), resulting in increased frequencies of services.

TOOLS & GUIDANCE

Tools & Guidance

Colorado Department of Transportation (2005). "CDOT Guidelines on Variable Message Signs (VMS)", A guidance document for the design of Variable Message Sign (VMS) messages. Available online from <http://www.cotrip.org/its/whitepapers/VMSGUIDE-rev-2005.pdf>

Alabama Department of Transportation (2007). "Traffic Signal Design Guide & Timing Manual" A guidance document with detailed guidelines and recommendations for the designing and timing of traffic signals in the State of Alabama. Available online from <http://www.dot.state.al.us/dsweb/Traffic/pdf/AldotTrafficSignalManual122007.pdf>

07 CONGESTION PRICING



DESCRIPTION

Congestion charging restrains access by selected vehicle types, usually the private car, into large urban areas during congested time of the day. Usually the aim is to discourage work-based commuting trips into a defined Urban Area. Measures range from complete restriction to discouragement through charging. It is a market-based mechanism for influencing driver behaviour, which looks to capture the 'external cost' of vehicle travel during congested periods of the day.

The main benefit is realised by reducing the volume of low occupancy vehicles entering the defined area. The aim is to induce modal transfer from low to high occupancy transport units, such as public transport. Maximum energy efficiency will be realised if there are complementary interventions on the public transport systems such as the implementation of energy efficient vehicles. Congestion charging should provide a revenue stream with the surplus (after operating costs) invested in more efficient transport systems.

ATTRIBUTES

- Energy Savings Potential**
100,000-200,000 kWh/annum
- First Cost**
> US\$1,000,000
- Speed of Implementation**
> 2 years
- Co-Benefits**

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Congestion pricing	The City Authority introduces congestion charging. The key to effective congestion relief is the price setting. Most effective systems will operate with a simple pricing structure although in practice it is likely that this will be difficult to achieve. Vehicles would be charged for entering a defined zone with the charge generally levied through the purchase of permits, in the case of congestion charging, or by conventional charging for toll roads, either by using automatic collection by means of signal-controlled devices or manually. Physical restriction of selected vehicles into a zone seeks to target a group that can vary by type or time of day/week/year. Implementation requires measures to be in place supported by legislation to enable adequate enforcement. These types of measures raise revenue which can be invested in other public infrastructure. See Stockholm and Singapore case study for further details.

- Reduced carbon emissions
- Improved air quality
- Enhanced public health & safety

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform traffic surveys of the number of vehicles in circulation pre- and post-implementation.
- Determine the mode share of people travelling in an area or the city.
- Collate registration data of users to paid schemes or voluntary schemes.
- Perform statistical analysis of rate of growth of car registration data.

CASE STUDIES

Congestion charge, Stockholm, Sweden

Source: C40 Cities (2010). "Stockholm: Congestion charge", available online from http://www.c40cities.org/bestpractices/transport/stockholm_congestion.jsp

Drivers are charged every time upon entry into and out of the congestion zone ('crossing the cordon') which encompasses the city centre. The charge varies according to the time of entry, and high definition cameras with Automated Number Plate Recognition software are used to register vehicles. Drivers are automatically billed, usually by 7pm the same day. Measures which have been key in addressing the perceived implementation barriers have been a simple and user-friendly zone charging structure; a simplified payment process; and a consideration of seasonal traffic variations to enhance public opinion (the month of July - a key holiday in Sweden - is exempt from the charge).

Congestion charge, London, UK

(1) Source: ESMAP (2011). "Good Practices in City Energy Efficiency, London, UK: Congestion Charges for Urban Transport" available online from <http://www.esmap.org/esmap/node/1279>

In February 2003, London, the capital city of the United Kingdom, introduced a daily congestion fee for vehicles travelling in the city's central district during weekdays. This fee was meant to ease traffic congestion, improve travel time and reliability, and make central London more attractive to businesses and visitors. According to analysis by the City, the program has largely met its objectives. After four years of operation, traffic entering the charge zone was reduced by 21 percent; congestion, measured as a travel rate (minutes per kilometer), was 8 percent lower; and annual fuel consumption fell by approximately 44-48 million liters or about 3 percent. These changes translated into 110,000-120,000 tons of carbon dioxide (CO₂) reductions annually, a 112 ton reduction in nitrogen oxides (NO_x), an eight-ton reduction in particulate matter (PM₁₀), and some 250 fewer accidents. In terms of the program cost-effectiveness, the identified benefits exceeded the costs by more than 50 percent. In addition, the scheme brought a steady net revenue stream for transport improvements, of which 80 percent has been reinvested in improving public bus operations and infrastructure. Among the first programs of its kind, London's congestion charging scheme was successfully developed and implemented. The city proved to be innovative and resourceful by ensuring key elements of the scheme were in place including technical design, public consultation, project management, information campaign and impact monitoring. London's innovation has helped other cities around the world assess this as a policy option in meeting their urban transport needs.

(2) Source: UN Habitat (2006). "London's Congestion Charging System", Habitat Debate, vol. 12, no.1, available online from <http://ww2.unhabitat.org/HD/hdv12n1/Vol12No1e.pdf>

The London USD 170,000,000 congestion charge scheme uses a flat-rate fee applicable during weekdays, normal working hours, as it is both easy to understand and implement, and is also reflective of the nature of congestion in London (consistent throughout the day). Video cameras at entry points to the zone and mobile units within the zone register vehicles which enter the zone by means of automatic number plate recognition technology. Payments are made electronically on the day of entry into the zone. There are discounts for monthly/annual payments, as well as 90% discounts for residents within the priced area. As a measure to meet the predicted rise in demand for public transportation, the CA invested in the pre-implementation expansion of bus. Results show that the scheme has reduced congestion in the central zone by 18%; reduced delays by 30%; and caused major reductions in road accidents (70 less per annum). Surplus revenues over operating costs for the original zone are used to improve the efficiency of public transport systems. The CA is now looking to expand the scheme at a forecast cost of USD 25m to USD 40m for the zone extension.

Congestion charge, Singapore, Singapore

Source: Singapore Land Transport Authority (2002). "Road Pricing - Singapore's Experience", available online from http://www.imprint-eu.org/public/Papers/IMPRINT3_chin.pdf

Implemented first in 1975, Singapore's congestion pricing initiative has evolved from a manual scheme based on paper permits and applicable during the morning peak period only to an electronic version that operates throughout the day. The City Authority enacted a pre-implementation expansion of the bus fleet to meet the predicted rise in demand and also developed new Park-and-Ride facilities to support the scheme. Results show that weekday traffic entering the RZ has been reduced by 24% (271,000 to 206,000 vehicles/day). Annual revenues are approximately 11 times the initial capital costs and annual running costs, giving a significant payback. However, the variable cost of entry to the Restricted has made the scheme difficult to enforce.

TOOLS & GUIDANCE

Tools & Guidance

US Department of Transportation (2009). "Value Pricing Pilot Program Planning and Decision Making Tools" A series of tools for estimating the impacts of congestion pricing strategies. Available online from http://www.ops.fhwa.dot.gov/tolling_pricing/value_pricing/tools/index.htm

ANEXO 4

06 TRAFFIC RESTRAINT MEASURES



DESCRIPTION

Discouraging potential drivers from using their cars leads to fewer cars in circulation. This encourages people to use alternative modes, which in turn will increase their viability (increased public transport patronage for example).

Removing vehicles from circulation reduces fuel use and reduces the need for road space.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Blanket bans	The City Authority imposes blanket bans. Possible types of blanket bans include vehicle-type bans which exclude entire vehicle categories from circulation; or licence plate bans, by which certain number plates are banned from circulation. A weakness of licence plate bans are that they tend to result in wealthier residents purchasing second cars, not only negating the aims of the ban, but thereby also disadvantaging those with lower incomes. See Guangzhou case study for further details.
Licensing	The City Authority rations permits. The establishment of quotas for private vehicles allows for only a certain number of vehicle registrations over a given period of time. However, as demand for cars tends to be inelastic, this often results in very high purchase prices for the licenses - a mechanism which favours the wealthy and marginalizes the lower income brackets of society. See Singapore case study for further details.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Civic initiatives	The City Authority sanctions and encourages 'no-driving days' to educate and lead by example. Participation in these initiatives is voluntary, however, and therefore not enforceable. See Puerto Princesa case study for further details.
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform traffic surveys of the number of vehicles in circulation pre- and post-implementation.
- Determine the mode share of people travelling in an area or the city.
- Collate registration data of users to paid schemes or voluntary schemes.
- Perform statistical analysis of rate of growth of car registration data.

CASE STUDIES

Vehicle bans: Motorcycle ban, Guangzhou, China

Institute for Transportation and Development Policy (2008). "Case study: motorcycles in Guangzhou", available online from <http://www.itdp.org/documents/Guangzhou%20Case%20Studies%20-%20Motorcycles%2015-Sep-08.pdf>

Motorcycles have been completely banned in the City of Guangzhou. The ban was implemented in phases, beginning with a moratorium on new licenses, extending to various roads and time periods. Gradual implementation has been crucial to allow time for the public to adapt, and efficient supply of additional infrastructure/services has supported the induced modal shift. Many motorbike riders have shifted to bicycles and buses, and cycle rickshaws have also emerged as a popular substitute. Road accidents have dropped by 40% since the initial implementation of the ban.

Rationing, Singapore, Singapore

Sustainable Urban Transport Project (2010). "The Vehicle Quota System in Singapore", available online from http://www.sutp.org/index2.php?option=com_content&do_pdf=1&id=1582

Singapore fixes the number of new vehicles allowed for registration. Potential buyers need to bid for a non-transferable licence, which entitles them to own a vehicle for a fixed number of years. The scheme had to be modified soon after implementation to safeguard against speculative action. The licences used to be transferable and within the first two months of the first round of release, 20% changed hands in "buy and sell" transactions with speculators making sizable profits of up to S\$5000. As the rationing system does not control annual mileage, the success of the rationed registration in limiting vehicle usage has been dependent on support from other traffic restraint measures, such as high road tolls, parking fees, and electronic road pricing.

No-driving days, One Day Rest, Puerto Princesa, Philippines

ICLEI (2001). "Vehicular Reduction Strategy for Air Pollution Prevention and Climate Change Mitigation; A Case of Puerto Princesa City, Philippines", available online from <http://www.iclei.org/index.php?id=1193>

Introduced as part of a zoning and rerouting, this program stipulates a one day rest for tricycle drivers in the central business district. Regulation of illegally operated tri-cycles is a major impediment, as enforcement irregularities pose questions of inequality between illegal and legal tri-cycle taxi drivers. Furthermore, the income potential of those who comply with the rest day is lost to the illegal operators

TOOLS & GUIDANCE

Tools & Guidance

Sierra Club of Canada (2001). "How to Stage a Car Free Day In Your Community" A guidance document for preparing and planning a community-driven car free day. Available online from http://www.worldcarfree.net/wcfd/documents/cfd_howto.pdf

ANEXO 5

08 NON-MOTORIZED TRANSPORT MODES



DESCRIPTION

Non-motorised transport modes have zero operational fuel consumption and require low capital costs for implementation. In addition to improving the health of users, their use reduces noise pollution and improves air quality.

Benefits include improved air quality, lower operating costs for users and providers, and lower infrastructure requirements.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Pedestrianization	The City Authority pedestrianizes networks of streets or larger city areas. Either permanent or temporary, the closure of streets to motor vehicles increases public awareness of non-motorised modes and removes noisy and polluting vehicles, as well as creating opportunities for street markets and other initiatives. The City Authority researches the feasibility and probable take-up from origin and destination surveys, existing mode splits, and subsequently designs networks to suit commuting patterns and local/neighbourhood travel. See Oxford case study for further details.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Dedicated networks	The City Authority includes dedicated cycle / walking route networks in its transportation or city land use plans. Replacement or reservation of rights-of-way in new-built areas creates the necessary conditions for adopting non-motorised modes that may otherwise be less favoured if roads cater to cars only. The key to success is the linkage of cycle and pedestrian networks at local level, and the quality of the environment provided, that requires good drainage and adequate lighting and shading. See Bogota case study for further details.
Microcredits	The City Authority makes micro credits available which can be used to increase the ownership of bicycles. Increased cycle ownership can have significant financial benefits to low-income workers who may no longer be dependent upon expensive, inefficient and infrequent public transport. See Lima case study for further details.
Rental programs	The City Authority introduces bicycle rental programs which provide bicycles on demand for a fee. The key factor for success to is the setting of tariffs that encourage use as well as security procedures that avoid and penalise theft. Registered-user schemes require a credit card or bank details of users, but are not necessarily open to all. Non-registered user schemes are more flexible, but more open to abuse. Branding of bicycles and facilities can create revenue for local authority. See Paris case study for further details.



MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform surveys of the number of cycles in circulation by using traffic counters on roads and cycle lanes.
- Determine the mode share of people travelling in the area or city.
- Determine KPIs such as % non-motorised transport mode, modal shift, km of dedicated cycle/walking infrastructure, take-up of cycle promotion schemes by analysing registers of subsidies

Bicycle micro credits, Lima, Peru

ICLEI (2009). "Case study 46: Assistance to purchase bicycles - Lima, Peru" in Sustainable Urban Energy Planning: A handbook for cities and towns in developing countries, available online from <http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=2839>

In 1990, the Municipality of Lima set up a micro-credit programme to help low income citizens purchase bicycles. By saving on daily public transportation costs, workers can see their income effectively rise more than 12% once the loan is paid off. In order to enhance the success of the program, efforts have been made at standardizing the use of bicycles in the city. Actions to achieve this have so far consisted of the development of a manual of technical standards for the design and planning of cycle ways.

Bicycle rental, Velib, Paris, France

C40 Cities (2010). "Paris, France Velib - a new Paris love affair", available from http://www.c40cities.org/bestpractices/transport/paris_cycling.jsp

Paris launched a 24/7 cycle hire scheme through Velib; a public private partnership between the city of Paris and a company led by a major advertising group. Users must purchase a subscription by day, week or year, and bike rental is free for the first half hour of every individual trip, after which it costs a fixed rate. The increasing price scale ensures the bikes are kept in circulation. Notably, the City of Paris generates revenues from the project without any investment (which cost USD 108 million). The public-private partnership is the reason for this success, with the private company paying operating costs plus rights to advertising space to the City, funded by advertising revenues.

TOOLS & GUIDANCE

Tools & Guidance

Sustrans (2007). "Technical guidelines for the development of cycle facilities" A series of guidance documents for professionals on the details of bicycle network design. Available online from <http://www.sustrans.org.uk/resources/design-and-construction/technical-guidelines>

Transport for London (2010). "London Cycling Design Standards" A guidance document for designing to reduce barriers to cycling, in order to support road safety targets. Available online from <http://www.tfl.gov.uk/businessandpartners/publications/2766.aspx>

ANEXO 6

02 TAXI VEHICLE REPLACEMENT PROGRAM



DESCRIPTION

Develop a program to scrap and recycle fuel-inefficient taxis and replace them with new low-emission vehicles. This program can be extended to minibuses, minibuses and buses where the City Authority has the funds and capability to implement a larger program.

The key benefits of the program are improvements in fuel efficiency and reduction in air pollution.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Legislation	The City Authority mandates all passenger vehicles to be of a defined standard, or legislates in favor of efficient performance vehicles. Standards, compliance schedules and application require detailed consideration and consultation to ensure practical and achievable outcomes. Compliance with such programs can be enforced by traffic officers with fines and/or repossession of vehicles. Considerations of the percentage of the investment that can be borne by public authority, and the expected contributions of private owners are important for successful implementation. See Cairo case study for further details.

