



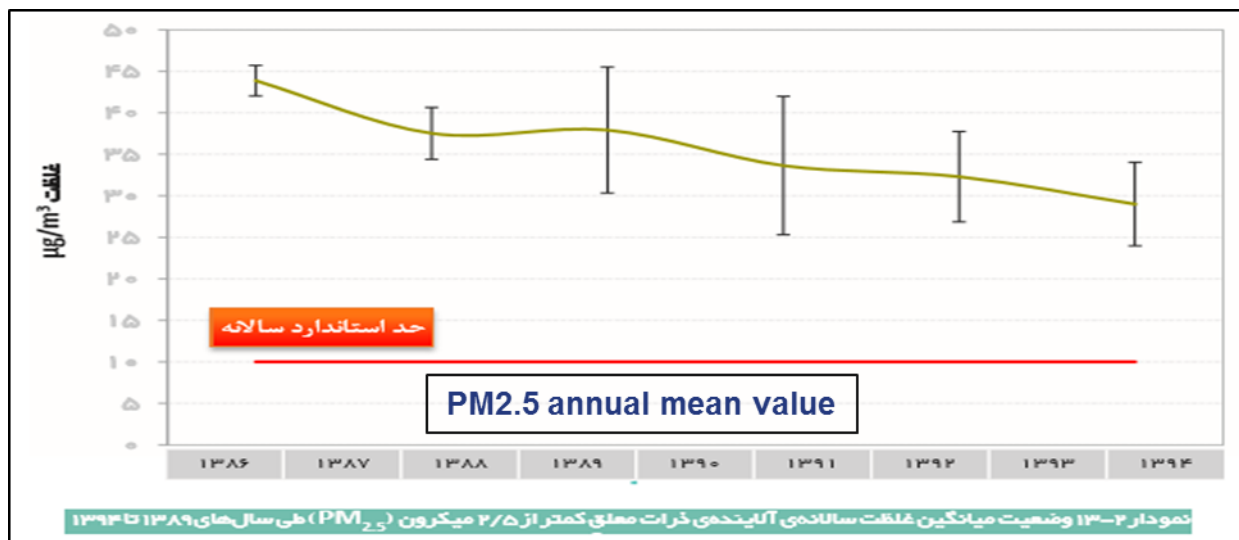
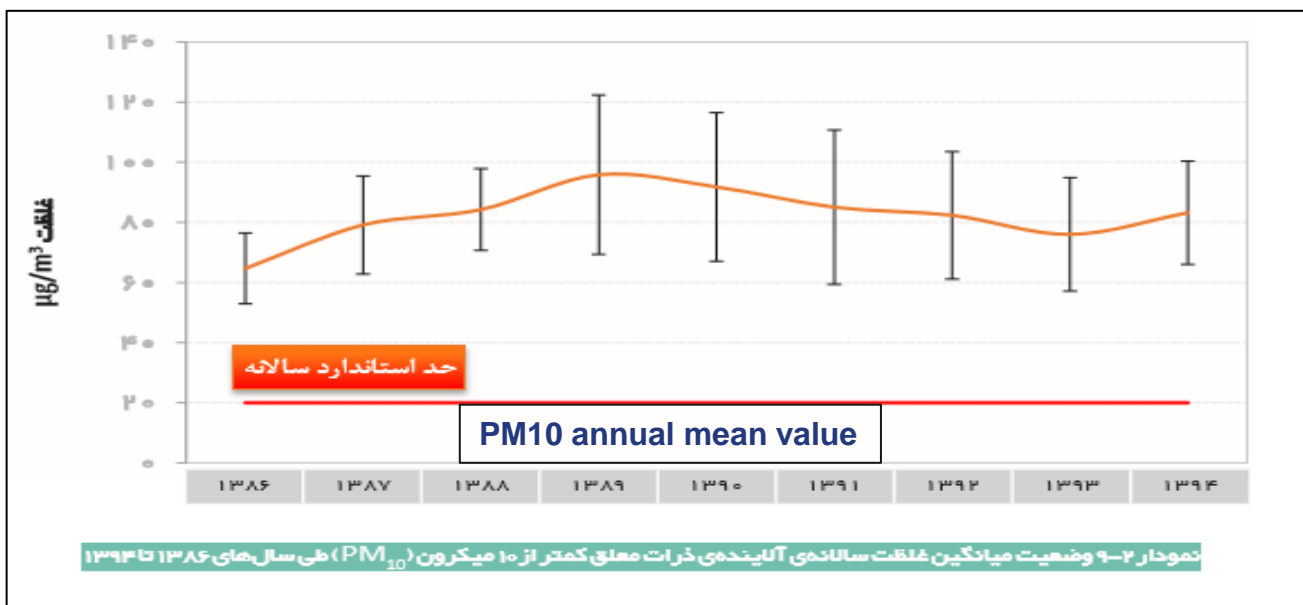
DPF Retrofit in Iran after 2 years of field experiences

SOOT-FREE TEHRAN, International Workshop, SEP. 2016, Hossein Izanloo

Table of Content

- PM problem and related legislative actions**
- Why DPF retrofit program for Tehran bus fleet**
- Project master plan**
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- Best practices**
- Availability of low sulfur fuel**

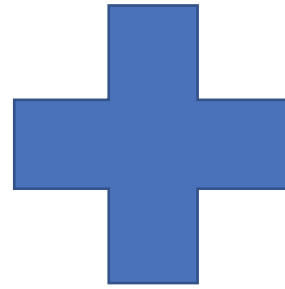
Tehran PM problem



منبع: شرکت کنترل کیفیت هوا، گزارش سالانه کیفیت هوای تهران در سال ۱۳۹۴، QM95/02/01(U)/1، خرداد ماه ۱۳۹۵

Fuel and Particulate Filter

Low Sulfur
Diesel Fuel



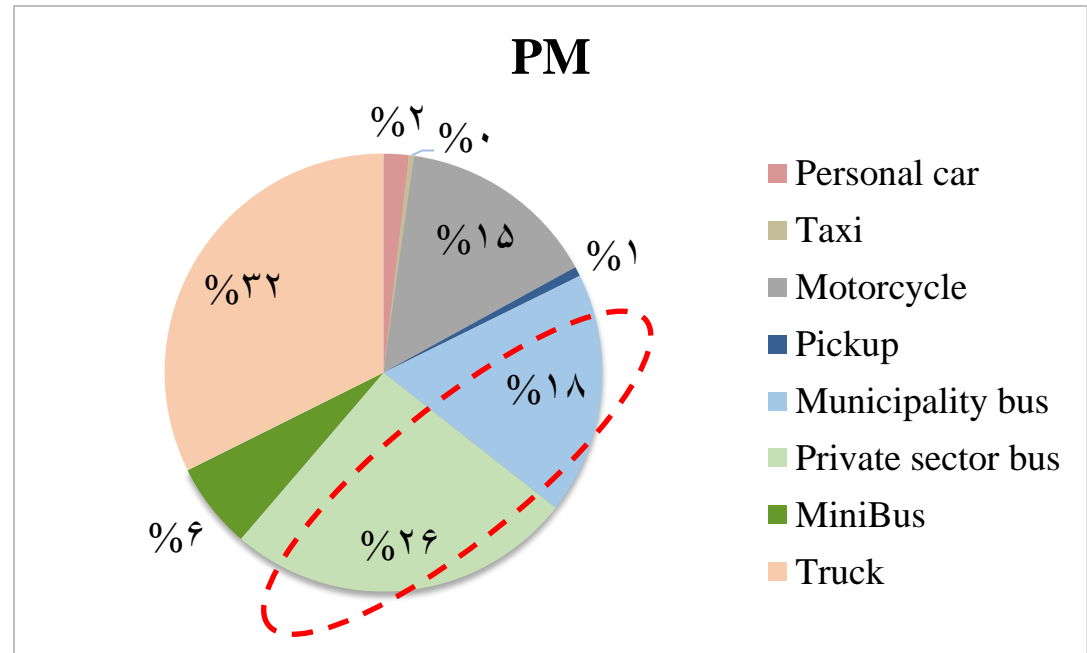
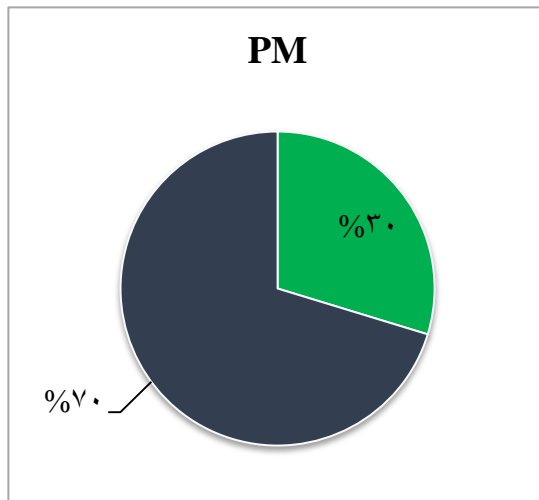
Particulate Filter Actions

- ❑ **All new diesel vehicles to install DPF according to new legislation, implementation date Sep. 2016**
- ❑ **Municipalities of major cities to retrofit diesel buses fleet with DPF**
 - ✓ **Tehran retrofit plan: 1. pilot fleet, 2. 200 buses, 3. 600 buses and 4. 2000 buses**

Low Sulfur Fuel Actions

- ❑ **Distributing Euro 4 fuel in six megacities in 2014**
- ❑ **Availability of Euro 4 and Euro 5 fuels across the country up to 2017-April**

Contributions of Tehran Primary PM Sources



- Personal car
- Taxi
- Motorcycle
- Pickup
- Municipality bus
- Private sector bus
- MiniBus
- Truck

منبع: شرکت کنترل کیفیت هوا، سیاهه انتشار آلاینده‌گی شهر تهران برای سال مبنای ۱۳۹۲ - جلد دوم: منابع متحرک

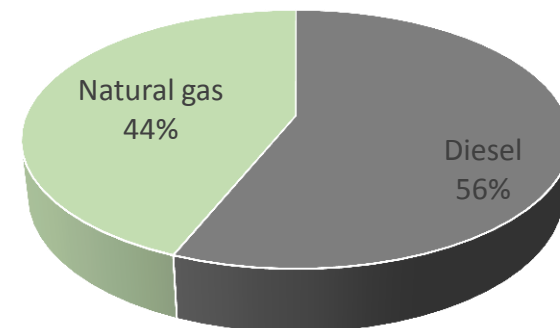
TEHRAN BUS FLEET

Tehran public bus fleet (municipality)

6554

Governmental Sector				Private Sector			
2497				4057			
Diesel		Natural gas		Diesel		Natural gas	
1956		541		1723		2334	
BRTs	Ordinary	BRTs	Ordinary	BRTs	Ordinary	BRTs	Ordinary
1504	452	0	541	0	1723	0	2334