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Campaigning	The City Authority informs owners of the benefits of vehicle replacement. The main barrier is addressing the perception of high capital cost of acquisition versus the gains in maintenance and operating costs. Consultation and lobbying with unions and trade associations can ensure the support to convince their members of the benefits.
Substitution subsidies	The City Authority subsidizes the purchase of fuel efficient vehicles in order to encourage owners to replace poor-performance vehicles. See Mexico City case study for further details.
Licensing	The City Authority makes taxi-operating licenses contingent upon use of efficient vehicle, in accordance with the defined standard.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Perform statistical analysis of license and performance registration data.
- Perform surveys of standard of circulating vehicles by using data from enforcement officers or roadside surveys.
- Monitor recycling levels of scrapped vehicle parts.

CASE STUDIES

Vehicle scrapping and replacement program, Cairo, Egypt

Source: ESMAP (2010). "Good Practices in City Energy Efficiency: Cairo, Arab Republic of Egypt - Taxi Scrapping and Recycling Project", available online from http://www.esmap.org/esmap/sites/esmap.org/files/CS_Cairo_Taxi_Scrapping_and_Recycling_062910.pdf

In April 2009, the Egyptian Ministry of Finance, with support from the Prime Minister, initiated the Vehicle Scrapping and Recycling Program for the Greater Cairo Region (GCR). Under this initial phase, a taxi replacement and recycling program was launched on a voluntary basis, where private taxi owners receive financial and other incentives to surrender their old vehicles for new, more fuel-efficient models, while the old vehicles are scrapped and recycled. With an initial focus on taxi replacement in the GCR, a collaborative effort between the government and private sector in the GCR offers an attractive financial package to attract owners of taxis more than 20 years old to participate. This includes a 25-30% reduction in the price of a new, replacement vehicle, €2,500 in subsidies and tax waivers, discounts on the loan terms and insurance agreements, and other incentives. The estimated total program cost would be about \$620.24 million, depending on the number of participants, share of each model, etc. The program will remain active for 28 years, replacing 45,000-50,000 taxis in the GCR during the first phase. Then, pending approvals, taxis and other mass transport vehicles in other regions would be replaced in later phases. The first phase will reduce emissions by an estimated 1.3-2.3 million tons CO₂e over 10 years. The project will be supported by carbon financing, which will support development of a recycling facility for the scrapped vehicles. As of 2009, a total of 17,000 taxis had already been replaced, resulting in 57,233 tons CO₂e emissions reduction and a 29% reduction in energy use.

Taxi vehicle replacement program, Cairo, Egypt

Source: World Bank Report No: 54430-EG (April 19, 2010) "Carbon Finance Assessment Memorandum on a Proposed Carbon Offset Project with the Ministry of Finance of the Arab Republic of Egypt for the Vehicle Scrapping and Recycling Program" http://www-wds.worldbank.org/external/default/WDSContentServer/WDS/IB/2010/05/18/000334955_20100518024726/Original/544300PGD0P1191gram1April019102010.docx

A closely monitored process in which taxi owners voluntarily surrender vehicles for managed scrapping and recycling in exchange for financial incentives which may be used towards the purchase of new vehicles from participating vehicle dealers. The total capital cost was approx. USD 52 million. The program critically supports the enforcement of a traffic law which states that owners of mass transport vehicles which are more than 20 years old are not eligible for license renewal. Without the replacement program taxi owners would be more likely to sell vehicles to regions where the law does not apply; convert vehicles to private use, which are not affected by the Law; or dismantle the vehicles and sell the engines for use in other vehicles.

Taxi substitution program, Mexico City, Mexico

Source: C40 (2010). "Mexico City: Fuel efficient taxis", available online from http://www.c40cities.org/bestpractices/transport/mexicocity_taxi.jsp

This is a program run by the municipal government to replace taxis which are at least 8 years old with more efficient models. All newer taxis have to have a fuel efficiency of at least 12.5 kilometers per liter. A subsidy of approx. USD 1,400 is provided by the municipal government for drivers to buy a new taxi. As a critical element in the success of the program, the municipal government formed a partnership with a local bank. The bank agrees to grant taxi drivers loans to pay off the typical remaining cost (approx. USD 5,000), with a development bank acting as the guarantor of this loan. If the loan is not repaid by the driver (approx. 4 years), the government revokes the new car. The first round of the program had a capital cost of USD 4,2 million.

01 WASTE VEHICLE FLEET MAINTENANCE AUDIT AND RETROFIT PROGRAM



DESCRIPTION

A well audited, maintained and/or more modern vehicle fleet can help ensure that waste collection and transfer is done in the most fuel efficient manner possible. A 'waste vehicle fleet maintenance, audit and retrofit program' will typically involve measures that reduce fuel use per tonne of waste collected, for example, engine upgrades and improved fleet maintenance.

The successful implementation of this recommendation will require an assessment of the current waste collection / transfer fleet to identify required upgrades.

A well maintained fleet is directly linked to better waste vehicle performance and reduced fuel consumption.

Co-benefits include improved road safety, increased reliability of waste services (reduced waste vehicle breakdowns), and reduced CO2 emissions.

ATTRIBUTES

Energy Savings Potential

<100,000 kWh/annum

First Cost

*t; US\$100,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Set fuel reduction targets	<p>The city authority sets 5 year targets to improve fuel efficiency by a set percentage, for example reduce fuel use per tonne of waste by 20% in 5 years. A City Fleet Manager can be appointed by the city authority to oversee the measurement of fuel use, total waste collection quantity in a year, and kilometres travelled to set baseline KPI's (Key Performance Indicators) and targets for individual vehicles and the entire fleet. This implementation activity can be managed internally, which allows the city control and flexibility. However, this methodology is most effective when the city authority has a relatively high level of knowledge and experience and may not be appropriate for cities that do not have the resources to implement it. This implementation activity can also be used in conjunction with penalty fines for operators of inefficient vehicles or an inefficient fleet.</p> <p>Complementary Activity: Include vehicle fuel performance in procurement criteria</p> <p>See Tashkent and Oeiras case studies for more details.</p>

- Improved air quality
- Enhanced public health & safety
- Increased employment opportunities
- Financial savings
- Operational Efficiency

<p>Waste vehicle maintenance and renewal schedule</p>	<p>Where waste vehicles are owned by the city authority (or public waste management enterprise), appoint a Maintenance Manager who ensures that every vehicle is serviced as recommended by manufacturers. As part of this task, he/she seeks to replace all failing vehicles either by retrofit or replacement, taking into account long-term cost-effectiveness and increased productivity. Vehicles should be reviewed on a regular basis (at least once every year), with failing vehicles being ideally replaced by vehicles that can be serviced locally.</p> <p>Where waste services are outsourced, the city authority can require regular servicing and maintenance of vehicles to be a demonstrable condition of the contract.</p> <p>See Tashkent case study for more details.</p>
<p>Include vehicle fuel performance in procurement criteria</p>	<p>As well as standard vehicle procurement requirements, the city authority ensures that the newly developed KPIs (Key Performance Indicators) are recorded and set targets are met by potential suppliers. This should relate to both new vehicles procured by the city authority and procurement of waste collection services from third parties.</p> <p>See Gothenburg, Philadelphia and Tashkent case studies for further details</p>
<p>Penalties for not meeting targets</p>	<p>The city authority imposes penalty fines on operators who continue to run inefficient waste vehicles and who fail to demonstrate an improvement in fuel use in their fleet. Clear guidelines on fuel-efficient use of vehicles must be provided and time-bound action plans for improvement agreed with operators before penalty fines can be imposed.</p> <p>See California case study for further details</p>

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- fuel use per vehicle per tonne of waste or km travelled
- fuel use per tonne of waste treated in the city

Set a mandatory minimum efficiency rating for each waste vehicle and entire fleet, e.g., fuel consumption per tonne (or cubic metre) of waste collected per km travelled using case study information.

Measure waste collected either by weight or volume. It is possible to do this using vehicle counts (linked to vehicle volume), or weighbridge data.

Importantly, create an accurate inventory of vehicles that is updated whenever a new vehicle is added or removed from the fleet. Check with the Maintenance Department as they typically keep such information.

Regularly assess existing fleet against the minimal efficiency rating and previous years' efficiency ratings. Use vehicle performance information to assess additional measures required and program success.

CASE STUDIES

Solid Waste Management Project, Tashkent, Uzbekistan

The World Bank "Uzbekistan - Tashkent Solid Waste Management Project" <http://www-wds.worldbank.org>

The post-Soviet transition severely disrupted Tashkent's Solid Waste Management (SWM), curtailing garbage collections until trash piled up in city streets causing risks to public health and safety. When the economy picked up again in 1997, the Uzbekistan city authorities sought advice and financial assistance from the World Bank and European Bank for Reconstruction and Development (ERBD) under the Tashkent Solid Waste Management Project. The project has led to the renovation of the waste collection vehicle fleet with modern equipment and waste compactors, improving their roadworthiness and operation ratio. Service equipment for district garages and a central repair workshop was purchased through a public waste management enterprise (Spetstrans). This helped improve operation and maintenance of vehicles and equipment and reduced operation and maintenance costs (maintenance work was previously done by Hyundai and Daewoo Service centres at a higher cost).

The upgrade of the waste fleet was carried out in conjunction with other improvements including the construction of three new district transfer stations, which has increased operational efficiency of waste collection vehicles by reducing idle mileage.

Equipment usage is audited under a regulatory framework that records the total waste collection quantity in a year, recording volumes of solid waste generation and removal. The US\$ 56.3 million project is being financed through loans of US\$ 24million from the World Bank, US\$ 19.2 million from ERBD in addition to a grant of US\$ 2.1 million, and the Uzbek Government which has contributed US\$ 11 million.

Energy Study on Oeiras' Municipal Fleet, Oeiras, Portugal

ManagEnergy "Good Practice Case Study: Energy Study on Oeiras' Municipal Fleet, Portugal"
<http://www.managenergy.net/download/nr263.pdf>

The Municipality of Oeiras (CMO) worked in partnership with the Technical University of Lisbon (IST) on a project to carry out a review of the current performance of the municipal fleet, which included waste collection trucks. The objectives were to assess the fuel consumption by vehicle type; establish performance indicators (km/L); propose simple measures to improve efficiency (eco-driving training); study the potential of implementing alternative fuels (biodiesel and natural gas) and perform an environmental assessment. In the absence of complete data, the project used refuelling data and mileage records to estimate the total fuel consumption of waste collection trucks and its impact on the municipality's budget. A more advanced fleet management system was planned for the later phases, utilising technologies supported by GPS to allow for better control over fleet operations and improve the data available. The total project costs amounted to US\$ 45,384, fully supported by the municipality.

By the end of 2006, the project allowed OEINERGE (the project coordinator) to estimate that simply by processing the existing used frying oils in the county into biodiesel and using it to fuel some of the fleet's waste trucks, a reduction of approximately 10% in fossil fuel consumption could be achieved. In addition to allowing the municipality to understand the full functionality of the waste vehicle fleet and helping identify the potential problems in its management, the project has had an important role for best practice dissemination, emphasising the importance of flawless data recording and monitoring to introduce fuel and cost savings.

Solar-Powered Trash Compacter Project, Philadelphia, USA

Clinton Climate Initiative, C40 Cities http://www.c40cities.org/bestpractices/waste/philadelphia_solar_powered.jsp

The City Philadelphia has installed 500 "BigBelly" solar-powered trash compactors (manufactured in Massachusetts) and 210 recycling containers on its busiest commercial downtown streets for waste collection services. When the receptacle gets full, a signal is sent to a Streets Department monitoring station alerting it to the need for waste collection. The waste is compacted (using solar power) so containers can contain 150 to 200 gallons of waste (traditional public waste containers hold 10 to 12 gallons). This has reduced city waste collection vehicles trips from 19 to 5 per week, decreasing fuel usage and saving more than US\$ 800,000 annually. City recycling rates have also increased thanks to the ease of depositing cans, bottles and newspapers in public spaces. The initial investment in the scheme amounted to US\$ 2.2million, which was funded through a state recycling grant.

Renova Waste Vehicle Fleet, Gothenburg, Sweden

Renova 2008 Press Release "World's First Hybrid Refuse Collection Truck Launched in Gothenburg"
<http://www.eltis.org/docs/studies/Worlds%20first%20hybrid%20refuse%20collection%20truck.pdf>

Waste Management World 2010 "Spark of inspiration: Gas-electric hybrid refuse collection vehicles are helping reduce pollution and noise in Gothenburg, Sweden" <http://www.waste-management-world.com/index.html>

Renova, owned by 11 municipalities in the region, is responsible for around 80% of waste management activity in the city of Gothenburg. A third of Renova's waste management fleet is fuelled by natural gas. In 2008, the company launched the world's first hybrid refuse collection vehicle (RCV) in collaboration with Volvo and Norba and with financial support from the Energy Authority. The hybrid RCV is driven by electricity or diesel and always loads and compacts with electric power generated by the truck's natural gas fuelled engine. This means that the hydraulic systems can work even when the truck is shut down, reducing fuel-consumption from idling. In addition, the truck uses only electricity when moving short distances, when starting and accelerating up to 20kph and when stationary, loading or compacting. Overall, the hybrid RCV achieves a total fuel consumption reduction of at least 30% compared to a conventional RCV. The vehicle also reduces emissions of carbon dioxide, nitrous oxide and particulate matter. The reduced noise of electric transmission improves drivers' working conditions and enhances road safety as the driver can more easily hear passing traffic.

The successful adoption of these vehicles was supported by enforced emissions zone legislation set by governments to provide a level playing field, coupled with incentives (financial support from the Swedish Energy Authority). As part of this project, Renova also carried out staff training such as "Heavy Eco-driving" courses from the Swedish National Association of Driving Schools (STR) and workshops on battery handling in coordination with Volvo and Norba.

Solid Waste Collection Vehicles, California, USA

California Environment Protection Agency, Air Resources Board "Solid Waste Collection Vehicles"
<http://www.arb.ca.gov/msprog/truckstop/diesel/solidwaste.php>

The Green Car Congress 2010 "California ARB Awarding \$200M to Reduce Diesel Emissions from Trucks, Locomotives, Harborcraft" <http://www.greencarcongress.com/2010/06/arb-20100625.html>

The Air Resources Board (ARB) of the California Environmental Protection Agency imposed regulations as part of a state-wide scheme to reduce fuel consumption and harmful emissions from heavy duty vehicles. The 'Idling Reduction Program' is a regulation which applies to vehicles over 10,000 lbs gross vehicle weight (which includes waste trucks), limiting idling to five minutes within Californian borders. The program calls for new engine and in-use truck requirements as well as emission performance requirements for technologies which provide alternatives to idling the truck's main engine, for example, newer models of heavy-duty diesel engines will be fitted with a non-programmable engine shutdown system which automatically shuts down the engine after five minutes of idling. Penalty fines on operators running inefficient solid waste collection vehicles are imposed for non-compliance to the regulations set. The fines range from US\$ 300- 1000 per day to persuade operators to comply. Idle reduction alternatives can require out-of-pocket expenses for waste collection services; but ARB estimates that cost recovery times can take up to 3 years from fuel and maintenance savings, dependent on the equipment selected.

The Idling Reduction Program is part of a wider group of regulations set to reduce emissions from heavy duty vehicles in the state of California, which provided US\$ 112million in financial assistance for diesel truck upgrades and truck grants to help local agencies and others comply with the regulations. The newly funded projects are also estimated to have brought 5,000 more efficient trucks to the roads.

TOOLS & GUIDANCE

Tools & Guidance

SMS Temp Critical guidance paper "Fuel efficiency factors and calculations" <http://www.smstempcritical.com/pdf/fuel-efficiency-gallon.pdf>

Electrical and Mechanical Services Department of Hong Kong publication "Fuel efficiency in vehicle fleet management"
http://www.emsd.gov.hk/emsd/e_download/pee/Vehicle_fleet.pdf

03 WASTE INFRASTRUCTURE PLANNING



DESCRIPTION

Waste treatment infrastructure design, allocation and distribution can directly or indirectly influence the use of energy. Measures that assess current waste infrastructure energy use and how it interacts with other aspects of the city's waste management strategy help ensure that waste treatment infrastructure is operating at its highest efficiency.