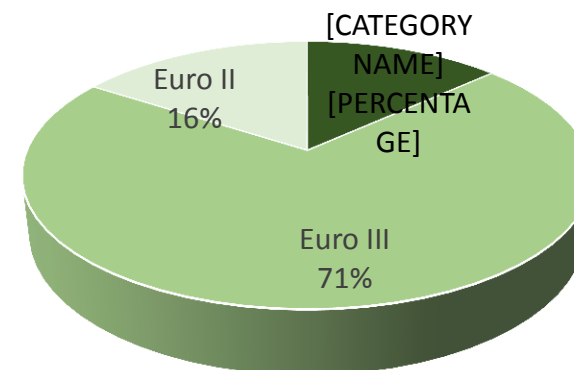
Fuel Classification



Tehran BRTs

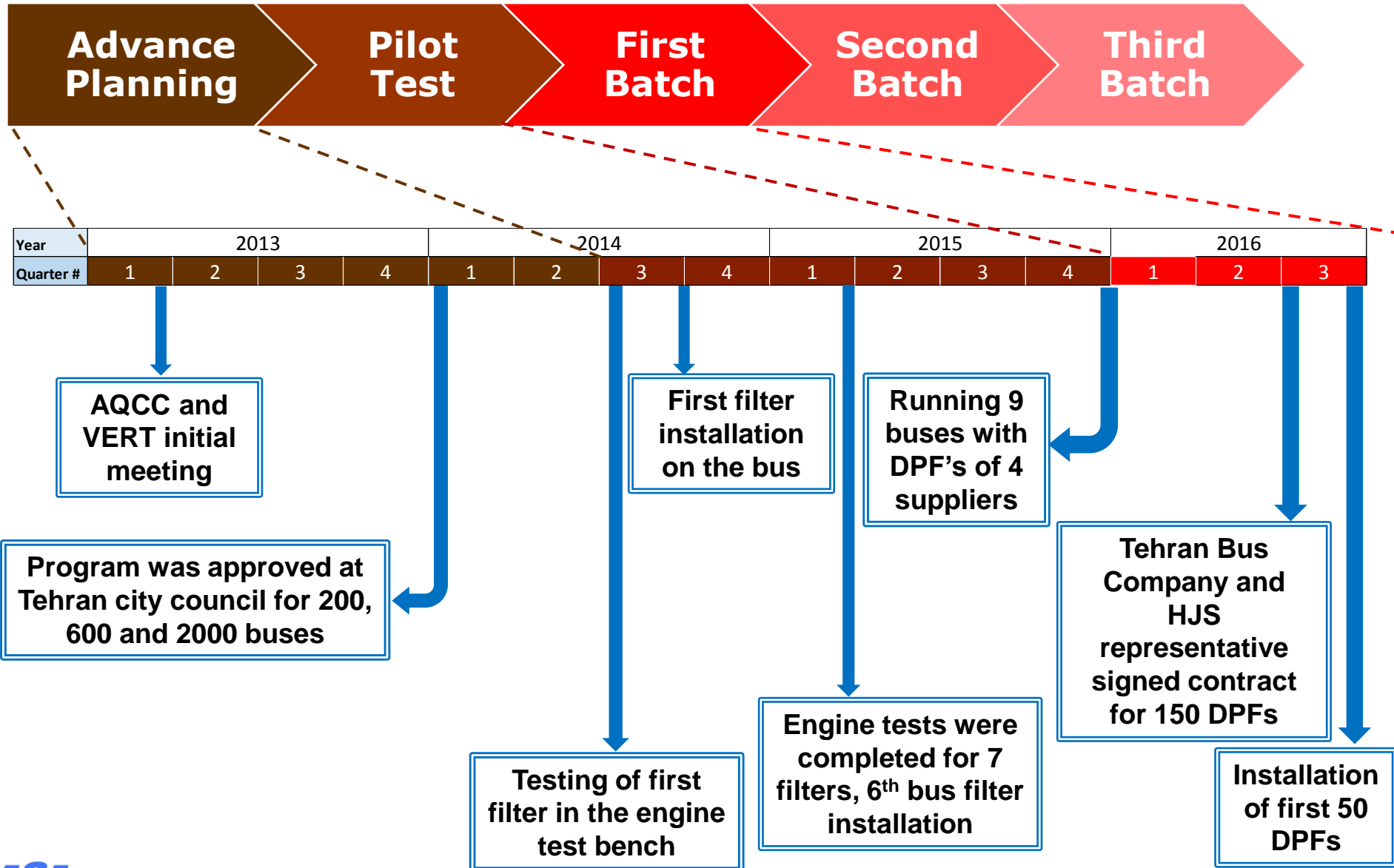
Average life	Entrance year	Count	Double cabin	Single Cabin	Engine	Bus Type
5 years	2009-2011	835	X		MAN Euro 3	King Long
5 years	2008-2011	200	X		MAN Euro 3	YOUNGMAN
1 year	2015	200	X		MAN Euro 4	Yutong
9 years	2004-2010	249		X	RENAULT Euro 2	SHAHAB
1 year	2014	20		X	RENAULT Euro 2	SHAHAB
-	-	1504	1235	269	-	Total