The objective of this recommendation is to enable the city authority to identify opportunities in waste treatment infrastructure that affect energy use.

Reduced fuel consumption and energy use as a result of good planning and allocation of suitable facilities.

More efficient and effective processes to treat more waste and/or more waste types.

Co-benefits include increased diversion of waste to recycling or reuse activities, reduced air emissions (odour) and reduced staffing requirements for the same tasks allowing wider coverage of waste services.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

< US\$100,000

Speed of Implementation

< 1 year

Co-Benefits

Reduced carbon emissions

Improved air quality

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Set up program to audit energy used in waste management	<p>The city authority sets up an auditing program for monitoring and collection of data, using either an in-house team or hiring a suitably qualified consultant where required. The audit program can be used to assess the city's performance and review the city's approach to waste management where necessary. This implementation lever can be easier for the city authority because much of the effort is centralised; however, close collaboration with waste authorities (if they are established) is essential to the success of this program.</p> <p>See Melbourne and London case studies for further details.</p>
Planning regulations: Plan for new infrastructure	<p>Ensure that city planning policy and strategies allocate land for new waste infrastructure that aligns with the city waste management strategy and wider urban plans. Allocating land on a city scale provides a framework that can bring together disparate planning procedures to establish the most effective waste management strategy for the city.</p> <p>See Melbourne and London case studies for further details.</p>

- Enhanced public health & safety
- Increased employment opportunities
- Operational efficiency
- Security of supply
- Time savings
- Reduced waste vehicle traffic

<p>Enforcement: Annual Environmental Reports</p>	<p>Assess energy use for all waste infrastructure by monitoring how much fuel and energy is used per tonne (or m3) of waste collected, transported and treated. Aim to require all operators and plants to submit yearly data on energy use in an Annual Environmental Report (AER). The AER is also an opportunity to capture waste tonnage data.</p> <p>See London case study for further details.</p> <p>This implementation activity works well with educating operators about the benefits of efficient operations.</p>
<p>Work with private waste collectors to seek energy savings in waste treatment infrastructure</p>	<p>Seek savings in energy by working with the private waste sector and community led waste collection schemes. Savings can be achieved by combining waste quantities and treating as a single bulk product. The private sector may be interested in filling infrastructure gaps via revised collection regimes, and a waste management strategy would identify such savings opportunities.</p> <p>See Dhaka, Melbourne and London case studies for further details</p>
<p>Subsidies: Encourage development of multi modal waste transfer systems</p>	<p>Offer land and or tax incentives to encourage movement of waste by rail or barge thereby reducing road traffic. National, regional or local funding streams should be tapped into to help finance more efficient waste treatment infrastructure.</p> <p>See London and Italy case studies for further details.</p>

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- energy use per tonne or cubic metre of waste treated city wide and for each plant
- % reduction in energy use per tonne of waste per year

Monitor fuel and energy use per tonne or cubic metre of waste treated in the city - include energy used in collection, transportation and treatment and monitor separately where possible.

Require all plants to submit yearly data on energy use in an Annual Environmental Report (this is also an opportunity to capture waste tonnage data). Assess changes in energy use each year.

Create a city waste management strategy (or assess and improve the current strategy), detailing allocation of city-wide waste infrastructure. Aim to reduce energy associated with pre-treatment of waste. Create 5 year schedule for review of waste management strategy.

Assess any involvement on third party waste operators who are collecting commercial or community waste in the municipality. Seek synergies for mutual gains, for example, increasing waste volumes to maximise energy efficiency in plants.

CASE STUDIES

The Metropolitan Waste and Resource Recovery Strategic Plan, Melbourne, Australia

Metropolitan Waste Management Group "The Metropolitan Waste and Resource Recovery Strategic Plan"
<http://www.mwmg.vic.gov.au>

BVSDE "Towards Zero Waste -A Material Efficiency Strategy for Victoria, Australia"<http://www.bvsde.paho.org/bvsacd/iswa2005/zero.pdf> The Metropolitan Waste Management Group (MWMG), a statutory body of the state government, produced the Metropolitan Infrastructure Schedule as part of the wider Metropolitan Waste and Resource Recovery Strategic Plan. The objective of the schedule is to give an overview and assessment of existing municipal waste infrastructure across Melbourne, with the aim of identifying improvements to enable MWMG to recover more waste in the future

In formulating the schedule, MWMG carried out studies on infrastructure needs, existing infrastructure, future recovery opportunities, future waste infrastructure considerations and upgrades or new infrastructure. Models to consider the merits of different improvement options were established to assess environmental, social and economic impacts. In addition, a private engineering consultancy was appointed to model and develop an analysis of options for the Strategic Plan to identify opportunities for recovery of materials sent to landfill for disposal, including municipal waste clustering opportunities. This incorporated economic costs and benefits, life-cycle assessment (greenhouse gas emissions, energy and water consumption, air emissions and waste to landfill) and an assessment of transport options and impacts.

The studies identified existing composting facilities, transfer stations and MRFs as being the key areas of improvement. For example, the options which provided the best results for "energy from fossil fuel use" were two types of 3 bin systems, one which included separate bins for recyclables, garden and food (for anaerobic digestion) and residuals (for landfill) or alternatively a system with separate bins for recyclables, garden (for aerobic composting) and residuals (containing food, for thermal treatment). These options will be financed from household collection fees, ranging from US\$ 137-158 per household per year.

The implementation of the schedule comes from US\$ 9 million in State Government funding, set aside for the wider Strategic Plan. Additionally, a landfill levy of up to US\$ 13.50 per tonne helps to support the funding of waste infrastructure, innovation, development and other improvements in efficiencies for waste management in Melbourne.

London Municipal Waste Strategy, London, UK

"The Mayor's Draft Municipal Waste Management Strategy" <http://legacy.london.gov.uk/>

"Research and Information Plans
2006/07"www.londoncouncils.gov.uk/London%20Councils/ResearchandINformationPlans0607FINA.pdf (must be downloaded as a .pdf)

Cory Environmental <http://www.coryenvironmental.co.uk/page/RRRCasestudy1.htm>

Clinton Climate Change Initiative, C40 Cities <http://www.c40cities.org/londonwasteworkshop/downloads/07%20-%20Shanks%20-%20ELWA%20Case%20Study.pdf>

Freight On Rail <http://www.freightonrail.org.uk/CaseStudyWasteByRail.htm>

WasteDataFlow <http://www.wastedataflow.org/home.aspx>

The London Municipal Waste Strategy aims to achieve greater regional self-sufficiency by developing new infrastructure, keeping the value of London's waste in the capital and focusing on new low-carbon technologies in waste management (e.g. away from bulking and transfer facilities to resource recovery parks). The Greater London Authority (GLA) is developing a London-wide site framework in partnership with waste authorities to collect data on current, planned and potential waste sites at a local and regional level to help the London Waste and Recycling Board determine the type, number and location of the waste facilities needed over a set period. Financial assistance from the board (US\$ 114 million) is dedicated to the development of new facilities for collection, treatment and the disposal of waste, supported by external funding from strategic partners (joint ventures, private investors, EU match funding). The Mayor also works with waste authorities to promote more sustainable forms of transporting waste, by maximising the potential use of rail and water transport.

The GLA works with national organisations, local authorities as well as private waste operators to deliver its strategy. For example:

o GLA works jointly with the national Department for Environment, Food and Rural Affairs (DEFRA), the Environmental Agency and London councils on the annual collection, validation dissemination of waste statistics for London. WasteDataFlow is an online web-based reporting system used by all UK local authorities, which provides information which can be used nationally, regionally and by boroughs to inform best practices and strategy.

o Cory Environmental (CE) has a 30 year waste management contract from four London boroughs from households and businesses. To support and safeguard its waste operations, CE is building the Riverside Resource Recovery Facility (RRR), claimed to be one of UK's most efficient energy-from-waste plants with an annual throughput of 670,000 tonnes. The new riverside operation will help remove more than 100,000 heavy good vehicle trips from the roads each year. The project is financed by a term facility of up to US\$ 728 million from private banks, with US\$ 124 million of equity finance provided by CE.

o The East London Waste Authority (ELWA) uses a private company to transport its solid household waste. The contract is via a Private Finance Initiative (PFI) Integrated Waste Management agreement, which provides \$US 204million for the construction of the waste-by-rail transfer service from an upgraded railhead as well as innovative technologies to improve ELWA's waste treatment facilities.

Solid Waste Management Project, Dhaka, Bangladesh

Kitakyushu Initiative for a Clean Environment "Solid Waste Management in Dhaka City"

<http://kitakyushu.iges.or.jp/docs/mtgs/seminars/theme/swm/presentation/3%20Dhaka%20%28Paper.pdf>

Dhaka City Corporation (DCC), responsible for solid waste management in Dhaka, encouraged private and non-profit organizations to organize community waste management programs in line with the implementation strategies set out in the citywide Solid Waste Management Plan. The

Dhanmondi Solid Waste Management pilot project was the first DCC-approved solid waste management project. The project was carried out by SCPL, a local private consultancy, with assistance from DCC. The main objectives of the project were to upgrade waste infrastructure (household collection containers and municipal garbage containers) and to provide door-to-door garbage collection services. After an initial assessment, SCPL supplied 2 waste bins (one red and one blue) to every household for separating waste into inorganic and organic waste at the source. The collected waste was disposed of at central dumping sites within each block, where the containers were monitored by SCPL workers. The waste was subsequently transferred by DCC waste vehicles to the central dumping sites. SCPL collects a monthly charge from each household, which also covers the workers' salaries. The project has significantly reduced air, water and soil pollution in the area and the separation of wastes has made it easier for the authorities to sell inorganic materials to recycling companies. This has reduced the volume of waste as only organic materials are carried by DCC trucks to secondary dumping sites. The project has also helped generate positive behavioural changes within the community

Local Authorities' Waste Management, Italy

The Chartered Institution of Waste Management "Delivering key waste management infrastructure: lessons learned from Europe"<http://www.wasteawareness.org/mediastore/FILES/12134.pdf>

CONAI Environmental http://www.pro-e.org/Financing_Italy.html

Waste services in Italy are delivered through public bodies known as 'ATOs', which are normally funded directly by local authorities and are responsible for defining the services required to manage local authority waste streams. New waste management infrastructure is often funded directly from the local authorities' own resources, although for large facilities some private finance is also obtained through a form of prudential borrowing. In some cases waste facilities or services are procured through a tendering process from private sector waste management companies, with contracts in place either directly with a local authority or the relevant ATO. An ATO can also fund a waste infrastructure project either in part or completely, through the use of eco-taxes. For example, the CONAI packaging management scheme, which places an eco-tax on all packaging used for the sale of goods on the Italian market, generates annual revenue of US\$ 324million, a proportion of which is used to finance new waste infrastructure.

07 SORTING & TRANSFER FACILITIES



DESCRIPTION

Waste treatment facilities such as materials recycling facilities and landfills can either use excessively large amounts of energy or not fully utilise energy produced by them.

Assessing energy efficiency opportunities in the waste sorting and transfer facilities can help city authorities invest in retrofits with a positive cost benefit. The resulting improvements in maintenance and use or replacement of equipment in waste management facilities can reduce energy use associated with their operation. Other benefits include reduction in environmental and social impacts from operation of waste sorting and transfer facilities, for example, odour control and staff welfare.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Reduce energy use via targets created in AER	<p>Better operations and maintenance programme costs can be offset by savings made in improved energy efficiency performance of facilities. Using Annual Environmental Reports (AERs) can focus individual sites to make a collective improvement to the energy used by this section of the municipality's waste system.</p> <p>See Nenagh case study for more details.</p>

ATTRIBUTES

Energy Savings Potential
100,000-200,000 kWh/annum

First Cost
US\$100,000-1,000,000

Speed of Implementation
1-2 years

Co-Benefits

- Reduced carbon emissions
- Improved air quality
- Enhanced public health & safety
- Increased employment opportunities
- Financial savings

Offer incentives for continued improvement	<p>The city authority offers incentives to encourage facility managers to meet AER targets. Incentives can be financial, planning or contract related or by way of public recognition, for example, an annual awards ceremony.</p> <p>See Summit County case study for more details.</p>
Showcase new practices in waste management	<p>The city authority raises awareness amongst operators about the benefits of fuel-efficient operations. Invite potential suppliers, existing waste management providers and or municipality waste teams to a conference to showcase new waste management equipment, processes and encourage trials. Aim to showcase examples of energy and cost-savings from efficient sorting and transfer operations and encourage attendees to form partnerships to implement energy efficient practices.</p> <p>See Naga City and Irvine case studies for more details.</p>

Operational Efficiency

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Energy used for sorting per tonne of waste (MWh/tonne)
- % of waste recovered by sorting (%)
- fuel use per vehicle per tonne of waste per km travelled (MWh/tonne/km)
- % of waste composted in city (%)

Create baseline for energy use in any municipality owned facilities, targeting individual plant equipment and seek implementation of Annual Environmental Reporting (AER) programme to monitor progress.

Setup monthly maintenance programme to ensure all plant are operating efficiently. Create programme for ensuring options for improved waste treatments are assessed and implemented where possible.

CASE STUDIES

Springfort Cross Waste Transfer Station Reporting Scheme, Nenagh, Ireland

http://www.epa.ie/licences/lic_eDMS/090151b280347fbc.pdf

The waste transfer station at Springfort Cross, Nenagh produces Annual Environmental Reports (AERs) in line with Integrated Pollution Prevention Control (IPCC) licensing in Ireland to reduce emissions, waste and to encourage efficient energy use. The AER contains annual summary reports on all aspects of environmental performance of the facility for effective site evaluation, including resource and energy consumption. The use of summarised energy efficiency audits and waste generation reports helps to focus specific future targets in energy efficiency improvements, with the scheduling of energy efficiency audits and to decrease fuel consumption in the transfer station. A solid waste management consultancy was hired to produce the AER for submission to Environmental Protection Agency.

Summit County Material Recovery Facility, Summit County, USA

http://www.thegbi.org/assets/case_study/MRFCaseStudy.pdf

As the first facility of its kind to be certified as green, the Summit County Material Recovery Facility (MRF) project was awarded two Green Globes by the Green Building Initiative (GBI) for energy efficiency (on the basis that MRFs typically have high energy consumption used for facility ventilation and lighting of the tipping floor). The MRF site location was oriented to optimise solar gain and provide natural day lighting, saving energy in lighting the tipping floor. The most energy efficient element was the mechanical system of the facility, using electric heating with energy recovery ventilators (ERVs) and ducted ventilation. The ERVs provided the largest energy savings and cost nearly \$40,000 less to operate than the typical radiant system, with payback of about 3 years. By focusing on specifying high-efficiency lighting fixtures, lamps, lighting controls/occupancy sensors and heating ventilation and air conditioning (HVAC) equipment, the project shows how incentivised investments in retrofits can provide energy efficiency in a cost-effective manner.

Community Materials Recovery Scheme, Naga City, Philippines

"Sustainable Urban Energy Planning: A handbook for cities" pg 46, <http://www.unhabitat.org/pmss/getElectronicVersion.aspx?nr=2839&alt=1> (must be downloaded as a .pdf)

To reduce the amount of garbage brought to landfill or dumped into rivers, Naga City begun materials recovery on a community scale in 1999, which developed into a city-wide Materials Recovery Facility (MRF) launched in February 2004. The facility sorts waste into biodegradable waste for conversion into organic fertilisers for sale in the market. Non-biodegradable waste recovered by the facility are either sold or recycled. The facility sorts 40% of the city's waste for recycling, saving 13,862 tonnes of CO₂e annually. Key to the project is the Build-Operate-Transfer (BOT) agreement with the Lacto Asia Pacific Corporation, which provides direct sales of equipment, shared training expertise, maintenance and service for the efficient management of MRF equipment. The local government invested in the project in terms of land, machineries and equipment, infrastructure and operational costs, totalling \$405,000.

'Waste Management' Sorting Line, Irvine, California, US

WM press release

http://www.wmsecurityservices.com/WM/press/pr2009/20091118_WM_Unveils_New_Sort_Line_to_Reduce_Landfill_Deposits_and_Carbon_Emissions.pdf

"Advanced waste sorting line boasts of higher capacity" <http://www.ecoseed.org/en/recycling/waste-management/article/84-waste-management/5198-advanced-waste-sorting-line-boasts-of-higher-capacity>

In 2009, the private waste services provider 'Waste Management' unveiled its \$1.7 million recycling line that would allow the company to recover more reusable materials and thereby reduce landfill deposits and carbon emissions. The new waste sorting line at the company's Irvine processing and transfer facility will be able to process commercial waste as well as recyclables from municipal solid waste streams.

The facility already has a construction and demolition sorting line in place. With the new sorting line, it will be able to process up to 30,000 tons of waste annually. The recycling line utilizes state-of-the-art infrared optical sorting to separate dry recyclables, along with sorting mechanisms such as drum feeders. The line can process up to 15 tons of materials per hour. Aside from reducing its local carbon footprint, the company said it would generate additional revenues through the new sorting line.

The company, which has several plants across North America, has actively promoting its environmental activities, stating that "Investing in green technology makes good business sense" as it increases consumer demand and provides cost and carbon savings.

The new recycling sort line is part of WMOC's recent environmental initiatives, including: a natural gas power fleet of collection vehicles, GreenOps Tracking Stations, reverse vending machines in Tustin; and food waste recycling machines in Laguna Beach. The company also has plans to provide solar-powered trash and recycling compactors in the near future.

ANEXO 10

06 INTERMEDIATE TRANSFER STATIONS



DESCRIPTION

Use transfer stations for bulking of waste to help minimise the number of trips to treatment facilities by smaller city based waste collection vehicles. This recommendation has good synergies with the recommendation "waste vehicle operations fuel efficiency standards" and the city authority should consider implementing them together.

Reducing the distance travelled per tonne of waste can reduce energy demand associated with transfer of waste to large treatment facilities (such as landfills). Co-benefits include a reduction in the number of waste vehicles travelling long distances, leading to reduced noise and dust in residential areas, improved road safety, and improved air quality.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Provide transfer stations as part of the Solid Waste Management Plan	The city authority works with its planning department and waste management team to identify shortfalls in the city's waste collection system and improve the city's Solid Waste Management Plan. Create a flow map of waste that includes the existing waste catchment and planned city development, to highlight gaps and inefficiencies in the city's waste management system and identify opportunities to provide waste transfer stations. The city authority can also seek support from private waste management companies in return for procurement of city waste collection catchments. See New York and British Columbia case study for further details.

ATTRIBUTES

Energy Savings Potential

>200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Increased employment opportunities

Financial savings

Reduced waste vehicle traffic

<p>Planning regulations for waste management</p>	<p>The city authority planning department makes waste management an integral part of the city's spatial planning strategies, allocating land for waste transfer stations and other facilities in accordance with the Solid Waste Management Plan.</p> <p>Where appropriate, waste management regulations and guidelines should also be included within the city's development control documents, for example, requiring developments above a certain size to integrate waste transfer stations into masterplans when certain densities are reached. In order to ensure a site's suitability, coordination is essential with the city's waste management strategy, urban development plans and environmental plans.</p> <p>See Kuala Lumpur and Birmingham case studies for further details.</p>
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Energy use per tonne of waste for collection transportation and disposal (MWh)
- Total city energy use for waste transportation per tonne of waste (MWh/t)
- Total annual waste mileage (km)
- Kilometres travelled per tonne of waste (km/t)

Assess number and location of waste transfer stations and map against waste catchments in municipality. Waste catchments can be based on daily collection route extent, districts, or capability of waste collection fleet.

Track city development and establish mapping regime of existing and potential waste transfer stations against expanding municipality catchments.

Ensure distances from collection points to treatment facilities do not exceed recommended travel distances as supplied by vehicle manufacturers.

Compare fuel use per volume or mass of waste transferred pre- and post-transfer station implementation.

CASE STUDIES

Solid Waste Management Plan, New York City, USA

<http://www.plannyc.org/taxonomy/term/762>

The mayor of New York initiated a Solid Waste Management Plan (SWMP) in 2006 as a framework for dramatically reducing the energy use associated with waste disposal in the city while implementing a cost-effective and environmentally sound system for managing the city's waste. The plan involved the assessment of existing transfer stations to maximise waste management efficiency and create a more equitable distribution of waste storage, transfer and disposal throughout the boroughs.

By exporting 90% of the city's residential waste by barge or rail (rather than by truck), the program will reduce waste truck miles by 2.7 million per year and reduce tractor-trailer travel by 3 million miles per year. This relies on updating transfer stations in every borough, re-opening eight disused transfer stations, and the building of seven new marine transfer stations within the city. The marine transfer stations, due for completion in 2013, are also expected to reduce waste truck travel by 3.5 million miles. However, some sources claim that the marine transfer stations will increase the cost of waste disposal from \$77 per tonne to \$107.

The project has faced challenges with the construction of the new transfer stations, which has been held-up by lawsuits and community organisations concerned about increased truck traffic, air and noise pollution and water dredging that may harm nearby wildlife. Due to this, only two of the seven marine transfer stations were under construction by May 2010 and none of the barges are being utilised. In March 2009, the Mayor signed a 30-year contract with a private waste management company to oversee a program for transporting waste from Brooklyn's transfer stations to out-of-state landfills by train.

Municipal Solid Waste Guidelines, British Columbia, Canada

<http://www.elj.gov.bc.ca/epd/epdpa/mpp/gfetsfms.html>

The regional authority (Ministry of Environment) funded a project to prepare a report on guidelines for establishing transfer station facilities for municipal solid waste. The authority hired a private engineering consultancy in Victoria, BC to produce the report on transfer station methodologies, using examples to recommend siting, design and operational guidelines for establishing transfer stations. The guidelines also include cost models that compare direct haul in collection trucks with transfer haul to a landfill, and rural landfills with rural transfer stations. Such cost models can be used as an aid to decide whether a transfer station is justified under particular conditions, as they identify operational and capital costs in detail per relevant case study. The report covers potential issues for future implementation, and the detailed examples of transfer station operation/capital costs in the report make it applicable to municipalities during the implementation of their solid waste management plans.

Kuala Lumpur Waste Structure Plan 2020, Kuala Lumpur, Malaysia

http://www.dbkl.gov.my/pskl2020/english/infrastructure_and_utilities/index.htm

The Kuala Lumpur Structure Plan 2020 is the strategic spatial development plan for the capital, which includes guidelines on improving the quality of its infrastructure and utility services. Solid waste collection and disposal services are integrated into the Structure Plan where coordination of existing landfill sites and capacities are outlined, supported by the allocation of new transfer stations in the city. The Structure Plan identified the limited capacity of the Taman Beringin landfill site, leading to the transfer of waste to a private landfill site outside the city in Air Hitam. Plans for a new transfer station at Taman Beringin is to be built to support this waste transfer, by sorting waste for recovery of recyclables and compacting of the remaining waste before it is transported to the Air Hitam site for disposal by sanitary landfill. The distribution of existing solid waste disposal sites and transfer stations are planned and mapped out in the structure plan.

Veolia Environmental Services Waste Transfer, Birmingham, UK

<http://www.veoliaenvironmentalservices.co.uk/Birmingham/>

Veolia Environmental Services, a private waste management company, operates two major waste transfer stations in Birmingham, in the north and the south of the city. These play a key role in managing the waste arisings of the city and act as focal points for recycling management.

The transfer stations accept kerbside collected waste from Birmingham City Council refuse vehicles. This waste is then bulked up and transported either to the recycling reprocessor, the Energy Recovery Facility (ERF) at Tyseley or to landfill.

A normal refuse vehicle will hold about 8 tonnes of rubbish. Bulk vehicles will hold up to 25 tonnes, which means that vehicle movements are reduced by a third by the use of the transfer stations. It also means that refuse collection vehicles do not have to travel across the city to deposit their rubbish, but rather they run into the nearest transfer station. A considerable portion of the rubbish brought to the ERF is transported at night to reduce traffic congestion and improve the efficiency of the operation.

The transfer stations also act as bulking stations for the recyclable materials that are collected either from the kerbside or from the Household Recycling Centres, reducing vehicle movements, easing congestion and reducing the environmental impact of transporting Birmingham's recyclable materials.

TOOLS & GUIDANCE

Tools & Guidance

"Guidelines for Establishing Transfer Stations for Municipal Solid Waste" <http://www.env.gov.bc.ca/epd/epdpa/mpp/gfetsfms.html>

"Waste Transfer Stations: A manual for decision making" (US Environmental Protection Agency)
<http://www.epa.gov/osw/nonhaz/municipal/pubs/r02002.pdf>

05 WASTE LANDFILL GAS CAPTURE PROGRAM



DESCRIPTION

Landfill gas, or biogas, is a natural by-product of the decomposition of organic waste (such as food waste, green waste and paper) in landfills. If captured, it can be used as a source of energy through the generation of electricity and/or heat or by being processed for gas supply.

Landfill gas capture has the potential to provide alternative energy sources for municipalities.

Reduced fuel consumption and energy use as a result of good planning and allocation of suitable facilities.

Gas from landfills that contains a high proportion of methane, which can be converted to electricity or used to power vehicles as an alternative fuel.

As methane is a potent greenhouse gas, reducing the volume released into the atmosphere has significant environmental benefits.

ATTRIBUTES

Energy Savings Potential

>200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility study for landfill gas capture	<p>A feasibility study establishes the technological and policy framework to implement a landfill upgrade program across the city. This should consider:</p> <ul style="list-style-type: none"> • Gas yields and generation rates over the next 10, 20, 30 years • Technology • Capital and operational costs • Procurement options • Finance options • Operation and management requirements • Coordination with environmental programmes <p>The establishment of appropriate partnerships is central to the success of the study - partners can include national and regional government with industrial and technical support from private sector companies, research companies, or universities. These partnerships help garner support for expansion of the initiative and inform how the program fits into the larger policy and commercial framework. If there is an existing general directive to support programs such as gas capture from landfill, the feasibility study should be formulated to fit with these policy prescriptions.</p> <p>Other municipality cost centres can also benefit from the study if biogas displaces other types of fuels, e.g., biogas-powered bus fleet.</p> <p>See Ho Chi Minh City case studies for further details.</p>

Enhanced public health & safety
 Increased employment opportunities
 Financial gain
 Operational efficiency

<p>Planning Policy Coordination / Regulation</p>	<p>The coordination of landfill gas capture programs with wider urban plans and planning policy allows the City Authority to develop a high level plan for gas capture, and through the policy system, the responsibility for developing landfill gas capture can be passed onto various bodies including developers or landfill operators. Planning policy that relates to gas capture should be developed in the context of the wider policy framework and existing resources, e.g. technical capability, landfill retrofit potential.</p> <p>See California, Hong Kong and Ho Chi Minh case study for further details.</p>
<p>Procurement Program</p>	<p>The City Authority institutes a procurement policy or guidelines that allow a third party to install and operate a gas capture system on existing or new landfills. This implementation activity has good synergies with Kyoto Protocol Mechanisms: Joint Implementation and the Clean Development Mechanism, and these and other routes for obtaining financial support should be investigated. Coordination with environmental regulations is essential, as some programs require close monitoring to ensure they are safe and don't negatively impact the environment.</p> <p>See Hong Kong, Dar Es Salaam and Ethekewini case studies for further details.</p>

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Increase in volume of gas captured (litres/annum)
- Increase in MW electricity produced

Assess gas quantities produced. Establish targets for gas generation rates for the next 10, 20, 30 years in phases.

CASE STUDIES

Landfill gas recovery program, Tianjin, China

Source: ESMAP (2009). "Tianjin, China - Landfill Gas Capture for Electricity Generation – A Case Study", available online from <http://www.esmap.org/esmap/node/661>

The city of Tianjin, the fifth largest city in China, has implemented a project to recover landfill gas (LFG), which was otherwise being released into the atmosphere, and burn pretreated LFG for electricity generation. The project was located at the Shuangkuo Landfill, one of five municipal waste landfills in Tianjin. The planned capacity of the project is 4.3 MW which is being installed in stages. The first generator, 1.03 MW, started operation in May 2008, currently utilizing 500-600 cubic meters of landfill gas. The electricity produced is being sold to the North China Power Grid under a long-term contract. Through the project, the city was able to use waste to generate revenues and gain local environmental benefits.

The project was initiated by the Tianjin Municipal Government, which has invested CNY46.7 million (US\$6.9 million) in the project. The project has been implemented and is being operated by a specially created entity, the Tianjin Clean Energy and Environmental Engineering Co. Ltd. (TCEE). The project will obtain revenues from the sale of electricity which, over the project's life, will amount to CNY245.2 million (US\$36.2 million). The project has been registered as a CDM project under the Kyoto protocol and reached an agreement with the World Bank to purchase the certified emission credits (CERs) from the project.

The successful implementation of the project provides an excellent demonstration of the technology and the institutional mechanisms for LFG recovery and electricity generation, which can be applied to many other large Chinese cities.

NENT Landfill Gas Utilisation Scheme, Hong Kong, People's Republic of China

Source: Environmental Protection Department, The Government of Hong Kong, available online from http://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/msw_lgu.html

Hong Kong has implemented large-scale schemes to extract gas from landfill sites in order to help reduce the use of fossil fuels in the town gas production process. The North East New Territories (NENT) Landfill Gas Utilisation Scheme is one of the largest off-site landfill gas utilisation schemes in the world, helping to minimise the use of fossil fuel in the town gas production process and reduce the release of methane into the environment. Landfill gas (LFG) is recovered from the NENT Landfill and used for on-site energy demands (electricity for site facilities and heat for wastewater treatment), whilst surplus landfill gas that is not utilised on site is used for the landfill gas export scheme. A LFG treatment plant has been installed at NENT landfill to treat the raw landfill gas, removing CO₂, hydrogen sulphide and non-methane hydrocarbons. The product gas (80% methane) is then delivered to the Towngas production plant through a 19km underground pipeline. The scheme produces annual reductions of up to 135,000 tonnes of CO₂e emissions annually. An agreement to construct the LFG treatment plant is held between the contractor of the NENT Landfill, Far East Landfill Technologies Limited (FELT) and the Hong Kong and China Gas Company Limited (HKCG). FELT and HKCG have invested US\$ 10.4 million in the LFG treatment plant and US\$ 19.6 million in the gas pipeline respectively.

Sanitary Landfill Gas CDM Project, Ho Chi Minh City, Vietnam

UNFCCC "CDM Project 1913: Phuoc Hiep I sanitary Landfill gas CDM project in Ho Chi Minh City" <http://cdm.unfccc.int/Projects/DB/DNV-CUK1214915267.84/view>

R.E.E. Mechanical & Electrical Engineering Joint Stock Company "Ground Breaking Ceremony the project to recover methane emitting from the landfill and to generate power according to the Clean Development Mechanism" <http://www.reeme.com.vn/Eng/tincongtyen.php?ldtin=39>

Ho Chi Minh City has contracted KMDK (Vietnam) Co. Ltd to develop projects for methane recovery and power generation from the three landfills of Phuoc Hiep, Cu Chi Ward and Dong Thanh, under the Clean Development Mechanism (CDM). At the three municipal landfills, REE and KMDK South Korea are the main partners responsible for the installation of landfill gas (LFG) collection systems, LFG flaring facilities, leachate recirculation systems and electric power generation facilities. One of the projects (at the Phuoc Hiep I landfill) involved the installation of a full-scale LFG collection system to monitor the flare systems, quantity and quality of gas available from the site. KMDK provided further support by producing a feasibility study and design report on landfill gas collection efficiency.