BRTs' Emission Standards

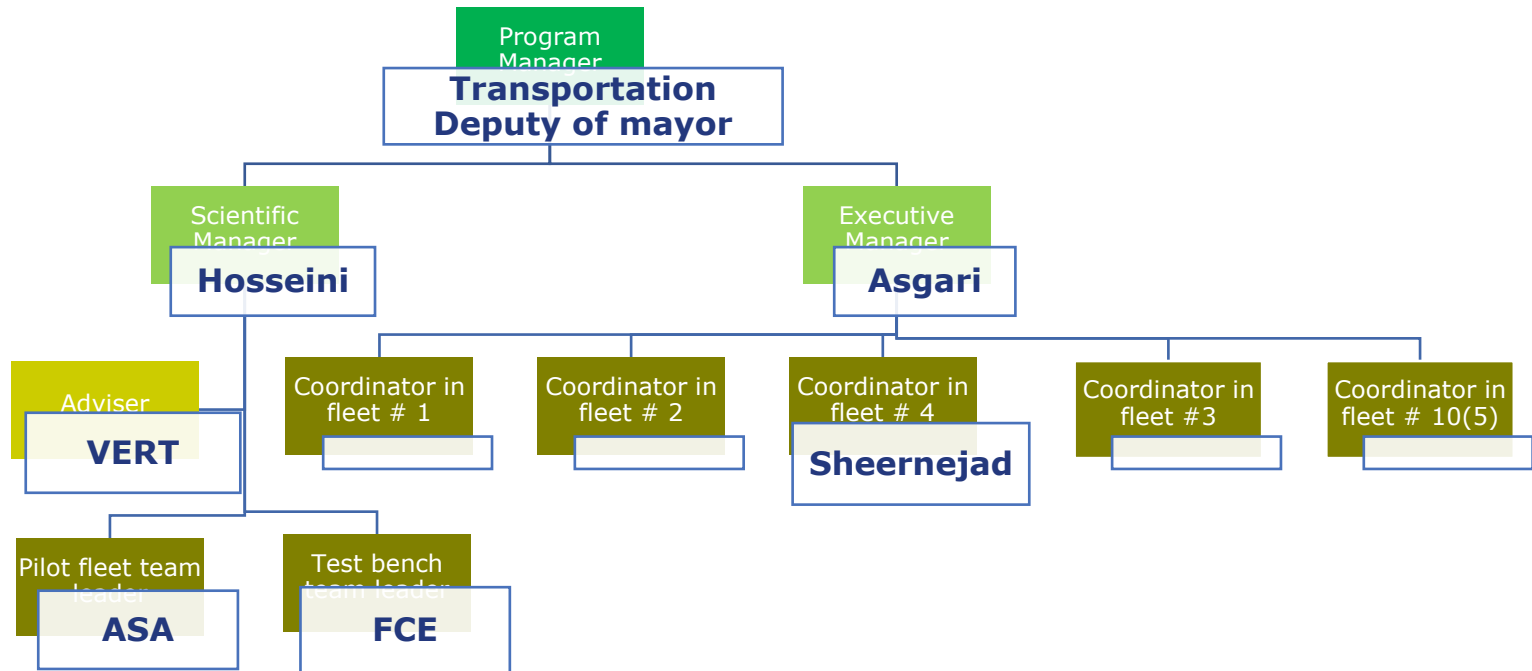


Tehran DPF Project Progress

Mater Plan

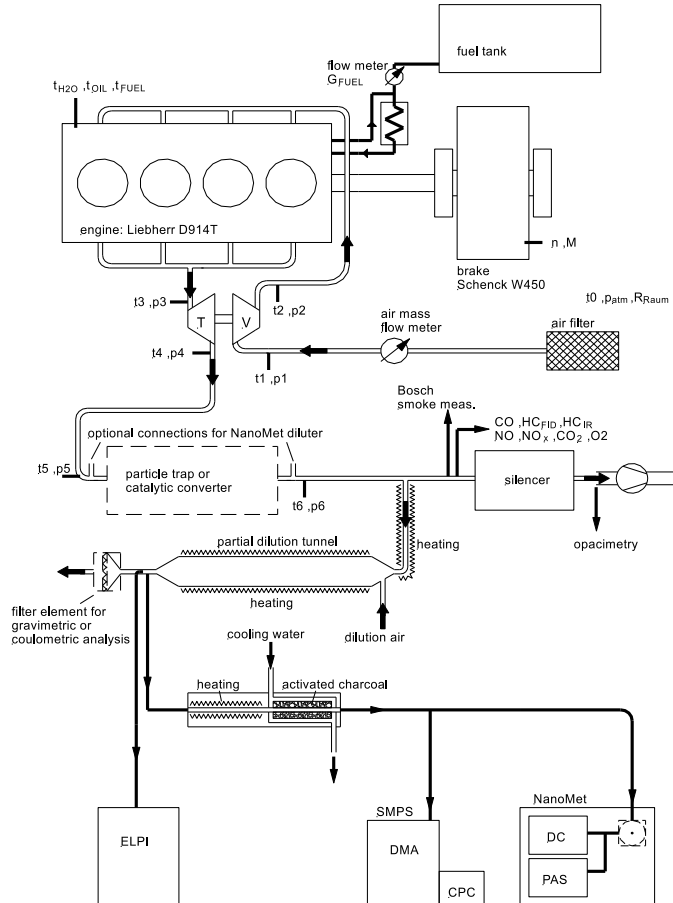


Tehran DPF Project Organization



General Information of Engine Testing

Set up for measurement of VFT1 and VFT3
 → PN, PM, EC, CO, HC, NO, NO₂ and metal particles



ELPI: Electric Low Pressure Impactor (DEKATI)
 DMA: Differential Mobility Analyser (TSI)
 CPC: Condensation Nucleus Counter (TSI)
 DC: Diffusion Charger (MA)

PAS: Photoelectric Aerosol Sensor (MA)
 SMPS: Scanning Mobility Particle Sizer (TSI)
 NanoMet: Nanoparticle Analyser (MA)
 T/V: Turbine, Compressor or Turbocharger

Phase 1 – Laboratory Tests

Start Date	July 2014
Test Site	IDEM Company's engine test bench
Taskmaster	AQCC
Executer	FCE (Sharif U of Tech)
Supervisor	VERT
Participated DPF Companies	HJS- Dinex- Puritech- Tehag- Huss- Hug...

Tested Engine Type

Manufacturer / type	IDEM(OM457)
Serial number / year of manufacture / operating hours	(AENR)P090737/2014/10
Emission legislation level	EU(II)
Cylinder number and configuration	6 inline
Bore x stroke / overall displacement	128 x 155 [mm] / 12 [dm ³]
Compression ratio	17.25
Cooling medium (air, water, etc.)	Water
Combustion process	direct injection
Supercharging / Charge air cooling / Charge pressure max.	Turbocharger/intercooler/
Exhaust aftertreatment measures to reduce emissions	No
EGR	No
Rated power / Rated speed	220 [kW] @ 2000 [min ⁻¹]
Max. Torque @ RPM	1250 [Nm] @ 1100 [min ⁻¹]
Max exhaust temperature downstream TC @ nominal RPM	500° C @ 1000 [min ⁻¹] /
Low idle speed / high idle speed	600 ± 50 [min ⁻¹]; 2100 [min ⁻¹]

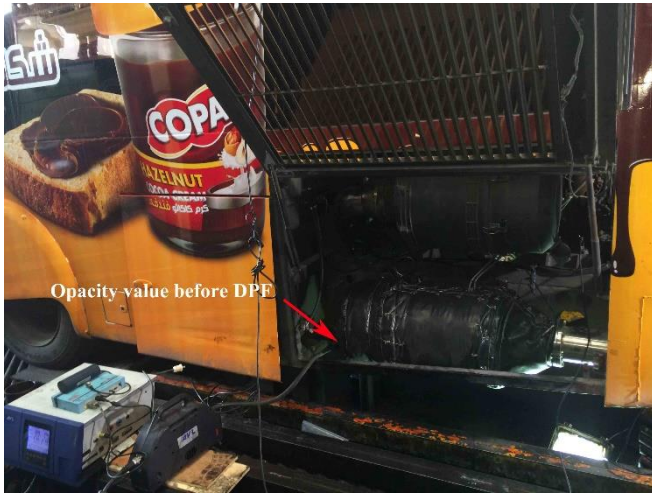


Sulfur Content of Used Fuels and Related Test Results

	Low Sulfur	Medium sulfur	High sulfur
Sulfur level	48-50 ppm	230-250 ppm	7000-7700 ppm

DPF producer company	DPF type	VTF1 (Low Sulfur)	VTF1 (Medium Sulfur)	VTF1 (High Sulfur)
A	Active - Electrical heater	Not tested	Pass	Pass
A	Passive - CRT	Incomplete	Failed	Not tested
B	Passive - FBC	Not tested	Pass	Pass
C	Passive - FBC	Not tested	Pass	Pass
D	Passive - CDPF	Not tested	Pass	Not tested
E	Passive - CRT	Not tested	Failed	Not tested
F	Active - Diesel burner	Not tested	Failed	Not tested
F	Active - Post injection	Not tested	Waiting for VERT and AQCC	Passed performance, safety issues

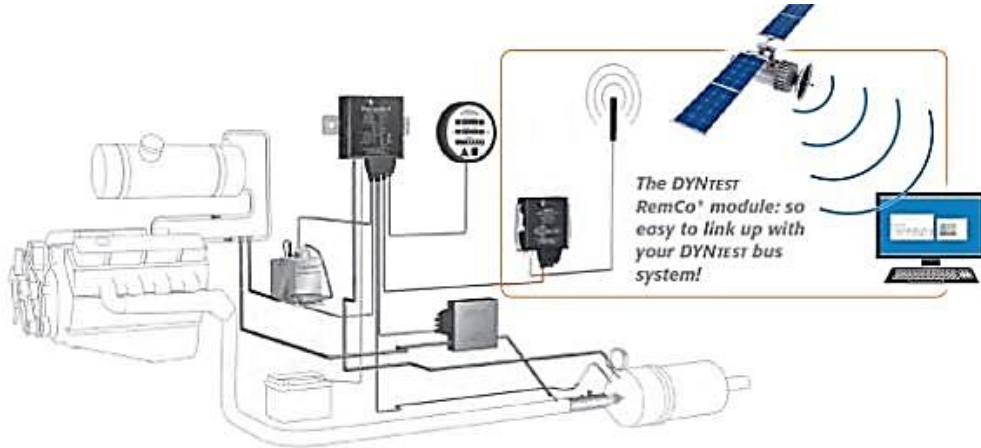
Sample DPFs Installation



Overall Status of DPFs Installation

DPF installation date	DPF producer company	DPF technology	Vehicle ID	Bus operated Line	Bus mileage until DPF installation (km)	K-value measurement (installation time)	
						B-DPF	A-DPF
10/Sep/2014	B	Passive system + FBC	78514	Line 4	229689	1.80	0.02
22/Oct/2014	A	Passive system + FBC	78515	Line 4	272444	2.00	0.04
28/Jan/2015	C	DOC + Passive DPF + FBC	78524	Line 4	239626	1.70	0.02
19/Feb/2015	B	Active system + FBC	85423	Line 4	280412	1.10	0.02
19/Feb/2015	B	Active system + FBC	33572	Line 2	142717	1.24	0.04
23/Feb/2015	B	Active system + FBC	85476	Line 10	212093	1.60	0.01
02/Jun/2015	A	Passive system + FBC	33637	Line 2	160695	2.00	0.02
24/Sep/2015	D	CDPF (Catalyzed DPF)	85182	Line 10	211553	1.76	0.00
23/Jan/2016	D	CDPF (Catalyzed DPF)	33592	Line 2	-	1.60	0.02

Data Logging



- Some of Important Features**
- Online information sending**
- GPS reports**
- Programmable SMS sending option**
- Recording temperature, pressure and operation parameters data**

GPS Reports for 001443

No.	Start Time	Stop Time	Duration	
1	16.12.2015 03:07	16.12.2015 09:45	6h :39 min.	DETAILS
2	14.12.2015 05:36	16.12.2015 01:26	43h :50 min.	DETAILS
3	12.12.2015 23:55	13.12.2015 23:17	23h :22 min.	DETAILS
4	12.12.2015 10:13	12.12.2015 10:33	0h :20 min.	DETAILS
5	12.12.2015 07:31	12.12.2015 07:46	0h :15 min.	DETAILS
6	11.12.2015 20:16	12.12.2015 06:07	9h :51 min.	DETAILS
7	11.12.2015 08:40	11.12.2015 09:03	0h :23 min.	DETAILS
8	11.12.2015 08:31	11.12.2015 08:33	0h :2 min.	DETAILS
9	11.12.2015 06:37	11.12.2015 06:42	0h :5 min.	DETAILS
11	10.12.2015 09:19	10.12.2015 09:25	0h :5 min.	DETAILS

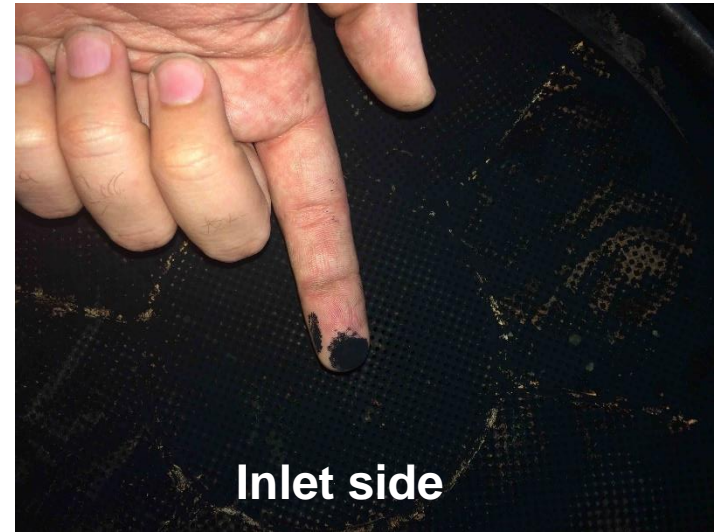
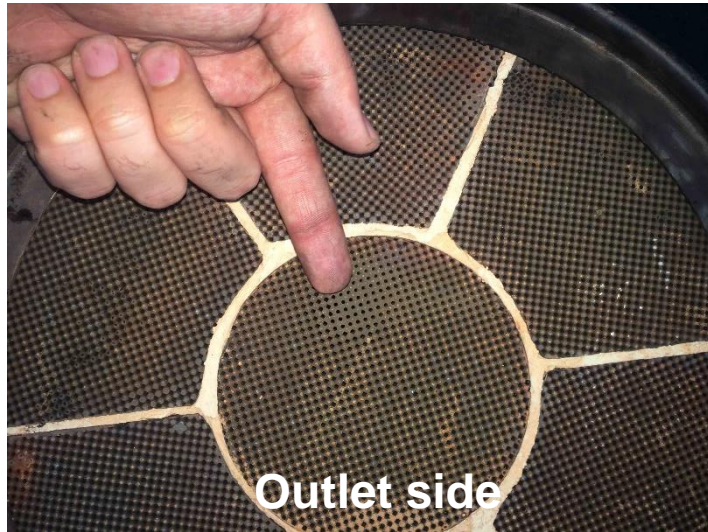
Delta Time	Speed (mph)	Direction (Degrees)	Altitude (ft)
Start: 16.12.2015 03:07	0	130	3609
Stop: 16.12.2015 09:45	0 : 0	82	1593 : 5226