The CDM projects by KMDK produce 42 million kWh/ year to supply nearly 20,000 households and reduce CO₂e emissions by 252,000 tonnes each year. Their estimated total capital investment has been between US\$ 25 - 30 million. Socioeconomic benefits from the project include new technology development, local employment and minimized explosion risks by controlling methane emission.

Landfill Gas Recovery and Electricity Generation Project, Dar Es Salaam, Tanzania

UNFCCC "CDM Project CDM Project 0908 : Landfill gas recovery and electricity generation at "Mtoni Dumpsite", Dar Es Salaam, Tanzania" <http://cdm.unfccc.int/Projects/DB/DNV-CUK1169853184.14>

UN HABITAT, ICLEI, Sustainable Energy Handbook http://www.iclei.org/fileadmin/user_upload/documents/Africa/Programs/Energy_and_Climate_Change/Sustainable_Energy_Handbook_Low_Res.pdf

Geneva Trade and Development Forum "Clean Development Mechanism as Tool for Sustainable Development: Case Study of Tanzania" <http://www.gtdforum.org/download/Case%20Study%20Tanzania.pdf>

The Dar Es Salaam City Council was approached by a private firm from Italy to establish a gas recovery and energy generation project at the Mtoni Dumpsite to reduce methane emissions, as a basis for a CDM project. The city authority granted the private firm, Consorzio Stabile Globus (CSG) the rights to capture and burn all biogas produced at the landfill over a 10 year period. CSG held responsibility for the construction and management of the gas extraction and flaring system, by setting up and operating an extraction plant. Annually, the project is estimated to reduce emissions by 202,271 tonnes CO₂e and generate about 200,000 carbon credits. Total investment costs for the project are approximately US\$ 5.3million. Revenue from electricity sales and revenue from sale of carbon credits (US\$ 2.65 -3.18 million) the expected return on investment is 2 years. CSG invested in the project whilst the city council continued to own and manage the landfill site, making the landfill capture program economically feasible for the city authority.

Altamont Landfill and Resource Recovery Program, California, USA

Waste Management World 2010 "Green Giant" <http://www.waste-management-world.com>

The Altamont Landfill and Resource Recovery Facility in northern California are owned by the private corporation Waste Management Inc., who commission the world's largest landfill gas (LFG) to liquefied natural gas (LNG) plant. Waste Management and Linde North America (a leading global gases and engineering company) joined ventures to build a LNG facility costing US\$ 15.5 million, receiving state grants from the California Integrated Waste Management Board, the California Air Resources Board, the California Energy Commission and the South Coast Air Quality Management District. The plant provides enough fuel to power 60% of Waste Management's LNG vehicles in California, reducing Waste Management's dependence on foreign fossil fuel and introducing a domestic green energy source to the fuel market. An estimated 18 million litres of Altamont biofuel is produced annually, reducing CO₂ emissions by an estimated 27,000 tonnes per year.

TOOLS & GUIDANCE

Tools & Guidance

United States Environmental Protection Agency tool "Landfill Gas to Energy Benefits Calculator" <http://www.epa.gov/lmop/projects-candidates/lfge-calculator.html>

ANEXO 12

08 WASTE TO ENERGY PROGRAM



DESCRIPTION

The objective of this recommendation is to capitalise on the energy generation potential of Municipal Solid Waste (MSW) by introducing new forms of waste treatment. In order to implement this recommendation, a city will have met essential waste collection and transportation requirements that enable sorting of solid waste for incineration, gas capture, and heat and/or power generation.

The introduction of waste-to-energy processes can be used to support existing energy infrastructure and reduce reliance on traditional energy providers.

By reducing waste going to landfill, waste-to-energy programs will not only reduce land-take pressures, but will also help reduce future methane gas emissions from landfills.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Develop feasibility study	A feasibility study establishes the technological and policy framework to roll out a waste-to-energy program. Create a team that includes city planners, waste managers and financial advisors so that the feasibility study can be closely linked to waste generation quantities, site availability, waste management strategy, technical ability, incentives and taxes, etc. Establishing appropriate partnerships is central to the success of the study, for example, through the city authority assessing procurement options and possible support from private waste contractors or investors.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

> 2 years

Co-Benefits

Reduced carbon emissions

Improved air quality

Enhanced public health & safety

Increased employment opportunities

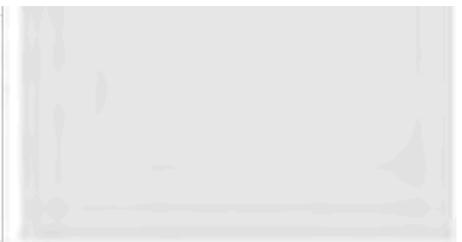
Financial gain

Security of Supply

	See Abidjan and Gothenburg case study for more details.
Regulation/ Planning policy coordination	<p>The city authority develops planning policy or guidance that supports the development of waste-to-energy as a treatment option. The resulting waste-to-energy programs should be coordinated with wider urban plans and policy framework. Additionally, taxes on landfill waste and incineration (without energy generation) can encourage operators to invest in more efficient waste-to-energy technologies.</p> <p>See Gothenburg case study for more details.</p>
Procurement Program (existing and new facilities)	<p>The city authority contracts a third party to capture energy from waste facilities (existing or new). This can be done through landfill gas capture and treatment, anaerobic digestion gas collection and/or MSW incineration with energy generation. This implementation activity has good synergies with Kyoto Protocol Mechanisms: Joint Implementation and the Clean Development Mechanism, and these and other routes for obtaining financial support should be investigated. This approach will enable the city to implement a waste-to-energy program without prohibitive up-front costs. Coordination with environmental programs is essential, as some programs require close monitoring to ensure they are safe and don't negatively impact on the environment.</p> <p>See Abidjan and Singapore case study for more details.</p>



Regulation/ taxes	<p>Taxes on landfill waste and incineration can be a good mechanism to encourage operators to implement waste-to-energy programs to bring in additional revenue that can in turn be used to invest in more efficient technologies. This implementation activity will benefit from mandatory minimum standards for all waste treatment sites.</p> <p>See Austria and Gothenburg case study for more details.</p>
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Net energy generated per ton or m3 of waste.
- tonnes of waste converted into energy
- % waste treated by waste-to-energy
- % increase in net energy generated (after facility energy use)

Estimate waste generation potential over next 30 years. Set KPI's based on performance and or size of other regional and or countrywide facilities, for example, minimum energy exported after facility energy use and maximum waste treated by waste to energy. Measure and report on any existing or planned regional or national waste to energy provision in tonnes and energy generated.

Abidjan Municipal Solid Waste-To-Energy Project, Abidjan, Ivory Coast

UNFCCC (2010) "Abidjan Municipal Solid Waste-To-Energy Project"

<http://cdm.unfccc.int/Projects/Validation/DB/WMCZWV34G1WDMVMQGPB2AXI3CZXQXF/view.html>

The municipal solid waste treatment plant in Bingerville was developed under a Clean Development Mechanism (CDM) project to manage 200,000 tons of municipal solid waste/year. After sorting, the project treats the waste by anaerobic fermentation. The resultant biogas is captured and used to produce renewable electricity for on-site consumption as well as for sale to a state-owned electricity company under Power Purchase Agreement (at US\$ 25.66/MWh). Residual waste from the fermentation process is also transformed into compost and sold to local farmers. The project was set to avoid 583,965 tCO₂ equivalent over the first 7 years crediting period, create more than 180 jobs, and generate 3MW of electricity per year at full operation in October 2009.

A key success factor to the project is the adoption of technology from an Italian-based company (PROMEKO Spa) specialised in engineering, planning and turnkey building of urban and industrial waste treatment plants. The Ivorian project developer (SITRADE) receives trainees from the technology provider, benefiting the project from know-how transfer. Due to the reliance on imported components and equipment, the project requires special assistance in the first months of operations to alleviate the risk of technological failure. Lack of public funding and difficulties in attracting investors in a high-risk business climate are a barrier to success, resulting in project developers taking out loans from local banks.

Singapore Waste Management Project, Singapore

"9.5 MW Food Waste Based Grid Connected Power Project implemented by IUT Singapore Pte Ltd., Singapore"

<http://cdm.unfccc.int/Projects/Validation/DB/OFKVAJIKYTB05GUR4JXMRLC0DREF3G/view.html>

IUT Global Pte Ltd., a Singapore-based waste management company has implemented a 9.5 MW grid connected power project produced by bio-methanisation of food waste generated in Singapore, using the ADOS (Anaerobic Digestion of Organic Slurry) technology. An additional benefit of this project is that it increases energy efficiency of solid waste incinerators, especially as food wastes have high moisture content (around 80%) and consume more energy to incinerate. The electricity generated is sold in the wholesale electricity market and residual material is processed for bio-compost for commercial use as an organic soil conditioner. At full capacity, the waste-to-energy plant will process more than half of the food waste being delivered to local incineration plants for disposal in 2008. Phase 1 of the project was expected to produce 10,599 MWh net incremental power per year and reduce emissions by 5,088 tCO₂ equivalent per year.

As Asia's first major organic bio-methanisation power plant based on food wastes, the project presents high operating and performance risks, requires training man-power with new skill sets, and incurs high capital costs for relatively small installed power capacity. An additional disadvantage in Singapore is that, because of the absence of a long-term Power Purchase Agreement, the tariff of power is determined by the open wholesale market, which means that the revenue brought in by the sale of electricity is inconsistent. The advantage of this project is that the design, implementation and operational experience of the state-of-the-art technology involved in the project can lead to its replication across Asia and the Middle East with Singapore as a base for export of such skills and technological advances.

have saved US\$6 million⁴ in annual operating costs and US\$1.1 billion that would have been needed to renovate the incinerators (City of Yokohama 2006). Around 5 percent of the fiscal year 2008 budget of the Resources and Wastes Recycling Bureau, the city's waste management entity, was derived from the sale of recycled material (US\$23.5 million). In addition, the city raises US\$24.6 million annually by selling the electricity generated during the incineration process.

Gothenburg Waste Management Project, Gothenburg, Sweden

Clinton Climate Initiative, Climate Leadership Group, C40 Cities
http://www.c40cities.org/bestpractices/waste/gothenburg_system.jsp

In Sweden, there is a tax on all landfill and a further tax on incineration, with tax benefits if electricity is produced. This encourages landfill operators to generate power from waste through gas capture or incineration.

Gothenburg uses an integrated waste system to collect, sort and burn the city's rubbish. Waste incineration is used to provide energy for heating and electricity through a highly efficient system at 3.3MWh/ton of waste. The project involves the coordination of city authority planners and waste management service companies in the sorting of wastes. Waste management services are contracted out to private companies such as Renova (Sweden's largest waste management company) and IL Recycling who bid for tenders to collect, treat and dispose of industrial and business waste, whilst the local authority is responsible for the collection and treatment of household waste.

Renova incinerates the waste in the Savenas plant, which provides 27% of the 3,970 GWh required for the district heating system. As a result of the construction of new boilers, flue gas condensers, other technologies and increased efficiency in sorting and separation of waste, the energy produced by the plant has increased by sixfold between 1974 and 2006 whilst incinerated waste volumes have only doubled. The waste-to-energy program reduces landfill reliance (of all the waste that is collected, only 8% remains for landfill) and the production of electricity reduces Renova's incineration taxes.

Durnrohr EFW Facility, Austria

"Delivering Key Waste Management Infrastructure: Lessons Learned from Europe"
<http://www.wasteawareness.org/mediastore/FILES/12134.pdf>

Durnrohr Energy From Waste facility is situated in Lower Austria. The project was conceived by EVN (a power supplier in the Region of Lower Austria) in 1995 in response to the requirements of the Landfill Ordinance and the increasing rate of landfill tax. EVN subsequently formed AVN, which although representing a partnership with the Region of Lower Austria, is made up of entirely private shareholders.

EVN financed the plant using both its own equity and private investment, which was raised on the back of securing two key contracts, one for 154kTpa of MSW from a network of waste management associations and another from a private contractor collecting non-hazardous industrial wastes from sources across Lower Austria. Gate fees charged by the facility are typically in the region of Euro 100 / tonne on both public and private contracts.

TOOLS & GUIDANCE

Tools & Guidance

Approved CDM methodology documents "Tool to calculate the emission factor for an electricity system"
https://cdm.unfccc.int/methodologies/PAMethodologies/tools/am-tool-07-v1.1.pdf/history_view

"Approved CDM baseline and monitoring technologies" <http://www.co2-info.com/downloads.html#Methodologies>

"Energy from Waste: A good practice guide"
[http://www.iswa.ch/Info/Documents/PublicationAwards04/Energy%20from%20Waste\(CIWM\).pdf](http://www.iswa.ch/Info/Documents/PublicationAwards04/Energy%20from%20Waste(CIWM).pdf)

01 IMPROVE EFFICIENCY OF PUMPS AND/OR MOTORS



DESCRIPTION

It may be possible to replace and/or improve the operating efficiency of pumps and motors associated with the following networks:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks.

Energy is wasted when motors run at inappropriate speeds and pumps are not working at their duty points. Conditions such as this may occur over time because of changes in network flow or general wear and tear. Remedial work which could achieve positive cost benefits could include:

- Upgrading or replacing pump and/or motor to match duty requirements with peak efficiency
- Consider replacing single speed pumps with multistage and/or extending to variable speed
- Re-winding motors
- Relining the pumps
- Trimming pump impellers
- Power factor correction
- Soft start and/or variable speed controls
- Off-peak pumping to even out and reduce daily energy demand and gain benefit of reduced tariffs.

ATTRIBUTES

Energy Savings Potential

> 200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

Efficient water use

Enhanced public health & safety

Increased employment opportunities

Financial savings

Security of supply

By adjusting, upgrading and/or replacing the main components of pumps and/or motors, general operations can be improved and considerable savings can be made in energy required to work the system. A more appropriately rated pump will be subject to less wear and tear. This in turn reduces the potential risk of damage to the associated pipeline and fittings. Off-peak pumping (for example refilling reservoirs overnight rather than during peak demand) assists power companies to achieve energy efficiencies at their main plant by levelling out the daily demand profile and enabling preferential tariffs to be offered to the end user.

To maintain optimal energy performance over the long term, an appropriate Operation and Maintenance Program should also be developed and implemented on pumps and motors.

NOTE: The appropriateness of replacement or upgrading will depend on the associated costs relative to the condition and remaining design life of the component. Each appraisal and development of implementation options must be conducted separately for each specific network.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study. The CA should engage a team that includes network planners, water and utilities engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study establishes the technological and financial viability, as well as procurement and policy options. It establishes the baseline city energy expenditure associated with water supply/waste water treatment and the efficiency of pumping and motors across the network(s). Technical ability, procurement methodology, incentives and taxes should also be given consideration. Each option should be appraised against the specific requirements and capabilities of the CA.

Direct expenditures & procurement	Where the water network is owned or run by the City Authority, the CA pays for the audit and upgrades of the pumping/motor infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation and policies. This activity may not be appropriate if the City Authority does not own the utility infrastructure.
Energy Services Company	The City Authority enlists an ESCo to undertake the audit and replacement project. There are multiple tactics for engaging an ESCo, including part- and full- ownership of the system. It is recommended that if the ESCo approach is pursued, the City Authority first explores numerous implementation options and assess the pros and cons of each.
Efficiency Standards	The City Authority regulates the Water Companies to ensure their pumps and motors meet required standards of energy efficiency.
Partnering Programs	The City Authority liaises with established organisations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the pumping/motor infrastructure. Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy/efficiency projects, promotion of technology development and deployment, and/or help to build public/private partnerships. Difficulty can arise where the partnering organisations do not have access or influence over the funds required to implement the initiatives.