CPK Automotive
Member of the Heilmann Group

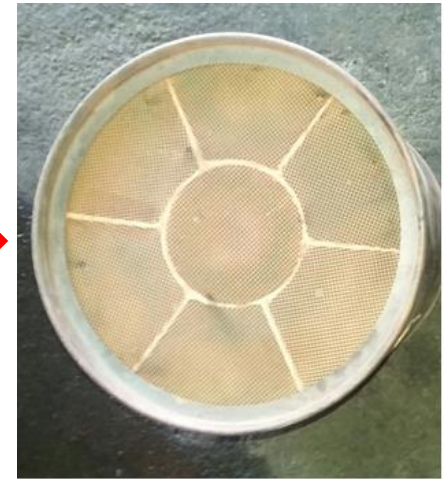
Welcome Project Iran -

Project	Vehicle ID	System	Install. Date	Vehicle Description	Fleet	Date, Time	Status	last known position	Action
PURtech	78-524 Line 4	LN: 001443 DN: 1930	28Jan2015	01 PURtech Installed (28Jan2015)	Iran	16.12.2015 09:45	In Motion	35.73062; 51.41633	In Motion Out Details
Dinex	78-515 Line 4	LN: 001490 DN: 1954	22Oct2014	01 Dinex Installed (22Oct2014)	Iran	18.09.2015 06:35	In Motion	35.65126; 51.41908	In Motion Out Details
	85-156 Line 10	LN: 001491 DN: 1930		CPK Problem (Date)	Iran	20.11.2014 11:14	Action	35.67239; 51.30826	In Motion Out Details
Dinex	33-437(04 119) Line 2	LN: 001492 DN: 1933	02Jun2015	02 Dinex Installed (02Jun2015)	Iran	16.12.2015 13:57	In Motion	35.64266; 51.47732	In Motion Out Details
	32-938 (Removed)	LN: 001493 DN: 1927		Line 3 - (CPK Temp Sensor Emor)	Iran	30.11.2014 10:02	Action	35.74635; 51.49235	In Motion Out Details
	85-162 (Removed)	LN: 001494 DN: 1927		85162 former CPK- before DPF installation	Iran	08.11.2015 15:21	Action	35.74433; 51.29508	In Motion Out Details
	33-457 Line 1	LN: 001495 DN: 1927		Engin problem/ Out of Service	Iran	27.10.2014 13:42	In Motion	35.74661; 51.49253	In Motion Out Details

Sample Filter After Six Months Operation



DPF Cleaning



Sample Fuel and Oil Specifications Measurement

Low sulfur fuel for public bus transportation

Fuel Station	Measured Season	Sulfur Content (ppm)	Cetane Number
Tehran- zone 2 (moshirie)	Spring	40.7	54.6
Tehran- zone 2 (moshirie)	Summer	40.8	-
Tehran- zone 2 (moshirie)	Fall	51.2	52.7
Tehran- zone 2 (moshirie)	Winter	78	-

Test Name: Oil Sulfated Ash-wt%

Test Method: ASTM D874

Vehicle ID: 78514

Sample #	Date	Result
1	2014-Nov.	2.29
2	2014-Dec.	2.3
3	2015-Jan.	2.31

Regular Monthly Report (ASA Data Analyzer)

The screenshot displays the Azmoon Sanat Data Analyzer software interface. The window title is "Azmoon Sanat Data Analyzer". The menu bar includes "File", "Configuration", and "Report Forms". The toolbar features the ASA logo (AZMOON SANAT ARVIN), a "Configuration" icon, a "Generate Report" icon, and several chart types: "Pressure", "Temp1/Temp2", "Speed", "Temp Diff", "Pressure/Speed", "Parameters", and a "REPORT" icon.

The main content area shows a report titled "Diesel Particulate Filters' Feasibility Study Report". The report's period is "2015/10/01 - 2015/10/31" and it is for "Tehran - Iran". The report features a blue bus with a diesel particulate filter, a green background, and various icons representing different transport modes (bus, car, motorcycle, bicycle, train, tram). The text on the right side of the report reads: "Diesel Particulate Filter an effective way to control solid particulate".

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www.ASAArvin.com | info@asarin.com

Tehran Program Test Matrix

Test Matrix of Tehran DPF Program							
Fuel Sulfur content	Type of DPF Technology Engine testing / Bus running	Active			Passive		
		electrical heater + FBC	post injection	diesel burner	FBC	CDPF	CRT
50 ppm	engine testing	-	-	-	-	-	-
	pilot fleet running	√	-	-	√	√	-
230 ppm	engine testing	√	√	√	√	√	√
	pilot fleet running	-	-	-	-	-	-
7000 ppm	engine testing	√	√	-	√	√	-
	pilot fleet running	-	-	-	-	-	-

Pilot fleet general information		
Emission level	Key tech.	Ave. mileage of selected pilot fleet
Euro III	EGR	> 220,000 km
note: tested engine emission level was Euro II		

DPF Cleaning Creterias
Continues back pressure: 250 mbar (10 S)
Maximum back pressure:

Overall Status of DPFs

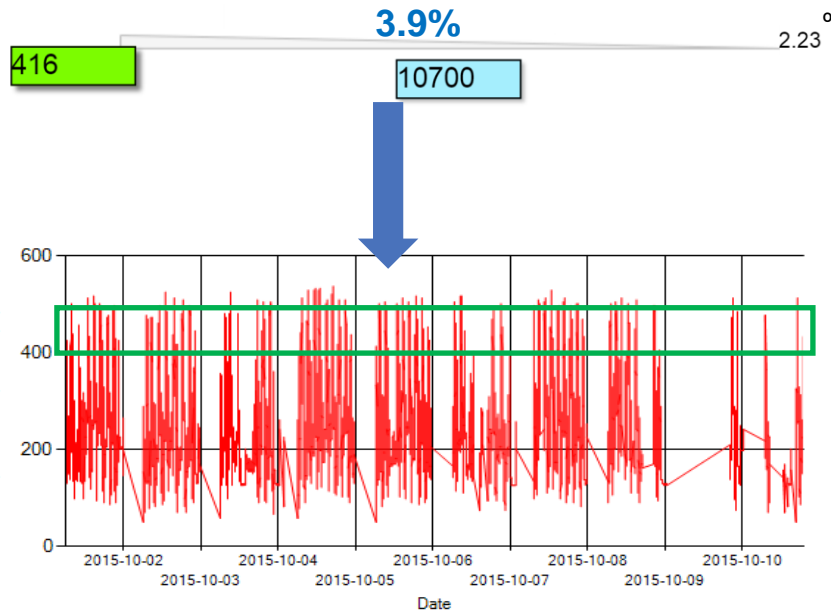
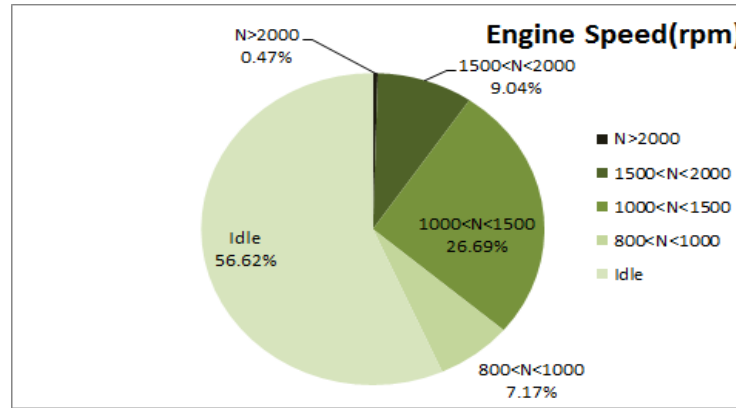
DPF Code		1X	2X	1Y	2Y	3Y	1Z	2Z	3Z	4Z
Working Line		Line 10- South to North Line		Line 2 – West to East Line			Line 4 – South to North Line			
Working Days		529	292	498	21	158	690	403	551	542
Mileage (km)		71,840	20,970	72,372	2,500	11,643	84,551	49,616	< 30,000	89,804
First cleaning	mileage	23,644	-	30,800			36,000	13,253	26,500	55,000
	comment	-	-	-	3 times cleaning	-	-	Doesing system was not adjust	-	-
Second cleaning	mileage	43,700	-	-			-	-	few thousands	-
	comment	-	-	3 times cleaning. 1 time core changing. (severe operating condition)	not suitable for low temp. line	-	The second cleaning was done on 2016/Jul/11	-	3 times cleaning, and 2 times core changing. cleanings were not efficient	The second cleaning was done on 2016/Jul/10

KEY RESULTS

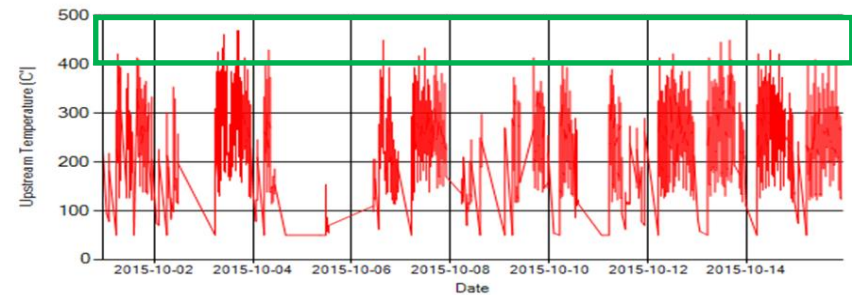
- ❑ **Maximum sulfur contents of sample fuels: < 100 ppm**
- ❑ **Mileage of 3 DPFs is between 72,000 km to 90,000 km, two cleaning times**
- ❑ **Mileage of 1 DPF is 50,000 km, one cleaning time**
- ❑ **Mileage of 1 DPF is 72,000 km, three cleaning times**
- ❑ **Mileage of 2 DPFs is less than 20,000 km, no cleaning**
- ❑ **3 types of technology passed pilot test**
- ❑ **DPFs of 3 suppliers passed pilot test, DPF of supplier needs more test evidences**