Water Company Collaboration	The City Authority incentivises water authorities and the organisations bearing the costs of pumping and treatment to drive a collaboration and negotiation process to develop a partnering program to maintain efficient water distribution systems across the city. If the organisations and/or water companies have no interest in the strategy, the City Authority may opt to subsidise the initial expense of any plant or hardware required and support the initiative through associated regulations. If the strategy is successful the CA may receive a rebate from the organisations bearing the costs of pumping and treatment.
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Energy per litre potable water supplied (kwh/litre): Measures the energy required to supply 1 litre of potable water to consumer.
- % Energy saving rate: Measures the percentage energy savings achieved at the end of the current reporting period against the historical energy consumption figure for the pumping station.

CASE STUDIES

No- and low-cost Energy Efficiency Measures, Pune, India

<http://www.watergy.org/resources/publications/watergy.pdf>

The Pune Municipal Corporation (PMC) partnered with the Alliance to Save Energy to help them to implement no- and low-cost efficiency measures across municipal water utilities. Energy audits were conducted on PMC's bulk water supply systems and hands-on training was held for PMC engineers. PMC also contributed a total of US\$189,000 (Rs. 8.5 million) to implement a series of capital intensive efficiency measures. Municipal water utilities in India spend upwards of 60 percent of their budget on energy for water pumping. As a result of energy efficiency measures, PMC experienced annual energy savings of 3.78 million kWh and annual cost savings of over \$336,000 (148 lakhs Rupees). The savings achieved at PMC are higher than projected in the energy audit report since the PMC municipal engineers implemented additional low and no cost energy efficiency measures at the pumping stations including distribution pumping stations. This is a direct result of the training provided to the municipal engineers by the Alliance to Save Energy. The implementation of EE measures also resulted in 10% additional delivery of water to community without adding any new capacity. In addition to direct reductions in energy costs, the utility also saved money by qualifying for a rebate program offered by the Maharashtra State Electricity Board to facilities maintaining a good power factor and reducing usage during peak hours. The efficient operation of the largest pumping station, Parvati Water Works, reduced the energy intensity of water supply by 6%, from 375 kWh/million litres of water to 352, and increased its rebate by almost 8% since fiscal year 2003-04, from \$110,000 (48.57 lakhs Rupees) to \$196,000 (86.27 lakhs Rupees).

Improving the Distribution of Water, Fortaleza, Brazil

<http://www.watergy.org/resources/publications/watergy.pdf>

The Alliance to Save Energy worked alongside the Companhia de Agua e Esgoto do Ceara (CAGECE) in the Northeast of Brazil to develop and implement measures to improve the distribution of water and the access to sanitation services. The water systems needed to expand to satisfy increasing demand without sacrificing efficient use of energy. The project improved system management by centralizing control. It also developed financing proposals with the Government of Brazil Fight against Electricity Waste Program (PROCEL) in order to implement energy efficiency projects with CAGECE's operations crew. These projects included automation of operations, rewinding and replacing motors, maximizing existing pump systems efficiency, and increasing storage capacity to allow pumps to be shutdown during peak electricity rate hours. Over the course of four years, CAGECE saved 88 GWh of energy, improving efficiency each year. Before CAGECE instituted their energy efficiency program, they provided access to 442,400 households. Four years later, the utility was able to provide 88,000 new connections over the original baseline, while decreasing total energy consumption and costs and maintaining water supply levels. Four years of official data show savings of over US\$2.5 million with an initial investment by CAGECE of only US \$1.1 million (R\$3 million). Another benefit was to introduce CAGECE to the tools and know-how to produce on their own initiatives that save energy and clean water. As a result of this 127 % return on investment after 4 years, CAGECE was initially approved for financing by the Energy Efficiency Fund of PROCEL to work with the World Bank to implement further efficiency measures.

Economical Pumping Solutions, Lichtenau, Germany

<http://www.lowara.co.uk/pressroom/casestories.php/24770>

Lichtenau is a small municipality with 3,600 inhabitants. Advice on water supply solutions was provided by a sales and service partner of the water pump company, ITT Lowara. This partner uses the knowledge and support of Lowara to propose more economical and innovative pumping solutions. These sorts of collaborations ensure that even the smallest water boards can achieve considerable savings through improving efficiency of water supply systems. By replacing an old pump with a variable speed version they have reduced energy consumption by around 40%. The frequency converter on the pump ensures that the flow rate can be easily adapted to that of the other pumps in the system. The pump installed has been running perfectly for more than 2 years in Lichtenau, and a recent audit at the same flow rate has shown that the pump consumes only 13.39 kW per hour, providing a saving of 8.34 kW/h against the old cast iron pump. This equates to a saving of 39%. During its service of some 5,827 hours to date, it has consumed less than 48,597 kWh. Based on a current energy cost of 0,18 Euro/kWh, the saving would be 8,748 Euros - and in environmental terms they emit less than 7,500kg/year CO₂, giving Lichtenau a production of CO₂ well below the federal average.

Energy Efficiency Strategies, Moulton Niguel, USA

<http://www.energy.ca.gov/process/pubs/moulton.pdf>

In the early 1990s, facing a major rise in energy costs, Southern California's Moulton Niguel Water District explored other methods to increase energy efficiency. Working closely with Southern California Edison and San Diego Gas & Electric to identify optimal rate schedules and energy-efficiency strategies, the district implemented a program in 1992 that has yielded substantial savings in the reservoir-fed branches of their distribution system. The District modulates wastewater flows by installing a proportional, integral, and derivative/variable frequency drives system. Automated controls and programmable logic controllers are also used to enable 77 district pumping stations to benefit from lower off-peak utility rates. It was also specified that all motors used in new construction should be 95-97% efficient. The District now saves nearly \$320,000 annually by using programmable logic controllers to control off-peak pumping. First-year savings for Moulton Niguel's Country Village station were over \$69,000. In 1994, the District's electric bill fell more than 20%-from \$1.5 million to \$1.18 million. These savings are particularly meaningful considering that Moulton Niguel has been impacted by a 14% electricity rate increase. The use of the proportional, integral, and derivative/variable-frequency drives system for wastewater pumping has reduced pumping energy costs by about 4%. In addition, San Diego Gas & Electric has paid cash rebates to the District for installing variable-frequency drives-over \$30,000 in 1993/1994. Electricity savings, combined with the utility rebates, offset the cost of installing the system.

Energy Management Program, Madera Valley, USA

<http://www.energy.ca.gov/process/pubs/madera.pdf>

Madera Valley launched an energy management program in 1991 that enabled it to meet higher demand in 1994 without increasing operating costs. The program focused on modifying two wells to better maintain system pressure. At two other wells, Madera Valley has since upgraded its standard-efficiency motors to energy-efficient units. The combined improvements to Madera Valley's pumping operations enabled the agency to provide 22% increased capacity in 1994-from 514 million gallons in 1993 to 627 million gallons in 1994. In addition, energy costs per household fell by 22%-from an average \$7.46 per household each month in 1993 to an average \$5.82 in 1994. System-wide, this translated into annual savings of about \$18,946, or over 15% of total energy costs.

Water Treatment Plant, San Juan, Puerto Rico

<http://www.energy.ca.gov/process/pubs/sanjuan.pdf>

The San Juan Water District's Sidney N. Peterson Water Treatment Plant was built to be energy efficient and is operated to encourage energy and water conservation among customers and staff alike. The district even created an incentive program for its employees that rewards them with a percentage of the first year's savings from new cost-cutting techniques that they identify. A state-of-the-art facility, the Peterson plant uses gravity flow to minimize pumping needs for a 120-mgd modular filtration system. Initial plant designs specified 15 horsepower backwash motors instead of 100 horsepower units, which reduced construction costs by 33% and lowered filtration energy requirements by 75%. A supervisory control and data acquisition (SCADA) system optimizes day-to-day performance and energy efficiency. To save more energy and money, district staff replaced standard-efficiency motors with energy-efficient motors to save \$5,000 per year. They also installed variable-frequency drives on flocculation and chemical feed pump motors to save \$11,000 per year and launched water conservation education, promotion, and enforcement programs. Avoided pumping due to water conservation measures saves around \$50,000 per year.

USAID funded Ecolinks Project, Galati, Romania

<http://www.munee.org/node/62>

As part of a USAID funded Ecolinks Project, the Cadmus Group assessed the city's water supply system and discovered that a series of energy conservation measures could save roughly \$250,000 per year in electricity costs. Low cost measures included trimming impellers to better match pumps and motors with required flows and pressures. Moderate cost measures included leak detection and reduction and limited pump replacement. A series of pumps replacements were recommended. For one pump's 5,854 hours of annual operation, it used roughly 2,500,000 kWh. A replacement pump and motor set could save roughly \$55,000 per year. For another pump with 6,000 hours of annual operation and consuming 3,000,000 kWh per year a replacement pump and motor set could save roughly \$42,000 per year. Cadmus also estimated that reducing the height of the discharge would decrease the static head between the wet well in a low voltage pump station and the actual discharge. If the height of the reservoir were an average of 1 meter below the discharge and the discharge were lowered, roughly 10 percent of the pumping costs could be eliminated. The cost of the measure would include labour and minimal parts (pipe extensions). This measure would save roughly 100,000 kWh/yr or \$5,000/yr.

TOOLS & GUIDANCE

Tools & Guidance

Kitakyushu Initiative: A report focusing on building the capacity of the local governments to overcome the urban environmental and water problems. http://kitakyushu.iges.or.jp/docs/sp/water/4%20Overview_Analysis.pdf

Pump Efficiency Calculator: An online calculator tool to work out exactly how much could be saved by replacing a fixed speed damped or throttled centrifugal load with a variable speed drive controlled solution. <http://www.abb.co.uk/cawp/seitp202/c253ae5e6abf5817c1256feb0053baf7.aspx>

ESMAP Public Procurement of Energy Efficiency Services - Guide of good procurement practice from around the world. http://www.esmap.org/Public_Procurement_of_Energy_Efficiency_Services.pdf

05 SLUDGE BENEFICIAL REUSE PROGRAM



DESCRIPTION

Develop a program to collect sludge and biogas from the sanitary treatment process. Biogas is created and captured in order to generate power through micro turbines and power treatment facilities. On site energy generation not only enables substantial energy savings but also makes the plant self sustaining and less reliant on local grid. In certain cases, excess energy created can be used onsite or sold back to the grid.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	<p>The City Authority can help to establish appropriate partnerships to undertake a feasibility study into bio-gas capture and energy generation. The CA should engage a team that includes network planners, water, energy and utilities engineers, environmental specialists and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability, as well as procurement and policy options. Options should be appraised against availability of land, funds and resources to introduce an onsite energy generator compared with current energy consumption, costs and level of treatment required. Technical ability, incentives and taxes should also be given consideration.</p>
Water Company Collaboration	<p>The City Authority incentivises water authorities to develop a partnering program that will create more energy efficient water treatment and disposal. If the organisations and/or water companies have limited interest in the strategy, the City Authority may opt to subsidise the initial expense of any plant or hardware required and support the initiative through associated regulations. If the strategy is successful the CA may receive a rebate from the profits of on-site energy generation.</p>
Efficiency Standards	<p>The City Authority regulates the Water Companies to encourage them to ensure their systems meet required standards of efficiency. The City Authority can advance negotiations through subsidy or by taking the lead or full ownership of the project if permission to work on the infrastructure is granted. Equally, where sufficient benefits to the utility providers may be identified, they may choose to take direct ownership and manage the intervention themselves. This strategy has the advantage of requiring less collaboration among parties and hence possibly being quicker to implement.</p> <p>Case Study: Mogden, UK; San Diego, USA; Sofia, Greece.</p>

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

> US\$1,000,000

Speed of Implementation

1-2 years

Co-Benefits

- Reduced carbon emissions
- Efficient water use
- Improved air quality
- Enhanced public health & safety
- Financial savings
- Security of supply

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Energy from Biogas re-used on site (kWh/annum)
- Energy from Biogas resold to the grid (kWh/annum)

CASE STUDIES

Mogden Sewage Treatment Works, London, UK (Thames Water)

<http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/883.htm>

Mogden Sewage Treatment Works is one of the largest in the UK. It was built between 1931 and 1935 at a cost of \$2.5 million and covers an area of 55 hectares. Over half of the power used by the plant is renewable energy that has been generated on site as part of the sewage treatment process. Mogden produces some 96,000 tonnes of sludge cake every year all of which is recycled to land. The methane produced during the sludge digestion process on site is contained in gas holders and used to run Combined Heat and Power (CHP) engines. These engines in turn produce heat for the digestion process and green energy for the National Grid, or to power the sewage treatment plant itself.

Point Loma Wastewater Treatment Plant, San Diego, USA

http://www.eesi.org/files/biogas_issuebrief_061609.pdf

http://www1.eere.energy.gov/femp/pdfs/bamf_wastewater.pdf

The Point Loma Wastewater Treatment Plant in San Diego, CA serves a 450-square-mile area and treats up to 240 million gallons of sewage a day, producing enough biogas to run a 4.5 MW generator. The plant is energy-self-sufficient and sells excess energy in the form of electricity to the grid. The generated electricity runs process pumps, lights, and computers. In 2000, the city of San Diego saved more than \$3 million in operational energy costs and was able to sell \$1.4 million worth of excess power to the electrical grid.

Sofia Energy Centre, Greece

<http://www.managenergy.net/download/nr305.pdf>

Psytaleia wastewater treatment plant serving Athens has a combined heat and power plant that runs on biogas. It is owned by a Public Power Company who is also the sole owner of the grid. The project includes biogas burning in specially designed turbines for electricity production. Waste heat from flue gases and the cooling water circuit of the turbines is used for sludge heating (inside the digesters) and drying (of the final product). In the early stages of the project, significant issues arose because this was the first power plant of its kind to be installed in Greece. In addition the nominal power output was quite significant. EYDAP personnel were sent to UK and Denmark to learn about similar type power plants. The electrical energy now produced is used to satisfy the site consumption. Any surplus energy is sold directly to the grid. The biogas is being produced from sludge digesters at a daily rate of 72 000 Nm³/day and can be used for producing 64 GWh of useful energy per year.

TOOLS & GUIDANCE

Tools & Guidance

Federal Energy Management Program - Biomass and Alternative Methane Fuels (BAMF) Fact Sheets:

http://www1.eere.energy.gov/femp/pdfs/bamf_wastewater.pdf

http://www.eesi.org/files/biogas_issuebrief_061609.pdf

02 ACTIVE LEAK DETECTION & PRESSURE MANAGEMENT PROGRAM



DESCRIPTION

Develop a leak detection and pressure management program to minimise losses along the following systems:

- Extraction works and pipelines
- Long distance water transmission mains
- Distribution networks
- Sewage pumping mains
- District cooling networks
- Irrigation networks

It is anticipated that most systems would already be subject to passive leak detection, i.e. identifying leaks through visual observation, but that provides limited information and benefits. This recommendation therefore focuses on a pro-active and more thorough leak detection program to locate and repair leaks. The following techniques could be used:

- Ground microphones
- Digital leak noise correlator
- Acoustic logger
- Demand management valves, meters and zoning
- Mobile leak detection programs
- Basic acoustic sounding techniques

In addition excess pressure can be reduced by installing:

- Flow modulating valves on gravity networks
- Pump controls and/or pressure sensors to modulate a pump's relative performance to suit the daily variation in flow demand, thus maintaining maximum efficiency and

A leakage detection program can facilitate the provision of minimal pressures and encourage, through less wastage, a more sustainable use of water resources. In sewerage systems, identification and elimination of leaks can also significantly reduce risk of ground contamination. Pressure management can cost-effectively reduce treatment and pumping costs by minimizing the required delivery pressure and leakage. It is particularly suited to pumped mains and may require estimates of how demand changes over the day. Appropriately rated pressure reducing valves will in turn reduce the flow through leaks and the total flow that must be delivered by the pump upstream at the source/treatment works. This solution may be particularly appropriate in gravity flow networks. The key advantage of pressure management over leak detection is the immediate effectiveness. It is most appropriate where the network is expansive and features multiple small leaks that would be difficult and expensive to locate and repair.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Feasibility Study	The City Authority can help to establish appropriate partnerships to undertake a feasibility study to assess leakage levels across the network(s). The CA should engage a team that includes network planners, water and utilities engineers and financial advisors to ensure the feasibility study captures all pertinent aspects. The feasibility study helps to establish the technological and financial viability, as well as procurement and policy options. Options should be appraised against baseline city energy expenditure associated with water leakage; monitoring flows and demands to refine value and pump controls accordingly. Technical ability, incentives and taxes should also be given consideration.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

US\$100,000-1,000,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

Efficient water use

Enhanced public health & safety

Increased employment opportunities

Financial savings

Security of supply

Direct expenditures & procurement	<p>Where the potable or wastewater network is owned or run by the City Authority, the CA pays for upgrades to the utility infrastructure, directly out of the city budget or through separate funding mechanisms. The advantage of this strategy is that having the legislative authority to take ownership of the intervention will facilitate compliance with local legislation, policies and obtaining planning permission.</p> <p>The main expenditure associated with pressure management will be mainly the acquisition and installation costs of the equipment (i.e. valve, control fittings).</p>
Build-Own-Operate-Transfer (BOOT)	<p>If the City Authority lacks ability to access capital and technical expertise, a Build-Own- Operate-Transfer (BOOT) type contracting mechanism may be deemed most suitable to implement an initiative. The Request For Proposals (RFP) calls upon bidders to implement efficiency measures and provide funding for the project, with remuneration paid through the resulting savings. This 'shared savings approach' is common in the electricity industry.</p> <p>The contractor is required to provide a basket of services including financing of capital, design, implementation, commissioning, operation and maintenance over the contract period as well as training of municipal staff in operations prior to handover.</p> <p>This sort of arrangement can be complex to set up and it can also be difficult to find an organisation willing to take on the risk associated with this form of partnership.</p> <p>Case Study: Emfuleni, South Africa.</p>

Efficiency Standards	<p>The City Authority regulates the Water Companies to meet leak reduction targets and ensure their pipes meet required standards of operational efficiency.</p>
Community led implementation	<p>The City Authority liaises with the local community to increase understanding of the benefits of leak detection initiatives. Simpler, less technical methods of leak detection and reporting provide a considerable opportunity for community involvement and participation. In so doing, amenity will be maximised and leaks may be identified more quickly. In turn, the baseline infrastructure may also be safeguarded against vandalism or poorly implemented operation and maintenance. This activity may be complemented by offering subsidies to those who take part or by passing on the associated monetary savings to the community through reduced water rates.</p>
Partnering Programs	<p>The City Authority liaises with established organisations and/or coalitions (frequently non-profit such as Alliance to Save Energy) to gain access to their experience and expertise in order to implement the most appropriate changes to the pipe/pumping infrastructure.</p> <p>Such organisations often undertake research, educational programs, and policy advocacy, design and implementation of energy-efficiency projects, promotion of technology development and deployment, and/or help to build public-private partnerships.</p> <p>Difficulty can arise where the partnering organisations do not have access or influence over the funds required to implement the initiatives.</p> <p>Case Study: Galati & Iasi, Romania; Phonm Penh, Cambodia.</p>

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- % Unaccounted for water (UFW): Measures the percentage of the water lost, due to leakages, wastage, theft, mechanical errors in meters at the source or human errors in correctly recording the meter reader, out of the total treated water produced.
- % Volume of water leakage per kilometre of water main per day: Measures the average volume of water leakage per kilometre of water main per day during the reporting period.
- Length of water mains inspected for leakages: Measures the total length of water mains inspected for water leakages during the reporting period.
- Properties affected by low water pressure: Measures the total number of properties affected by low water pressure due to aged pipe network or repair works during the reporting period.

CASE STUDIES

Pilot Leak Detection and Abatement Program, Iasi, Romania

<http://www.resourcesaver.com/ewebeditpro/items/O50F1144.pdf>

With an EcoLinks Challenge Grant of \$46,820, Regia Autonoma Judeteană Apa-Canal Iasi (RAJAC) partnered with a U.S. environmental technology provider, Cavanaugh & Associates, to develop a pilot leak detection and abatement program. The total project investment was \$118,074. The program trained RAJAC personnel in leak detection, implemented a leak detection system and developed a water conservation program and public outreach campaign. This pilot leak detection and abatement study was a prerequisite for the implementation of an infrastructure program. Awareness of new technology was significantly increased through training and seminars. The company's public awareness-raising program encouraged and enhanced consumers' capacity to participate in water conservation efforts. Environmental and economic benefits were derived from the more efficient use of water and energy resources. In the short-term, it was estimated that three of the leaks identified in the pilot scheme were responsible for a water loss of 60,000 m³/year and a revenue loss of \$24,000. Since the equipment used during the pilot project cost approximately \$20,000 and no further significant investments were needed to eliminate the leaks, the payback period for the equipment was less than one year. This project contributes to a larger effort to improve water efficiency throughout Iasi County that will ultimately reduce water loss by 8 million m³ and provide a savings of \$3 million per year, however, this level of savings, would require significant investment in the infrastructure.

USAID funded Ecolinks Project, Galati, Romania

<http://www.munee.org/node/62>

As part of a USAID funded Ecolinks Project, the Cadmus Group assessed the city's water supply system and discovered that a series of energy conservation measures could save roughly \$250,000 per year in electricity costs. Low cost measures included trimming impellers to better match pumps and motors with required flows and pressures. Moderate cost measures included leak detection and reduction and limited pump replacement.

Pressure Management, Emfuleni, South Africa

Energy and Water Efficiency in Municipal Water Supply and Wastewater Treatment in Emfuleni, South Africa, available online <http://www.watergy.org/resources/publications/watergy.pdf>

The Sebokeng/Evaton pressure management project uses a Build-Own-Operate-Transfer (BOOT) type contracting mechanism because the municipality had only limited access to capital and lacked the technical capacity to implement the project. The savings in water were so significant that both the municipality and contractor gained, with 80% of the savings accruing to the municipality and the remaining 20% used as remuneration to the contractor for services provided over a five-year period. As the installed infrastructure is permanent in nature and has a design life of at least 20 years, the municipality will continue to achieve savings well beyond the initial five-year period. The staff also benefit from access to additional expertise and training. This project reduced water losses by over 30%, saving about 8 mega-litres per year with an equivalent financial value of around \$3.5 million. These water savings also translate into energy savings of around 14,250,000 kWh per annum due to the reduction in energy required to pump water. The project clearly demonstrated that the intervention of a suitable technology with a shared savings arrangement could succeed in low-income communities; a private firm providing financing for technical innovation at no cost to the municipality received remuneration from sharing the resulting savings in water purchases.

Good Practices in City Energy Efficiency. Emfuleni Municipality, South Africa: Water Leak Management Project (Case Study), available online <http://www.esmap.org/esmap/node/663>

The water supply project in South Africa's Emfuleni Municipality resulted in lower costs for water—including lower energy costs associated with water supply—and also improvements in the municipality's financial status through a new leakage management system for bulk water supply. Innovative pressure management technology was applied to the water supply system of two low-income residential areas, yielding significant savings in water and energy costs for pumping and treating water for distribution. The payback period was only 3 months and financial savings, from both reduced energy use and water losses, was estimated at US\$3.8 million per year for a lifetime of 20 years. Under the performance contracting arrangement employed to finance and implement the project, the municipality retains 80% of the water and energy cost savings during the first five years and 100% of the savings thereafter. The project has been hailed as a great success for South Africa. It clearly demonstrates that the use of suitable technology under a shared savings arrangement can succeed in low-income communities. A private firm providing financing for technical innovation—at no cost to the municipality—received remuneration from sharing savings in water purchases. The contractor provided a basket of services, including financing of upfront investment capital, design, implementation, commissioning, operations and maintenance (O&M) over the contract period, as well as training municipal staff in operations prior to handover of the installation. The project resulted in substantial financial savings that led to a "win-win" situation, both for the municipality and contractor, through a successful public private partnership (PPP).

Water Pressure Management Program, Sydney, Australia

<http://www.sydneywater.com.au/OurSystemsAndOperations/WaterPressureManagement/index.cfm>

Sydney Water has a water pressure management program to target those areas where pressure levels are well above average and there is a history of water main breaks. Excessive water pressure can lead to water main breaks and cause leaks in the city's water system. Water pressure management aims to adjust water pressure levels in the supply system to achieve more consistent pressure levels which will reduce the number of watermain breaks, improve the reliability of the water supply system and conserve water. The Water Pressure Management program is an important part of Sydney Water's leak prevention program and the New South Wales Government's Metropolitan Water Plan.

Water Supply and Drainage Project, Phnom Penh, Cambodia

<http://www.adb.org/water/actions/CAM/PPWSA.asp>

<http://www.adb.org/water/actions/CAM/Internal-Reforms-Fuel-Performance.asp>

Asian Development Bank's (ADB) Phnom Penh Water Supply and Drainage Project provided the opportunity for PPWSA, the government-owned water supply utility, to partner with ADB and demonstrate its capacity for catalyzing water sector reforms. To phase out non-revenue water, i.e. consumers gaining access to water supplies for free, PPWSA started metering all water connections. It gradually equipped each network with a pressure and flow rate data transmitters that provide online data for analyzing big leaks in the system. They also set up a training centre to respond to in-house training needs. PPWSA renewed old pipes using state-of-the-art materials and labour from PPWSA staff. PPWSA also institutionalized performance monitoring, coming up with progress reports and performance indicators on a regular basis and annually subjecting its accounts and procedures to an independent audit. The project advocated the transfer of more managerial autonomy to PPWSA to enable it to use its own funds on maintenance and rehabilitation programs. The result of the project was that PPWSA became financially and operationally autonomous, achieved full cost recovery, and transformed into an outstanding public utility in the region.

01 MUNICIPAL BUILDING ENERGY EFFICIENCY TASK FORCE

**DESCRIPTION**

This recommendation applies to large cities where there is a large number of municipal buildings. Convene a Building Energy Efficiency Task Force that reports directly to the Mayor with a mission to coordinate all ongoing building energy programs and to ensure implementation of retrofit and upgrade programs happen quickly, effectively and are coordinated. This program will provide a focal point for all municipal building energy efficiency projects which will provide economies of scale for more efficient government services, one point of contact for potential implementation partners (ESCOs, etc), and a line of authority directly from the Mayor.

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Establish Task Force	Executive Order or legislative action to create a Task Force that reports directly to the Mayor whose mandate is to identify and execute EE projects across all municipal buildings. Budget for staff may come from Mayor's discretionary funds.
Appoint Task Force Leader	Appoint an individual who can administer the coordination and facilitation of all programs and projects. This should be someone with leadership skills and a political network who can work across agencies to get approvals for energy upgrade projects.

ATTRIBUTES**Energy Savings Potential**

100,000-200,000 kWh/annum

First Cost

< US\$100,000

Speed of Implementation

< 1 year

Co-Benefits

Reduced carbon emissions

Improved air quality

Increased employment opportunities

Financial savings

Acquire Technical Capability	Hire one or two staff with the technical experience with a wide range of building energy systems and the ability to conduct audits, write RFPs for subcontractors or ESCOs and manage construction and renovation projects. Alternatively hire an outside consultant with the above expertise.
Begin Data Collection and Audits	Begin collecting information for all municipal buildings (name, address, electric utility account #, electric bill, water bill, etc.). Then begin a cursory overview of all buildings and identify pilot projects.
Identify Key Programs	Recommend energy efficiency programs (from list of all RAF measures) which have the most opportunity for energy efficiency, will be implementable and will have political support.
Administer Programs	Run the energy efficiency programs and monitor progress and total energy saved by Task Force.

MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- Number of EE projects completed per year by the Task Force
- Number of EE programs currently being run by the CA
- Number of press articles per year on EE projects by the CA
- \$ / yr saved by EE projects by the Task Force

CASE STUDIES

DCAS Division of Energy Management (DEM), New York, USA

http://nyc.gov/html/dcas/html/resources/dcas_oec.shtml

DCAS' Division of Energy Management (DEM) handles accounts that serve 80 agencies and more than 4,000 buildings, providing energy services to all Mayoral agencies, the Health and Hospitals Corporation, the City University of New York, and 34 cultural institutions.

DEM develops an annual energy budget for City agencies, in consultation with the NYC Office of Management and Budget; purchases energy; establishes, reviews, and pays utility accounts; reports on energy consumption; and develops and manages energy conservation programs.

Municipal Network for Energy Efficiency (MUNEE) Program

<http://www.munee.org/>

The Municipal Network for Energy Efficiency (MUNEE) Program in Central and Eastern Europe and the Commonwealth of Independent States was established in 2001.

MUNEE targets city officials, utilities and housing associations, as well as national level policy makers, compiling and disseminating energy efficiency information in local languages.

The program has helped municipalities in 17 countries implement cost effective energy-efficiency measures that provide better heating in homes, schools, hospitals and municipal buildings, and that improve efficiency of municipal water supply systems.

Ekurhuleni Metropolitan Municipality (EMM) Energy Efficiency Strategy, South Africa

http://www.peponline.org/publications/Ekurhuleni%20EE%20Case%20Study%204_06.pdf

Ekurhuleni Metropolitan Municipality (EMM) was able to implement different cost-saving and energy-saving measures in three municipal headquarters buildings. The Environment and Tourism Department lead the initiative and involved a wide range of other departments to develop an Energy Efficiency Strategy.

The total cost of the project, including labour and equipment, was R249,120 (\$41,063). ICLEI secured a grant totalling R242,761 (USD \$40,000) from the United States Agency for International Development (USAID) to fund this project.

This small scale retrofit project resulted in 328,988 kWh of energy saved in one year, this represented economic savings in the order of \$ 50,664 USD per year (using the value of 0.157 USD/kWh for Ekurhuleni Municipal Buildings under tariff C given by EMM).

A simple payback period, taking into account the total investment, was 1.2 years. This is a very significant output considering the co-benefits in GHG emissions reduction: 308 tonnes of CO₂e, 3 tonnes of SO_x, and 1 tonnes of NO_x reduced.

Energy Management System, Frankfurt, Germany

<http://www.managenergy.net/download/r164.pdf>

In 1996 the City of Frankfurt (Building department) entered into a contract with a private company to install and operate an energy-management system for the city hall (Romer), Paulskirche and Museum Schirn. The goal of the project is to reduce the costs for energy- and water as well as the CO₂-emissions.

Based on the annual costs of 2.6 Million DM in 1992/1993 the potential cost reductions were estimated to be approximately 320,000 DM per year. To reach these cost savings an investment of 1 Million DM for control equipment was necessary. Repayment of the invested capital will be provided from the energy savings (54%) over a period of 8 years. The remaining 46% will reduce the operating costs for the buildings.

Energy Plan, Ann Arbor, USA

http://www.a2gov.org/government/publicservices/systems_planning/energy/Pages/AboutTheEnergyOffice.aspx

The Ann Arbor Energy Plan was created in 1981 as part of longstanding commitment to environmental quality. The plan established goals and programs to reduce energy use and costs in Ann Arbor while moving the City towards more sustainable energy use. The Ann Arbor Energy Office supports energy-efficient building projects for over 50 municipal facilities including a performance contracting retrofit of City Hall.