Sample Experiences

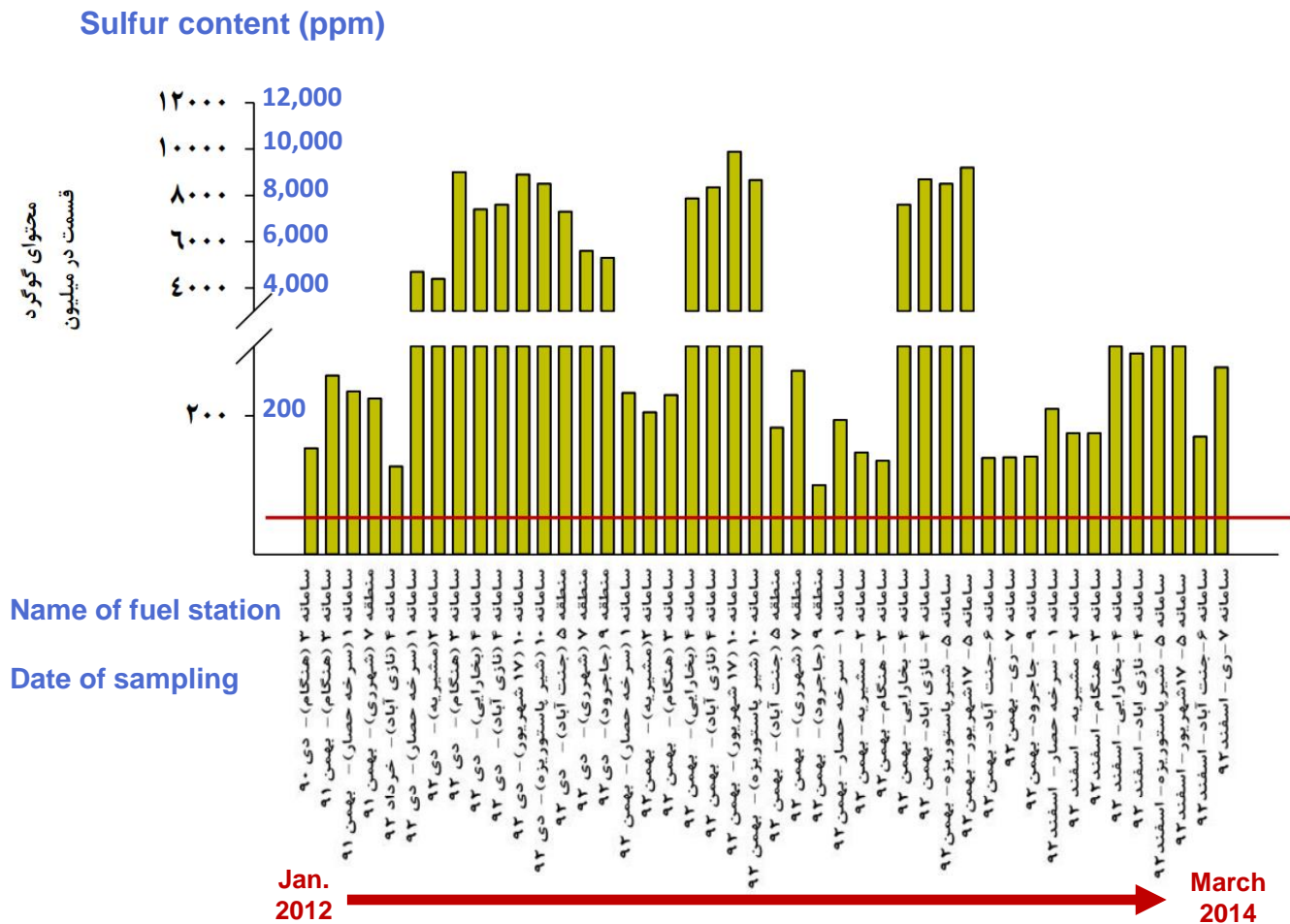
High idling time share



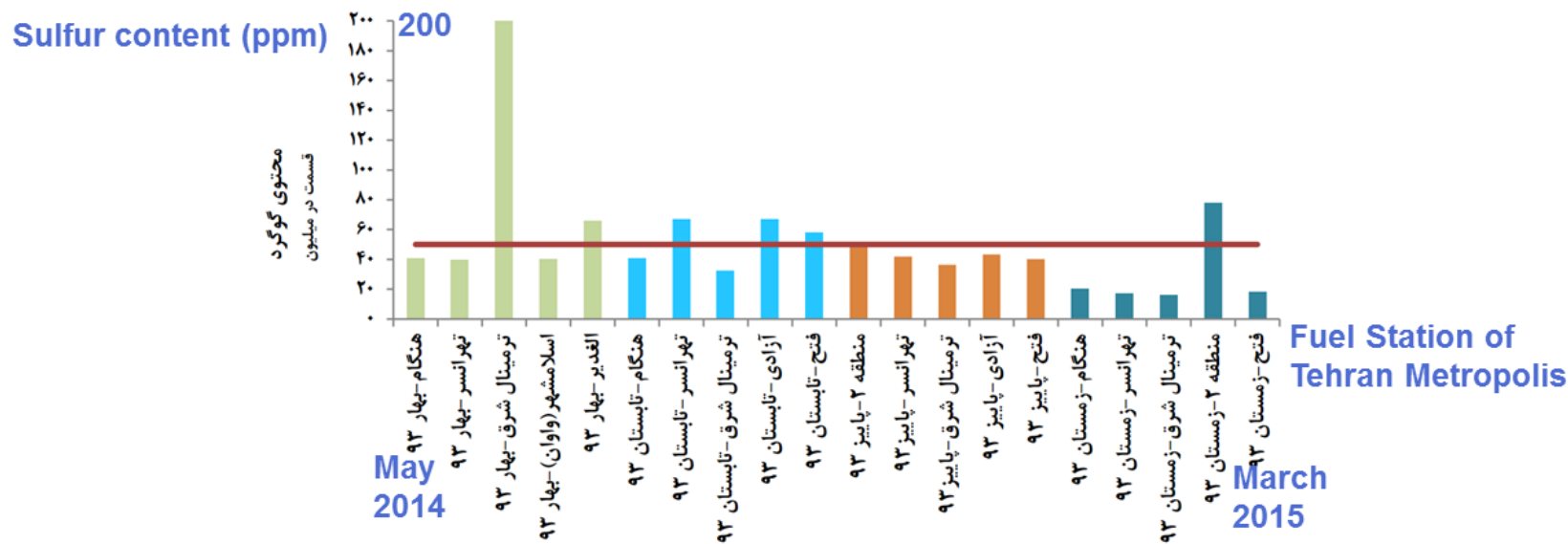
Different temperature patterns in different lines



TEHRAN FUEL SULFUR CONTENT BEFORE 2014



TEHRAN FUEL SULFUR CONTENT in 2014



CURRENT STATUS

- ❑ **Total diesel fuel production in Iran: 90 mil lit/day**
- ❑ **Diesel fuel consumption in road transport sector: 48 mil lit/day**
- ❑ **Production of low sulfur fuel (< 50 ppm): 29 mil lit/day**

1. **production capacity of low sulfur fuel is much more than needed low sulfur fuel for Euro IV vehicles and vehicles with DPF**
2. **Challenge is mixed system of transportation, storage tanks and fuel stations**

Realistic estimates based on ongoing projects

- ❑ **Beginning of 2018**
 - ✓ **Total diesel fuel production in Iran: 110 mil lit/day**
 - ✓ **Diesel fuel consumption in road transport sector: < 50 mil lit/day**
 - ✓ **Production of low sulfur fuel (< 50 ppm): 54 mil/day**
- ❑ **Production of low sulfur fuel in beginning of 2019: 95 mil lit/day**

- 1. In beginning of 2018 the only available fuel in any fuel station will be low sulfur fuel**
- 2. Iran oil industry is more capable than Iran auto industry to accelerate development projects in new atmosphere created by sanction lifting**
- 3. All stockholders including DOE, OEMs, DPF Suppliers, Oil Industry and Legislators should manage transient period of 2016 and 2017**

*Discussions are welcome
Thank you for your attention*



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