An innovative Municipal Energy Fund has been utilized to implement energy improvements in over 20 city facilities. Energy Office initiatives have saved city taxpayers more than \$5 million in energy expenditures over the last decade.

The Energy Office has also obtained and managed over \$680,000 in grants and rebates from federal, state and corporate sources. Some of these grants, such as Clean Cities grants, have given the Energy Office valuable experience in nurturing partnerships between various departments, levels of government, and public and private sectors in support of alternative fuel vehicles.

TOOLS & GUIDANCE

Tools & Guidance

IFC India Manual for the Development of Municipal Energy Efficiency Projects, 2008.

<http://www.ifc.org/ifcext/southasia.nsf/AttachmentsByTitle/Manual+for+Development+of+Municipal+Energy+Efficiency+Projects+2008.pdf>

A presentation by Berlin Energy Agency on Berlin's Energy Saving Partnership - "a Model of Success" , June 29th, 2010.

http://siteresources.worldbank.org/INTRUSSIANFEDERATION/Resources/305499-1280310219472/CArce_BEA_ENG.pdf

Energy Efficient City in Russia: Workshop Proceedings, June 2010. A guidance document for Preparing, Financing and Implementing Municipal Energy Efficiency Programs.

<http://www.esmap.org/esmap/sites/esmap.org/files/Russia%20EE%20Cities%20Proceedings%20ENG%20080210.pdf>

Energy accounting software ASE 2.3 (original version 2.0) designed for comprehensive accounting and analysis of resource utilization in public buildings. <http://www.munee.org/node/74>

ANEXO 17

02 MUNICIPAL BUILDING BENCHMARKING PROGRAM



DESCRIPTION

Develop a municipal buildings energy benchmarking program which collects and reports on an annual basis the energy use, energy bills, water use, water bills, floor areas, and names of building facility managers (if any). The goal of the program is to identify the highest energy intensive buildings in the CA portfolio so as to focus on the best energy efficiency opportunities.

The benefits of the program are to use energy efficiency program resources most effectively and to spend time and money on the easy wins first. The program will also establish annual data for use in energy/carbon footprint for municipal operations.

This recommendation is best-suited to larger cities with the size and capacity to implement such a program. Regular monitoring and analysis of building energy consumption and identifying improvement opportunities is a good starting point for most cities. However, setting a proper benchmark requires detailed analysis because similar buildings can have significantly varying underlying factors, for example, types of tenants, occupancy density (people per square metre).

IMPLEMENTATION OPTIONS

Implementation Activity	Methodology
Appoint Benchmarking Leader	Appoint, or allocate 1-2 staff with the skills, experience and personality required to be able to gather a wide variety of data from many departments across the city administration. Alternatively hire an external consultant as a leader for the below activities.

ATTRIBUTES

Energy Savings Potential

100,000-200,000 kWh/annum

First Cost

< US\$100,000

Speed of Implementation

1-2 years

Co-Benefits

Reduced carbon emissions

Efficient water use

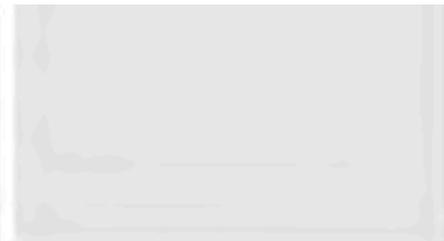
Improved air quality

Financial savings

Identify Benchmarking Requirements	<p>Define essential and desirable information useful for an energy benchmarking database. Electricity bills are only one part of the benchmarking database, and many other key data points are required to contextualize the information. Data may include:</p> <ul style="list-style-type: none"> • building name and address • electrical, gas, water utility account numbers • electrical, gas, water utility bills for past 3 years • building floor areas • energy and water meter locations and associated floor areas • date constructed and date of major renovation • building facilities manager (if any) • building heating, cooling, lighting system types
Set data collection strategy	<p>Set up an efficient process to collect data for the database. Identify which department and which individuals are likely to have access to desired information. Define which data should be collected every year and set up a method to receive the data every year. Set up a method to check and verify data and allow time for validation. Some data may not exist in CA departments, and if so, primary data must be collected by Benchmarking Team (i.e. floor areas, areas allocated to meters)</p>
Begin collecting data	<p>Appoint junior staff to begin the arduous process of requesting data, receiving data, checking data, and collecting primary data from the source.</p> <p>Alternatively write an RFP and award a contract with a specific scope of work to gather energy benchmarking data for all municipal buildings. Data can be stored in spreadsheets or dedicated energy software tools. Care should be taken to ensure quality checks are undertaken at a detailed level to ensure accuracy of data entry.</p>

Analyse and Interpret Data	<p>Conduct an analysis of collected data to ensure accuracy and begin to identify opportunities. Some examples of analysis include:</p> <ul style="list-style-type: none"> • compare kWh/m²/yr electricity consumption by building type • compare kWh/m²/yr heating energy by building type • compare total \$/m²/yr energy consumption by building type <p>Starting with buildings with the highest and lowest performance, verify the floor areas allocated to the utility meters and note any special situations which may increase or decrease energy use (server rooms, unoccupied space, renovations, etc.)</p>
Formulate a Bespoke Benchmark	<p>The results of the analysis stage must be used to formulate a benchmark suitable for the underlying factors affecting energy use in the city. This is required as these factors may vary significantly from city to city and between different buildings. These factors could include:</p> <ul style="list-style-type: none"> • types of tenants • occupancy density (persons/m²) • building energy management <p>This benchmarking is usually done for the purposes of building labelling. See Singapore case study for further details.</p>
Present Benchmarking Internally	<p>One of the most significant motivators for energy efficiency in building operations is peer pressure as no building owners or operators want to be seen as having the worst performing buildings. So sharing building energy intensity internally across departments and operators will inherently improve energy consumption. This will also allow operators to share experiences to allow knowledge sharing across the CA.</p>

Publish Benchmarking Publically	The boldest statement to show leadership in building energy efficiency is to publish energy performance data to the public, press, voters, and potential political opponents. This last stage of the benchmarking program may be many years after the commencement of the program when the data shows improvements and tells a good story of progress toward efficiency in government operations. The CA could then challenge (or require as some cities have begun to do) private building owners to benchmark their buildings and publish their results.
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MONITORING

Monitoring the progression and effectiveness of recommendations, once implemented, is fundamental to an accurate understanding of their value over the longer term. Where the CA implements a recommendation a target (or set of targets) should be defined that indicates the level of expected progress over a given timescale. At the same time a monitoring plan should be designed. The monitoring plan does not need to be complicated or time consuming but should, as a minimum, cover the following aspects: identification of information sources, identification of performance indicators, a means of measurement and validating measuring equipment or processes, record keeping protocols, a schedule for measurement activity (daily, weekly, monthly etc.), assignment of responsibilities for each aspect of the process, a means of auditing and reviewing performance and finally, establishment of reporting and review cycles.

Some suggested measures that relate specifically to this recommendation are as follows:

- kWh/m² - annual electrical energy intensity by type of building (Schools, Offices, Residential, Hospital, Misc)
- kWh/m² - annual heating energy intensity by type of building
- \$/m² - annual energy cost intensity by type of building

CASE STUDIES

Energy Efficiency in Public Buildings, Kiev, Ukraine

Source: ESMAP (2010). "Good Practices in City Energy Efficiency: Kiev, Ukraine - Energy Efficiency in Public Buildings", available online from <http://www.esmap.org/esmap/node/656>

Under the Kiev Public Buildings Energy Efficiency Project, 1,270 public buildings in the city of Kiev—including healthcare, educational and cultural facilities—were retrofitted with cost-effective, energy-efficiency systems and equipment. The project focused on the supply-side, such as automation and control systems, and demand-side measures, including installation of metering and weatherization, as well as a sound heating tariff policy. The project was undertaken by the Kiev City State Administration (KCSA). Savings from the retrofitting were estimated at 333,423 Gigacalories (Gcal)/year by 2006—normalized by degree/days in the base-line year—or about a 26% savings compared to the buildings' heat consumption before the project. These upgrades also improved the buildings' comfort level, helped foster an energy efficiency services industry, and raised public awareness of the importance of energy efficiency.

The project cost US\$27.4 million and was financed through a World Bank loan, Swedish Government grant, and KCSA funds. Based on the project's success, many other cities in Ukraine have requested information on the project and expressed interest in implementing similar ones for their public buildings.

Building Energy Efficiency Master Plan (BEEMP), Singapore

http://www.esu.com.sg/pdf/research6_greece/Methodology_of_Building_Energy_Performance_Benchmarking.pdf

http://www.bdg.nus.edu.sg/BuildingEnergy/energy_masterplan/index.html

The Inter-Agency Committee on Energy Efficiency (IACEE) report identified strategic directions to improve the energy efficiency of the buildings, industries and transport sectors. The Building Energy Efficiency Master Plan (BEEMP), formulated by the Building & Construction Authority (BCA), details the various initiatives taken by the BCA to fulfil these recommendations. The plan contains programmes and measures that span the whole life cycle of a building. It begins with a set of energy efficiency standards to ensure buildings are designed right from the start and continues with a programme of energy management to ensure their operating efficiency is maintained throughout their life span. The BEEMP consists of the following programmes:

- Review and update of energy standards
- Energy audit of selected buildings
- Energy efficiency indices (EEI) and performance benchmark
- Energy management of public buildings
- Performance contracting
- Research and development

Energy Smart Building Labelling Programme, Singapore

<http://www.e2singapore.gov.sg/buildings/energysmart-building-label.html>

The Energy Smart Building Labelling Programme, developed by the Energy Sustainability Unit (ESU) of the National University of Singapore (NUS) and the National Environment Agency (NEA), aims to promote energy efficiency and conservation in the buildings sector by according recognition to energy efficient buildings. The Energy Smart Tool is an online benchmarking system that can be used to evaluate the energy performances of office and hotel buildings. It enables building owners to review the energy consumption patterns within their buildings and compare them against the industry norms. An Energy Smart Building Label, reviewed every three years, is awarded to winners as part of an annual awards ceremony.

Apart from helping to reduce energy consumption and carbon emissions within the buildings sector, Energy Smart Buildings stand to:

- Reap energy savings due to active energy management
- Enjoy higher satisfaction levels by occupants
- Enhance the company's corporate image

Municipal Energy Efficiency Network, Bulgaria

<http://www.munee.org/files/MEEIS.pdf>

Thirty-Five Bulgarian cities have established the Municipal Energy Efficiency Network (MEEN). EnEffect is the Secretariat of the Network. Since April 2001, MEEN has admitted four municipal associations as collective members. In order to create a successful municipal energy plan, MEEN promotes the development of two key elements: an energy database and a training program for municipal officials.

General information is collected into municipal "Passports". This information is gathered through surveys of various organizations and entered into a database, or energy efficiency information system (EEIS). The EEIS has two layers: database and analysis. The database, a Microsoft Access application, contains objective, technical information, and the analysis contains non-technical information, such as financial, institutional and regulatory documents generated at the national level. This information is organized into three categories: municipality-wide consumption, site-specific consumption, and municipality-wide production.

Energy Management Systems in Public Building, Lviv, Ukraine

Source: ESMAP (2011). "Good Practices in City Energy Efficiency: Lviv, Ukraine - Energy Management Systems in Public Buildings", available online from

http://www.esmap.org/esmap/sites/esmap.org/files/Lviv%20Buildings%20Case%20final%20edited%20042611_0.pdf

The Ukrainian city of Lviv was able to reduce annual energy consumption in its public buildings by about 10 percent and tap water consumption by about 12 percent through a Monitoring and Targeting (M&T) program to control energy and water consumption. This generated an estimated net savings of 9.5 million UAH (US\$1.2 million) as of 2010. The M&T program was launched in December 2006 and became fully operational by May 2007. It provided the city management with monthly consumption data for district heating, natural gas, electricity and water in all of the city's 530 public buildings. Under the program, utility use is reported and analyzed monthly; targets for monthly utility consumption are determined annually based on historical consumption and negotiations on an adjustment (in cases of foreseeable changes in consumption patterns). Actual consumption is reviewed monthly against the target, with deviations spotted and acted upon immediately and the performance of buildings is communicated to the public through a display campaign.

The M&T program achieved significant savings with minimal investment and recurring program costs. These utility bill reductions have been valuable in light of fiscal constraints and increasing energy prices. The program benefited from a crucial initial condition where most of the city's public buildings were already metered for energy and water consumption and that the city had been collaborating with international aid programs in municipal energy since the late 1990s.

Strong city government leadership and commitment were key success factors of Lviv's public buildings energy and water M&T program. A new Energy Management Unit (EMU) was established within the city administration and resources were mobilized to train all personnel with line responsibility on building utility use in an administrative division, unit, or building. The M&T system established responsibility, created transparency, and enabled informed control of energy and water use in public buildings, laying a solid foundation for sustained improvements in energy and water efficiency.

Public Building Energy Management Program, Lviv, Ukraine

<http://www.ecobuild-project.org/docs/ws2-kopets.pdf>

As part of the Energy Efficiency Cities of Ukraine initiative, launched in 2007 as initiative of 4 cities, supported by MHME, NAER and European Association of local authorities "Energie-Cities", Lviv has promoted sustainable energy policy and action plans at a local level.

The city has developed a Public Building Energy Management Program through the Energy Efficiency Cities of Ukraine initiative. These involve regular data gathering through various agencies and a subsequent monitoring and analysis of building energy consumption in order to identify easily achievable improvement opportunities.

SMEU Software, Romania

<http://www.munee.org/files/SMEU-romania.pdf>

The SMEU software was created to set priorities for municipal energy action plans and to assess global energy costs and consumption. The goal of this software is to gather, organize and use energy data so that decision-makers could analyze trends in energy use by consumers and by resources and accurately predict the energy budget for the following period.

The SMEU software divides data into individual and interacting modules to collect data on various aspects of the energy cycle. The Locality Module collects information on an annual basis, including area, population, and average temperature, as well as general information on the municipality such as number of buildings and number of dwellings per building.

NYC Greener Buildings, USA

http://council.nyc.gov/html/releases/prestated_4_22_09.shtml

New York City Municipal Buildings were benchmarked for Energy Efficiency. The project, initiated on December 9, 2009 with the passage of the "Greener, Greater Buildings Plan" (formally known as Intro. No. 476-A, Benchmarking Energy and Water Use), puts the city at the head of a national effort to improve building energy efficiency aimed at reducing America's carbon footprint and its use of highly pollutive fossil fuels to generate electricity.

The project used the U.S. Environmental Agency's (EPA's) Energy Star Portfolio Manager energy management tool, which is integral to the LEED (Leadership in Energy and Environmental Design) certification process, as established and managed by the U.S. Green Building Council, or USGBC.

The Plan aims to reduce the city's total carbon footprint by 30 percent by 2030 (originally 2017), with five percent of that reduction coming from government, commercial and residential building. After the initial phase is completed, building owners will be required to benchmark yearly.

TOOLS & GUIDANCE

Tools & Guidance

Target Finder helps users establish an energy performance target for design projects and major building renovations.

http://www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder

Portfolio Manager is an interactive energy management tool to track and assess energy and water consumption across the entire portfolio of buildings. http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

A presentation by Berlin Energy Agency on Berlin's Energy Saving Partnership - "a Model of Success" , June 29th, 2010.

http://siteresources.worldbank.org/INTRUSSIANFEDERATION/Resources/305499-1280310219472/CArce_BEA_ENG.pdf

Energy Efficient City in Russia: Workshop Proceedings, June 2010. A guidance document for Preparing, Financing and Implementing Municipal Energy Efficiency Programs.

<http://www.esmap.org/esmap/sites/esmap.org/files/Russia%20EE%20Cities%20Proceedings%20ENG%20080210.pdf>